A National Review of Vaccine Preventable Diseases in Australia

A thesis submitted for the Degree of Masters of Philosophy (Applied Epidemiology) of

The Australian National University

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National Centre for Immunisation Research and Surveillance (NCIRS)

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Originality Statement

'I hereby declare that this submission is my own work and to the best of my knowledge it contains no materials previously published or written by another person, or substantial proportions of material which have been accepted for the award of any other degree or diploma at Australian National University or any other educational institution, except where due acknowledgement is made in the thesis. Any contribution made to the research by others is explicitly acknowledged in the thesis. I also declare that the intellectual content of this thesis is the product of my own work, except to the extent that assistance from others in the project's design and conception or in style, presentation or linguistic expression is acknowledged'.

Signed _____

Date 08/11/2018

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Acknowledgements

Firstly I would like to thank each of my academic supervisors at the Australian National University (ANU) and field supervisors at the National Centre for Immunisation Research and Surveillance (NCIRS): Professor Martyn Kirk, Professor Ross Andrews, Dr Aditi Dey, Dr Frank Beard, and Dr Helen Quinn. Your expertise, guidance, and support has been appreciated beyond belief. This thesis would not have happened without your patience for all of my impromptu meetings and office drop-ins, so I thank you for every piece of advice and feedback you have provided throughout this process. Additional thanks goes to the staff at the National Centre for Epidemiology and Population Health and NCIRS who have assisted me on this journey, especially Dr Alice Richardson, who provided me with last minute statistical advice on more than one occasion, and Dr Sanjay Jayasinghe, who guided me through the complex world of pneumococcal disease.

I would like to express how grateful I am for all of the support, encouragement, and friendship I've received from the 2017 MAE cohort throughout this process. We started together and finished together, and I am in awe of the complex level of, and exceptional quality of, research this group has been involved in over the past two years. I am truly thankful for the journey we have all taken together over these past two years.

Lastly I would like to thank my partner Julian for his ongoing support, love, and patience throughout this journey, as well as our pup Rogue for all of the puppy cuddles I received after returning home each day.

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Master of Philosophy Applied Epidemiology Overview

1. Introduction

MAE Experience

Upon acceptance into the MAE, I was selected for a placement at the National Centre for Immunisation Research and Surveillance (NCIRS). NCIRS is an independent research organisation which provides evidence-based advice on vaccine preventable diseases which is used to shape immunisation policy and services nationally in Australia. I worked with my primary supervisor, Dr Aditi Dey, in the coverage, evaluation, surveillance, and social research division, along with Dr Frank Beard and Dr Helen Quinn as support supervisors. This division's work focuses on Australian vaccine preventable disease surveillance, indigenous vaccination surveillance, vaccination coverage, program evaluation, serosurveillance, social research, and data linkage research.

I found the staff at NCIRS to be extremely experienced with a high level of knowledge. Being able to work with and receive advice from others within the organisation exposed me to additional aspects of research and policy-focused work which I may not have been exposed to otherwise. I had a well-rounded experience at NCIRS and gained a deeper understanding and appreciation for the work the organisation does.

In addition to my placement at NCIRS, I was fortunate enough to undertake one of my projects at the Western Sydney Public Health Unit (WSPHU). I was able to spend time with the WSPHU director, lead epidemiologist, and infectious disease team, which exposed me to the practical side of public health work in action.

In addition to the support I received in the workplace, I was also guided by Professor Martyn Kirk who acted as my academic supervisor. Having led the MAE program for many years, Martyn was able to provide me with expert guidance and advice on my

projects and becoming a well-rounded epidemiologist through the process of completing the MAE program. When a change in program leadership occurred, Professor Ross Andrews joined my supervisory team as a support academic supervisor. Ross was able to facilitate an international deployment for me during the program, in which I was able to gain fieldwork experience as a team leader for a research team collecting baseline data for a study on lymphatic filariasis and scabies in Samoa.

Through the MAE I was able to present for the first time at a conference, submit my first peer-reviewed paper for publication, and participate in several experiences outside of the MAE requirements. Some of these experiences included contributing to enhanced disease surveillance efforts at the 2018 Gold Coast Commonwealth Games with the Gold Coast Public Health Unit, and the preparation and delivery of university-level lecture materials for the University of Sydney on vaccine-preventable disease surveillance in Australia.

Abstract

My MAE projects centred around vaccine preventable diseases in Australia. My projects consisted of: a national audit of the Australian Immunisation Register, an epidemiological review of pneumococcal disease, an evaluation of the enhanced surveillance system for *Haemophilus influenzae* type b (Hib) disease, and contributing to response efforts of the exposure of an active case of tuberculosis to immunocompromised patients.

My epidemiological project (Chapter 2) consisted of an audit of the Australian Immunisation Register (AIR), which captures vaccination status for all Australians, to assess the effectiveness of the transfer of immunisation encounter records to the AIR and to identify ways to improve it. Through this research, I documented an error rate of 13.7%, meaning 13.7% of antigen-specific records on the register which were classified as being overdue for administration were actually up to date. Recommendations to reduce vaccination encounter data transfer errors in the AIR included improving data entry in electronic systems and considering options to reduce the failure of electronic data transfer to AIR via practice management software.

Topical to an upcoming change on the Australian National Immunisation Program (NIP) to a 2+1 pneumococcal immunisation schedule, I analysed notification, hospitalisation, and mortality data for pneumococcal disease from 2002-2016 for my data analysis project (Chapter 3). Focusing on the impact of the 13-valent pneumococcal conjugate vaccine (13vPCV) since its NIP introduction mid-2011, I analysed national trends by age group, Indigenous status, and serotype. Through this review I identified the decline or stabilisation in rates of invasive pneumococcal disease (IPD) in all age groups except

those <5 years of age, adding to the evidence which supported the immunisation schedule change to include a booster dose at 12 months of age. This change aimed to increase protection in those <5 years of age. I also identified similar trends to that of IPD, although to a lesser extent, in presumptive non-invasive pneumococcal community acquired pneumonia hospitalisations, presenting national trends for the first time.

The *Haemophilus influenzae* type b (Hib) Case Surveillance Scheme (HCSS) is the national enhanced Hib disease surveillance system which captures data not routinely collected from Hib disease case notifications. Additional information collected includes detailed case immunisation status, risk factor history, and laboratory diagnostic information. I conducted the first evaluation on the HCSS (Chapter 4). This evaluation supported the collection of enhanced Hib disease data, however areas identified for improvement included: data quality, output production, system simplicity, and the return of the HCSS to the Department of Health with adjusted methods for enhanced data collection.

My final project was a response to an acute public health incident; the exposure of immunocompromised patients to an active tuberculosis case (Chapter 5). Tuberculosis screening was prioritised to those deemed of highest risk based on immunocompromised status. I developed a database using REDCap data management software which captured case and patient information for reference and future analysis. I developed and generated reports to produce epidemiological snapshots of response efforts. In addition, I undertook a risk assessment to identify key risks, barriers, and areas for improvement regarding the response.

Summary of Core Course Requirements

I was able to successfully complete all MAE coursework requirements (Table 1) and MAE project-based requirements (Table 2).

Table 1: Summary table of MAE coursework requirements

Unit of Study	February - March 2017	August 2017	February - March 2018
POPH8915 Outbreak Investigation	X		
POPH8917 Public Health Surveillance	X		
POPH8913 Analysis of Public Health Data		X	
POPH8916 Research Design and Methods		X	
POPH8914 Issues in Applied Epidemiology			X

Table 2: Summary table of MAE project-based requirements

Thesis Chapter	Epidemiological Study	Data Analysis of a Public Health Dataset	Evaluation of a Surveillance System	Response to an Acute Public Health Incident	Late Draft of a Peer-Reviewed Publication	Conference Presentation	Communication with a Lay Audience	Teaching Activities
Chapter 2 Australian Immunisation Register Data Transfer Audit - Stage 2	X							
Chapter 3 Epidemiological review of pneumococcal disease in Australia, 2002-2016		X			X	X		
Chapter 4 Evaluation of the Haemophilus influenza type b (Hib) Case Surveillance Scheme			X				X	
Chapter 5 High-risk Patient Exposure to an Active Tuberculosis Case: An Epidemiological and Risk Assessment from a Baseline Contact Investigation and Follow-Up				X				
Chapter 6 Lesson From the Field & A Case Study Teaching Session								X

Publication

Through my work on pneumococcal disease, a peer-reviewed paper was submitted to *Clinical Infectious Diseases* for publication.

1. Meder K, Jayasinghe S, Beard F, Dey A, Kirk M et al. Incidence of invasive pneumococcal disease and pneumococcal community acquired pneumonia in Australia, 2002-2016 [unpublished manuscript]. Clinical Infectious Diseases; 2018.

Presentations

During the MAE I was fortunate enough to present at a national conference on my pneumococcal disease work. I also co-presented at an NCIRS Academic Meeting on the Australian Immunisation Register Audit.

1. Meder K, Jayasinghe S, Beard F, Dey A, Pennington K et al. Pneumococcal disease trends in Australia, 2002-2016. 16th Public Health Association of Australia National Immunisation Conference; June 2018; Adelaide, Australia.
2. Dalton L, Meder K. Australian Immunisation Register Data Transfer Audit - Stage 2. Presentation presented at Monthly NCIRS Academic Meeting; 2017; National Centre for Immunisation Research and Surveillance.

2. Epidemiology Project

Australian Immunisation Register Data Transfer Audit - Stage 2

2. Epidemiology Project

Prologue

Background

This epidemiological study was the first of the four required MAE projects which I became involved in. Having a background in health research, I was looking forward to contributing to this study, applying my current knowledge base, and having the opportunity to learn additional skills. Knowing of the recent shift in Australia to the use of a whole-of-life immunisation register, I took on this project knowing that this piece of work may influence future decisions regarding the recording and transfer of immunisation encounters for the country, having a potential beneficial effect on national coverage rates for all ages.

My Role

This project was part of a NCIRS-managed high-priority study under contract to the Australian Government Department of Health (Health) that involved numerous stakeholders and contributors. For this project I was responsible for developing the study protocol, determining the sample size requirements, managing the ethics approval process, merging data files at Health Protection NSW (HPNSW), NSW Health, sorting, randomising, and distributing merged 11A report records for site follow-up, cleaning and analysing the collected data, and contributing to a final report. In addition to these duties, I assisted in the development of the data collection tools, attended key stakeholder meetings, and provided input throughout the study process. Lauren Dalton, project coordinator, played a key role in the coordination of the project with Health, the Jurisdictional Immunisation Coordinators (JICs), and Primary Health

Network (PHN) staff. Lauren oversaw the development of, and provided content for, the final report, including the executive summary, a majority of the report discussion, and the study recommendations.

Lessons Learned

This project challenged my knowledge of epidemiological concepts and practices. Conducting an epidemiologic study from inception through to completion has allowed me to experience the full process of undertaking an operational health research project. My understanding of methodological concepts and the reasoning behind their implementation was tested. Additionally, my data analysis skills greatly improved through using both SAS and STATA statistical packages. This project taught me the intricacies of more advanced techniques in epidemiology, including stratified sampling techniques and weighted data analysis.

In addition to enhancing my epidemiological skills, this project improved my knowledge on the data transfer processes between vaccination providers' records from an immunisation encounter and the Australian Immunisation Register (AIR). I learned about the role of PHN staff in providing support to vaccine providers. I also learned of the importance of truly working together as a united team to produce an outcome.

Public Health Implications

Expected benefits of this research included the identification of improvements to the data transfer process of immunisation encounter information to the AIR, the reduction

of errors in AIR records and the subsequent reduction of unnecessary follow-up of those children identified as up to date. An increase in immunisation coverage rates could be an indirect result if the recommendations are acted on, affecting future research and policy. Additionally, with increased accuracy in children's records lies the potential to reduce unnecessary repeated vaccinations, of particular importance in the context of the No Jab/No Play policy. Lastly, action on the recommendations provided could reduce the workload of immunisation providers, AIR staff, Public Health Units (PHUs), and PHNs.

Acknowledgements

I would like to acknowledge my team members at NCIRS for all of their guidance and contributions in making this study a success, as well as all of the stakeholders who contributed to the study development process, collection of data, and input into the final report.

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Abstract

Introduction

The National Centre for Immunisation Research and Surveillance (NCIRS) was contracted to undertake the first national audit to assess the effectiveness of the transfer of immunisation records to the AIR, and to identify ways to improve it. Records of immunisation encounters are currently transferred to the AIR via paper-based methods, directly onto the AIR online site, or by practice management software. It is important to assess the accuracy of the data transfer to understand to what degree children who are up to date are incorrectly identified by the AIR as overdue, as misclassification of records can have financial consequences for families and contribute to incorrect reporting of national vaccination estimates.

Methods

A cross sectional study design was used to review overdue immunisation records by overdue antigen, for children aged 9-<12, 15-<18, 21-<24 and 51-<54 months old as of 4th October, 2017, who were at least three months overdue for a vaccine antigen, according to the National Immunisation Program Schedule.

Data was sourced from the AIR via 11A reports, which provide clinical and contact details for individuals nationally. Descriptive analyses and weighted multivariate logistic regression were used to assess the relationship between records which were determined to contain an error and Indigenous status, area coverage level, provider type, method of data transfer of immunisation encounters to the AIR, vaccine antigen and dose number, and geographic remoteness category.

Ethical approval was sought and granted by Australian National University, application #2017/370.

Results

Of six participating jurisdictions and 2400 identified records, five collected data which was able to be included in the study analyses and results. We were able to assess 905 records, while 892 records were lost to follow-up, and 603 records were excluded, including all records from the Northern Territory due to variation. Of the 905 records assessed, 781 records were truly overdue and 124 records contained an error, giving an error rate of 13.7% (defined as the proportion of overdue AIR records actually up to date due to identified error). The most common error types related to practice management software transmission failure (43%) or being a duplicate record (27%). Transmission of immunisation encounter information to the AIR via paper-based methods or via AIR online secure site, living in a remote area, and being between 9-<12 months of age were all significantly associated with a record containing an error.

Conclusion

While the overall error rate was identified as lower than previous literature at 13.7%, a number of recommendations were provided to improve data quality even further. Recommendations include for action to be taken to: support providers to discontinue the use of paper-based methods of data transfer; increase knowledge and skills surrounding AIR online processes, data entry, and common error observed; improve the accuracy of recording overseas vaccination history; and identify where errors occur

during the communication processes between practice management software, particularly Best Practice and Medical Director, and the AIR.

Introduction

The Australian Childhood Immunisation Register (ACIR) was established in 1996 to record immunisation history for all children less than 7 years of age. In 2016, the ACIR expanded to a whole of life register and was renamed the Australian Immunisation Register, or AIR, in 2016 to capture complete immunisation history. The AIR is used for a range of purposes including: assessing vaccination status and planning catch up immunisations for those who miss scheduled doses, assessing regional and national vaccine coverage rates, assessing eligibility for family payments, and enabling program responses to public health concerns.

The effectiveness of the transfer of data from immunisation providers' records to the AIR has not been systematically assessed. In 2001, NCIRS conducted a national study examining the accuracy of the ACIR by comparing self-report at telephone interview by parents quoting other records against their child's ACIR record. The study estimated that missing data led the ACIR to underestimate the true level of vaccine coverage at the national level by 2-3%.[1]

In 2016, the Australian Government Department of Health funded NCIRS to undertake a two stage project to: assess the effectiveness of data recording, handling and transfer to the AIR; to identify any barriers to the timeliness and accuracy of data; and scope and propose options for improving the efficiency and effectiveness of data recording, handling, and transfer. NCIRS conducted the project with support from the Australian Government Departments of Health and Human Services (DHS), who own and fund the AIR, and state and territory health departments.

In early 2017, NCIRS completed Stage 1 of this project, which identified relevant published and unpublished studies across Australia assessing the effectiveness of the transfer of immunisation data into the AIR (formerly ACIR).[2] Information from these studies was collated and analysed to identify key issues and barriers in relation to the timely and accurate transfer of data; these included: children vaccinated overseas and data not entered into AIR, electronic data transfer issues from practice software to AIR, and data entry and AIR data handling issues.

This report details Stage 2 of the project.

Aim

The aim of this study was to assess the effectiveness of the transfer of immunisation records to the AIR and identify ways to improve it.

Objectives

The key objective of the study was to undertake an audit of the records of children recorded as overdue for vaccinations on the AIR. If incomplete or erroneous data were identified, to investigate and identify the factors, barriers, and causes of inaccuracy of the data;

1. Evaluate whether these factors varied by:
    a. geographical area
    b. level of coverage (low/medium/high)

c. provider type

d. method of data submission (including specific practice management software type)

2. Develop recommendations for improving the effectiveness and efficiency of the transfer of immunisation information to AIR.

Methodology

Study Type and Population

This study was conducted using a cross sectional study design. The study population was children aged < 5 years who resided in New South Wales, the Northern Territory, Queensland, South Australia, Victoria, or Western Australia and had an AIR record.

Inclusion Criteria

The inclusion criteria for the study population was children aged 9-<12 months, 15-<18 months, 21-<24 months, and 51-<54 months as of 4th October 2017. Children who had a record on the AIR who were at least three months overdue for a vaccination, and who were born between the following dates (Table 1), based off of the median extraction date of October 4th, 2017, were able to be included in the study.

Table 1: Study population age and birth date cut offs

Cohort	6 Months	12 Months	18 Months	48 Months
Age Range	9 to <12 Months	15 to <18 Months	21 to <24 Months	51 to <54 Months
DOB Inclusive	5 October 2016 – 4 January 2017	5 April 2016 – 4 July 2016	5 October 2015 – 4 January 2016	5 April 2013 – 4 July 2013

Participating Sites

All eight state and territory JICs were invited to participate in the audit. Individual discussions were held with each JIC or their nominee to ascertain their capacity to participate. Following these discussions, Primary Health Networks (PHNs) were approached in some states and territories to determine whether they could assist their relevant jurisdiction in participating in the audit. PHNs were approached for assistance in this study due to their access to AIR records and capacity for study participation. Six states and territories agreed to participate with varying partnerships with PHNs, as detailed in Table 2.

Table 2: Participating sites conducting audit follow up

State/Territory	Participating sites
New South Wales	Hunter, New England, Central Coast PHN South Eastern Sydney PHN Murrumbidgee PHN South Western Sydney PHN Northern Sydney PHN Western NSW PHN
Northern Territory	NT Health
Western Australia	WA Health WA PHN Alliance
Queensland	Queensland Health
South Australia	SA Health SA PHN Immunisation Hub
Victoria	Department of Health and Human Services

Extraction of Population Sample

Each participating study site extracted an 11A report which was produced by the AIR. 11A reports, each consisting of four separate data files, were used to identify the study sample for this audit. The 11A reports identified individuals who were due or overdue for vaccination, by their locality, and were broken down by postcode and age range. The 11A report extracts provided the following information.[3]

- individual's details - name, address and overdue status
- immunisation history of each individual - all vaccines recorded on the AIR at the time the report is produced
- due/overdue vaccine antigens (e.g. measles, pertussis)
- last immunisation provider's details - name, address and phone number
- natural immunity/medical contraindication details

Sample Size

Required sample sizes were calculated using a 95% confidence interval, 0.05 level of precision, and an estimated error rate of overdue records that are actually up to date of 45% (Appendix 2.A).[1,4,5] The estimated sample size was calculated to be 400 records for each state and territory, to provide power to an 80% level to detect differences within and between jurisdictions for analysis by up to two variables (e.g. age cohort, coverage level, error type, geographic area remoteness classification, provider type, and/or method of data submission). More in-depth stratification involving three or more variables required grouping at national level to reach sufficient power.

Child records considered overdue for vaccination were extracted from the AIR by jurisdiction for the milestone ages of 6, 12, 18, and 48 months of age, covering a 3-month span. Based on AIR jurisdictional population counts for each age cohort, true population proportions were derived for application to the total of 400 records required per jurisdiction (Table 3). In addition, to account for the disproportionate number of overdue records falling within low coverage areas, weights were applied by coverage area as such that per jurisdiction, 50% of records selected were sourced from low coverage areas, 30% from medium coverage areas, and 20% from high coverage areas. Coverage areas have been previously been defined for routine, national vaccination coverage reporting as:

- Low coverage area (<90%)
- Medium coverage area (90 -<95%)
- High coverage area (≥95%)

The final sample size table excluded Tasmania (TAS) and the Australian Capital Territory (ACT), as these jurisdictions chose not to participate in the study (Appendix 2.B).

Table 3: Proportions of overdue children in Australia on the AIR, by age cohort

Jurisdiction	Age Cohort			
	6 months	12 months	18 months	48 months
ACT	19%	23%	21%	37%
NSW	20%	22%	23%	35%
VIC	20%	24%	22%	34%
WA	19%	24%	24%	32%
NT	24%	21%	31%	25%
TAS	24%	22%	26%	28%
QLD	20%	20%	26%	34%
SA	18%	20%	22%	39%

Questionnaire Development

A study questionnaire (Appendix 2.C) was developed based on previous audit questionnaires identified in Stage 1 of this project, in addition to other examples that were being used by jurisdictions and PHNs. Following review and feedback from sites, 44 numeric codes were included to categorise the reason why a child was overdue or actually up-to-date, along with other relevant categories.

The questionnaire provided follow-up sites with a written script and aimed to collect the following information for each record: Aboriginal or Torres Strait Islander status of the child; provider type recording the immunisation encounter; primary method for transmitting immunisation encounters to AIR; if the online AIR Secure Site was used;

method of advising AIR of vaccinations given overseas, medical contraindications, and natural immunity; and the assignment of one of the 44 explanatory codes.

Pilot

All participating sites were invited to pilot the study questionnaire to provide feedback on its usability and whether the codes provided were suitable. Pilot sites were requested to extract an 11A overdue report from AIR for their region and select the first five children's records that appeared on the report who were aged between 9 months and 5 years of age, were at least 3 months overdue, and were linked to a provider. Sites were given one week to complete the pilot from 15-22 September 2017. Six sites participated in the pilot and provided feedback. Following feedback, minor changes were made to the questionnaire and instructions.

Data Collection and Handling

The collection and handling of study data involved a four stage process.

1. Participating sites extracted 11A reports via the online AIR Secure Site. The extracted files were securely emailed to HPNSW for data handling via NSW Health's secure web platform Accellion Mobile File Sharing Solution. Data files were reviewed at HPNSW due to restrictions on access permissions for viewing identifiable information at NCIRS.

2. Upon receipt at HPNSW, all sites' 11A files were merged and then combined by jurisdiction. Records relating to a specific overdue antigen were then selected

based on pre-determined date of birth and coverage level cut-offs. All records not satisfying the criteria were excluded and deleted from the dataset. For each participating jurisdiction, 400 records were stratified and then randomly selected within the stratum to fulfil sample size requirements, divided up equally among the participating sites in that jurisdiction, and electronically sent to sites via the secure platform Accellion Mobile File Sharing Solution.

3. Participating sites performed the audit of the provided records using the audit tool questionnaire and site instructions. The questionnaire provided guidelines and suggested dialogue for liaising with the last known provider, or parent/carer contact if no provider was listed.

   In New South Wales (NSW), PHNs, which extract 11A reports, are not provided with telephone contact details of the parents/carers of overdue children due to limited AIR extracting permissions. If no provider was listed for follow up, letters were mailed from one central site, using the relevant PHN letterhead, to families asking them to contact the relevant site (Appendix 2.D).

   All sites were given an initial four weeks from 13 October 2017, with a subsequent three week extension, to complete the audit.

4. Upon completion of the audit, participating sites emailed de-identified data to NCIRS for analysis. Files were downloaded to the secure NCIRS server, and placed into secure network drives accessible to selected NCIRS study staff only.

Data Analysis

Data were analysed using STATA statistical software for Windows, Release 14.2 College Station, TX: StataCorp LP.

A number of variables were analysed:

- overdue status (generated) - truly overdue or up to date
- Indigenous status (collected) - Indigenous/other
- area coverage category (generated) – high, medium, low
- provider type category (collected)
- transfer method category (collected)
- vaccine antigen and dose number (provided by 11A reports)
- weighting (generated)
- Accessibility/Remoteness Index of Australia (ARIA++) category (generated) – remote, regional, major cities.[6]

Frequency counts were generated at the national and jurisdictional level using STATA to provide descriptive statistics on AIR transmission-related data. The error rate (defined as the proportion of overdue AIR records actually up to date due to identified error) was also calculated for all categories.

To identify any associations between a record being misclassified as overdue for the relevant antigen, when actually up to date, and a number of explanatory variables, weighted univariate logistic regression was performed. The following weights were assigned to each record, to account for the over and under-sampling of records based

on area coverage level: 0.34 to records from low-coverage areas, 1.09 to records from medium coverage areas, and 2.52 to records from high coverage areas (Appendix 2.E). The following variables were tested for significance: area coverage level, Indigenous status, ARIA++ remoteness, provider type, transmission method, age cohort, and vaccine and dose number. All variables with a p-value <0.25 were then included in the weighted main effects model. Tests for multicollinearity were conducted and variables reviewed for confounding. A base model was constructed which included all significant variables identified. Variables were then eliminated sequentially using a stricter cut-off p-value of ≤0.05 to arrive at a final model. A main effects model without interaction terms was used as this study focused on associations rather than predictions. Following completion of the main effects model, testing for model fit was conducted using Akaike information criterion (AIC) and Bayesian information criterion (BIC) diagnostics.

Ethical Considerations

Confidentiality was considered in all steps of this study. Site-specific ethical approval and participant consent was not required to conduct this audit as it fell within the scope of conducting a quality assurance exercise on a government register. I worked on a temporary placement as an MAE Scholar at the HPNSW to be able to review and randomise the extracted 11A report data. Accellion Mobile File Sharing Solution, a secure NSW Health data transfer platform, was used to transfer identifiable files to and from follow-up sites. All data was then de-identified prior to the transfer and receipt at NCIRS for analysis.

There were no cultural and/or social considerations and sensitivities relevant to this study as patient participation was not required. Immunisation records were randomly selected to include children of all backgrounds.

Australian National University provided ethical review and approval for this study, application #2017/370.

Results

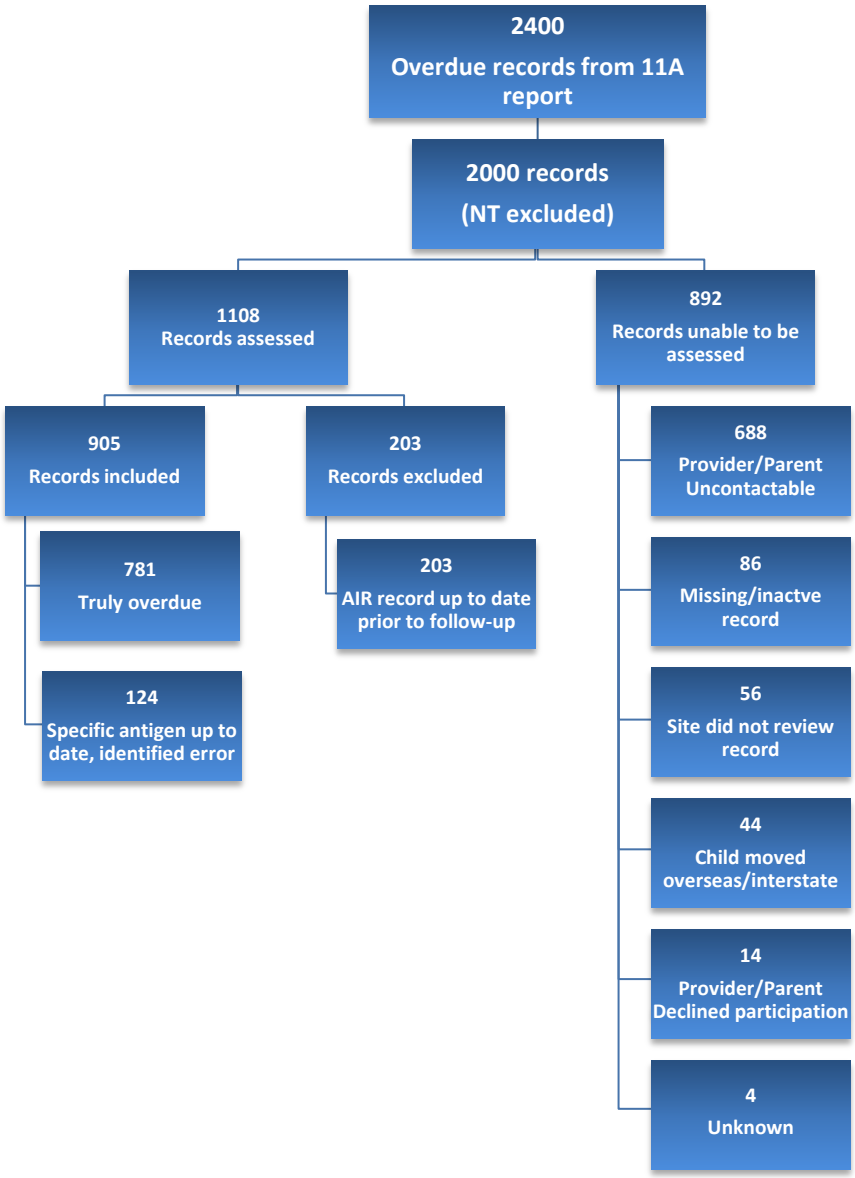
Classification and Analyses

In the initial sample, there were 2400 records selected from 11A reports. Figure 1 provides a breakdown of the categorisation of the 2400 overdue AIR records provided to participating sites for follow up.

All 400 records from the Northern Territory (NT) were excluded as initial descriptive analyses identified major variations compared with other jurisdictions and resultant skewing of overall results (Appendix 2.F). This largely related to 235 NT records being 'baby of' duplicate records, due to the now ceased process whereby data on doses of hepatitis B vaccine given at birth were sent from the Northern Territory Immunisation Register (NTIR) to AIR, recorded as 'baby of [mother's name]'. The NT and DHS are working together to identify and remove these duplicate records (personal communication, Holly Carmichael, NT Health, January 2018).

Of the remaining records, 44% (892/2000) were unable to be assessed: 77% (688/892) due to no contact being made with provider or parent, either due to missing contact details or being unable to get a response via telephone or mail; 7% (86/892) reported by the provider to be missing or inactive; 6% (56/892) unable to be reviewed during the allocated timeframe; 5% (44/892) reported by providers/parents to be for children that had moved overseas or interstate; 2% (14/892) because provider or parent refused to participate; and for 0.4% (4/892) the reason was not identified.

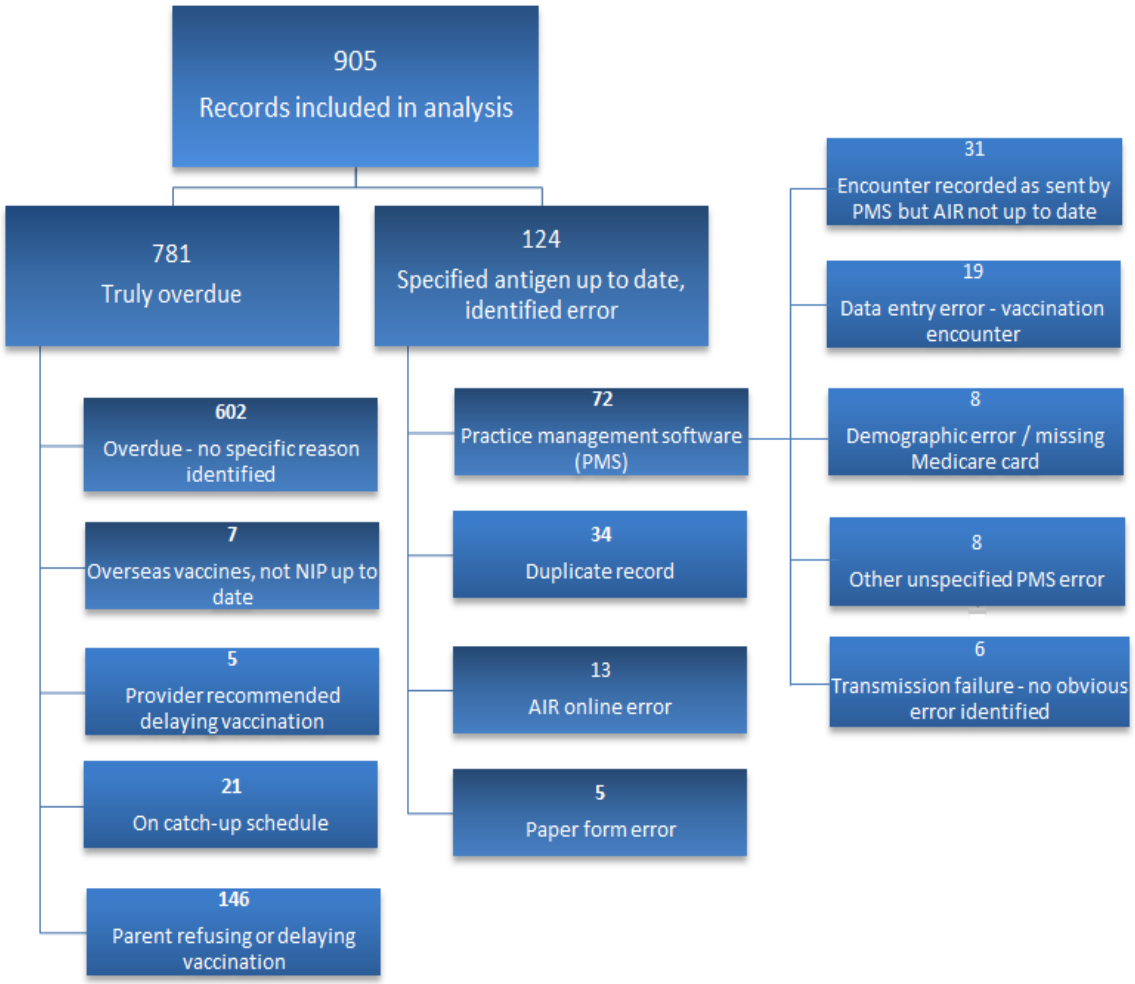
Figure 1: Categorisation of 2400 records selected from 11A reports for follow up



Of the 1108 records ultimately assessed, 82% (905/1108) of records were included and 18% (203/1108) excluded from further analyses as they were already recorded as up to date on AIR at the time follow-up was scheduled to commence i.e. they had been updated in the period between the date of 11A report extraction and commencement of follow up. Figure 2 provides a breakdown of how the 905 records included in the analysis were ultimately categorised as either truly overdue or up to date (due to identified error in AIR record), and relevant subcategories.

Of the 905 records included in the analysis, 13.7% (124/905) were determined to be actually up to date, due to the following identified errors: practice management software transmission failure 43% (53/124), duplicate records 27% (34/124), practice-level data error 15% (19/124), incorrect information entered onto AIR online 10% (13/124), and incorrect information entered on paper forms 4% (5/124). Appendix 2.G provides a full list and description of categories. Eighty-six per cent (781/905) of records assessed were classified as truly overdue. Of these, 19% (146/781) were reported to have parents who had refused or delayed vaccination, 3% (21/781) were on a catch-up schedule, 1% (7/781) had received overseas vaccinations but remained overdue according to the NIP schedule, 1% (5/781) had been recommended by a provider to delay vaccination, and for 77% (602/781) no specific reason was identified.

Figure 2: Categorisation of records included in final analysis



Error Rate

The calculated error rate, or proportion incorrect, (defined as the proportion of assessed overdue records that were actually up to date) ranged from 2.6% in Victoria to 28.5% in NSW, with an overall rate of 13.7% (Table 4).

Table 4: Error rate† calculations by participating Australian jurisdictions on 4th October, 2018

Category	Jurisdiction					
	NSW	QLD	SA	VIC	WA	Total
Up to date	47	19	36	4	18	124
Truly overdue	118	205	152	151	155	781
Total	165	224	188	155	173	905
Error Rate†	28.5%	8.5%	19.2%	2.6%	10.4%	13.7%

*Number of records actually up to date divided by the total number of records, multiplied by 100
†Defined as the proportion of overdue AIR records actually up to date due to identified error

Descriptive Analyses – National Level

A total of 124 records were assessed as incorrect, due to the following identified errors: failure of transfer of vaccination encounter information from practice management software (PMS) — computer-based software that captures patient details — to AIR 58% (72/124); duplicate records 27% (34/124); AIR online error 10% (13/124); and error arising from use of paper forms 4% (5/124).

Of the 72 records with an error identified as failure of transfer of vaccination encounter information from PMS to AIR, 43% (31/72) were recorded by the PMS as having been transmitted to AIR, but the AIR record remained incorrect. The reason for this error is unknown. Twenty-six percent (19/72) were due to practice-level data entry error in relation to the encounter, 11% (8/72) were documented as PMS transmission failure due to either a demographic error or a missing Medicare card in the record, 8% (6/72) were documented as PMS transmission failure with no obvious errors in encounter, demographic or Medicare information, and 11% (8/124) were reported as due to unspecified PMS-related errors. Breakdown of error type by PMS brand is detailed in Table 5.

Table 5: Practice management software (PMS) transfer to AIR – error type by PMS brand

Error Code	Practice-level data entry error - vaccination encounter	PMS Brand (n)				
		MD*	BP†	Other‡	No ID§	Total
9	Wrong vaccine name recorded	1	1	0	1	3
10	Vaccine sequence/dose number incorrect or not recorded	2	0	2	1	5
12	Vaccination recorded in notes section of patient record, not immunisation tab, and encounter not transmitted	0	0	1	1	2
13	Nurse listed as provider and encounter not transmitted	1	0	0	0	1
23	Overseas history not completed correctly	0	2	0	5	1
49	Other practice-level data error	1	0	0	0	1
No Medicare number						
17	No Medicare card for record, transmission failed	1	1	0	0	2
Child demographic error						
18	Child demographic error, transmission failed	3	2	0	1	6
Transmission failure due to documented practice software issue						
19	Other practice software error, transmission failed	3	3	0	0	6

Recorded by PMS as having been transmitted to AIR						
20	Encounter recorded by PMS as sent but AIR record not up to date	8	12	8	3	31
Unspecified PMS-related error						
21	Practice could not determine exact nature of error	3	3	0	2	8

*Medical Director/Pracsoft
†Best Practice
‡Includes: ZedMed, Communicare, WINVaccs and two identified as 'other' brands
§No PMS identified

The error rate by age cohort was higher in the 9 to <12 months cohort at 21% (36/173) compared to the other three age cohorts at 12% each (24/195, 28/231, 36/306), as shown in Table 6. Of the 36 records in the 9 to <12 months cohort where an error was identified, the most common reasons were duplicate records (31%, 11/36) and encounter recorded by PMS as sent but AIR record not up to date (31%, 11/36). The lowest error rate by provider type was for local councils at 8% (9/108), followed by general practitioners at 16% (91/563), and the highest for jurisdictional health departments at 44% (4/9) and 'other' provider types, which included public and private hospitals, public health units, and flying doctor services at 35% (9/26). The error rate in records from remote areas was higher at 23% (6/26) than in records from regional and major city locations at 13% (19/145) and 13% (97/629) respectively. The error rate by transfer method was highest for paper-based methods at 54% (7/13), and via the online AIR Secure Site at 26% (23/90), and lowest for PMS at 13% (77/630). National frequencies with NT data included can be found in Appendix 2.H.

Table 6: National* frequencies and error rates by category

	Up to date (n)	Truly overdue (n)	Error Rate† (%)
Coverage level			
Low (<90%)	63	384	14.1
Medium (90-<95%)	37	223	14.2
High (≥95%)	24	174	12.1
Total	124	781	13.7
ARIA+ remoteness			
Remote	6	20	23.1
Regional	19	126	13.1
City	97	629	13.4
Total	122	775	13.6
Provider type			
General practitioner	91	472	16.2
Local council	9	99	8.3
Aboriginal health worker/community health centre	8	61	11.6
Other‡	9	17	34.6
Jurisdictional health department	4	5	44.4
Total	121	654	16.1
Transfer method			
Practice Management Software	77	553	12.6
Pracsoft (Medical Director)	26	170	13.3

Best Practice	33	197	14.3
Other	18	186	8.8
Paper-based	7	6	53.9
Online AIR Secure Site	23	67	25.6
Other§	1	7	12.5
Total	108	633	14.6
Age cohort			
9 to <12 months	36	137	20.8
15 to <18 months	24	171	12.3
21 to <24 months	28	203	12.1
51 to <54 months	36	270	11.8
Total	124	781	13.7

*Includes NSW, Victoria, Queensland, Western Australia and South Australia; data with NT included can be found in Appendix 2.H
†Number of records actually up to date divided by the total number of records, multiplied by 100
‡Includes public hospital, private hospital, public health unit, The Royal Flying Doctor Service
§Other transfer method not included in the listed categories, these were not specified

Descriptive Analyses – Jurisdictional Level

Records Up To Date due to Identified Error

Records that were determined to be up to date due to identified errors were compared by jurisdiction and error category (Table 7). The number of errors due to practice management software transmission failure was highest in NSW. The number of errors related to practice-level data entry, use of paper forms, and AIR Secure Site data entry was 5 or less per jurisdiction and the number of duplicate records 11 or less.

Truly Overdue Records

Records determined to be truly overdue were compared by jurisdiction and category (Table 8). The highest proportion of truly overdue records that were due to parents refusing or delaying vaccination was in Queensland with 66% (96/146) of all records identified as such. The number on catch-up schedules, those who had received overseas vaccinations, those which were recorded on AIR but were still not up to date according to the NIP schedule, and those where providers had recommended delaying vaccination, was less than 3 for each jurisdiction.

Detailed data tables and summaries of the categorisation of records unable to be assessed and jurisdictional-specific descriptive analysis results can be found in Appendices 2.I and 2.J, respectively.

Table 7: Records determined to be actually up to date by error category and jurisdiction

Error category	Jurisdiction					
	NSW	QLD	SA	VIC	WA	Total
Use of paper forms	5 (10.6%)	0	0	0	0	5 (4%)
Online AIR Secure Site data entry	4 (8.5%)	1 (5.3%)	6 (16.7%)	0	2 (11.1%)	13 (10.5%)
Transfer from practice management software to AIR	28 (59.6%)	10 (52.7%)	19 (52.8%)	3 (75.0%)	12 (66.6%)	72 (58.0%)
Duplicate record	10 (21.3%)	8 (42.2%)	11 (30.6%)	1 (25%)	4 (22.2%)	34 (27.4%)
Total	47	19	36	4	18	124

Table 8: Records determined to be truly overdue by category and jurisdiction

Error Category	Jurisdiction					
	NSW	QLD	SA	VIC	WA	Total
Overdue - no specific reason identified	96 (81.4%)	103 (50.2%)	129 (84.9%)	142 (94.0%)	132 (85.2%)	602 (77.1%)
Overseas vaccines, not NIP up to date	0	3 (1.5%)	2 (1.3%)	0	2 (1.39%)	7 (0.9%)
Provider recommended delaying vaccination	4 (3.4%)	0	0	0	1 (0.7%)	5 (0.6%)
On catch-up schedule	4 (3.4%)	3 (1.5%)	7 (4.6%)	0	7 (4.5%)	21 (2.7%)
Parent refusing or delaying vaccination	14 (11.9%)	96 (46.8%)	14 (9.2%)	9 (6.0%)	13 (8.4%)	146 (18.7%)
Total	118	205	152	151	155	781

Logistic Regression Results

Logistic regression analysis was performed on the 905 included records. Explanatory variable categories found to be significant on the basis of p value <0.25 are shown in Table 9. These categories included remoteness status, provider type, transfer method, age cohort, and vaccine antigen and dose. These variables were included in the initial weighted multivariate logistic regression model. The variables coverage level and Indigenous status had p values ≥0.25 and were excluded from further analysis.

Table 9: Weighted univariate logistic regression results for significant variables with p<0.25*

Explanatory variable	TOTAL	
	OR[†] (95% CI[‡])	p-value
Remoteness Status		
Remote	3.49 (0.92-13.27)	0.066
Regional	ref	ref
Provider Type		
Other[§]	3.46 (1.18-10.13)	0.023
GP	ref	ref
Transmission Method		
Paper-based	6.63 (1.80-24.47)	0.005
AIR Online	2.15 (1.09-4.22)	0.027
PMS	ref	ref
Age Cohort		
9<12 months	2.85 (1.48-5.49)	0.002
15<18 months	1.07 (0.53-2.19)	0.848
21<24 months	0.92 (0.45-1.85)	0.808
51<54 months	ref	ref
Vaccine Antigen and Dose[¶]		
Diphtheria dose 1	ref	ref
Diphtheria dose 3	0.16 (0.01-2.08)	0.162
Hepatitis B dose 1	0.15 (0.01-1.88)	0.141
Hepatitis B dose 2	3.25 (0.42-23.38)	0.242
Measles dose 2	0.21 (0.02-2.74)	0.232
Mumps dose 1	0.14 (0.01-1.72)	0.125

Pertussis dose 1	0.13 (0.01-1.68)	0.119
Pertussis dose 2	4.89 (0.85-28.24)	0.076
Pneumococcal dose 2	4.9 (0.68-35.20)	0.114

*Includes data from NSW, Victoria, Queensland, Western Australia and South Australia
[†]Odds ratio
[‡]Confidence interval
Ref=Reference group
[§]Public hospital, private hospital, public health unit, or flying doctor service
[¶]All other antigen and dose combinations had p-value >0.25

Weighted Multivariate Logistic Regression Results

The final weighted model showed statistically significant associations, with p values <0.05, between an overdue record being actually up to date due to identified error and the following: living in a remote area (OR 4.53 [95% CI: 1.10-18.59] p=0.036), transfer to AIR via paper-based methods (OR 8.53 [2.08-35.06] p=0.003) or via online AIR Secure Site (OR 2.19 [1.03-4.69] p=0.043), and being in the age cohort 9 to <12 months old (OR 3.93 (1.84-8.40) p<0.001) (Table 10). AIC and BIC diagnostics were conducted to examine overall model fit, with the main effects model (AIC=578.2, BIC=619.5) and the base model (AIC=581.7, BIC=770.4) indicating that the main effects model was a more precise fit, and thus more accurate, than the base model.

Table 10: Weighted main effects model results*

Explanatory variable	TOTAL	
	OR† (95% CI‡)	p-value
Remoteness Status		
Remote	4.53 (1.10-18.59)	0.036
Regional	ref	ref
Major Cities	1.09 (0.53-2.26)	0.813
Transmission Method		
Practice software	ref	ref
Paper-based	8.53 (2.08-35.06)	0.003
AIR Online	2.19 (1.03-4.69)	0.043
Other	5.03 (0.60-42.10)	0.136
Age Cohort		
9<12 months	3.93 (1.84-8.40)	<0.001
15<18 months	1.17 (0.54-2.54)	0.687
21<24 months	1.31 (0.61-2.80)	0.487
51<54 months	ref	ref

*Includes data from NSW, Victoria, Queensland, Western Australia and South Australia
† Odds ratio
‡ Confidence interval
Ref = Reference group

Discussion

This study assessed the effectiveness of the transfer of immunisation records to the AIR and identified ways to improve it. The error rate of 13.7% found in this study is lower than a recently published Australian study auditing all children overdue for one or more vaccinations among children aged 12 to-<15 months in Eastern Sydney in 2013.[5] The study identified that 33% of overdue records were innacurate, although that study assessed 'fully immunised' status rather than specific antigens as in our study, so it is not strictly comparable.[5]

Apart from the NT, which was excluded from the analyses due to major variation in the data, the calculated error rate by jurisdiction in our study was highest in NSW at 29% (47/165) and lowest in Victoria at 3% (4/155). It is possible that the low rate in Victoria could be partly due to the No Jab No Play policy/legislation in place in that state since 2016, which imposes strict immunisation requirements for enrolment in childcare services.[7]

Of the 13.7% (124/905) AIR records in which an error was identified, the most commonly identified source of error was failure of transmission from PMS to AIR at 58% (72/124). Of these 72 records, 46% (33/72) were due to documented issues (including data entry error and PMS-specific issues) at the practice level; for the remaining 54% (39/72) it is not possible, on the basis of our study methodology, to determine the proportion related to issues with PMS, AIR receipt or combination thereof. Two unpublished studies, one in NSW and one in WA, which audited episodes of vaccination in general practices using Best Practice PMS, found that data did not successfully transmit to AIR for 23% of encounters.[2] While it is unclear to what extent

this is representative of PMS more broadly, our cross-sectional analysis of AIR records did not identify instances where data are subsequently retransmitted successfully when transmission failure was identified by providers or patients (e.g. on receipt of AIR statements, particularly in the context of No Jab No Pay and No Jab No Play policies).

The next most common source of error identified was duplicate records at 27% (34/124), of which 85% (29/34) of records had different spelling of first and/or surnames. The NT Immunisation Register allows users to search for multiple spellings in an 'also known as' field or for parts of names, which may facilitate the identification of duplicates.

Practice-level data entry error was identified in 26% (19/72) of records where there was failure of transmission from PMS to AIR, including 37% (7/19) relating to vaccinations given overseas. Improved provider understanding of data entry requirements and procedures may be required to minimise such errors. This study was not specifically designed to estimate the true level of under-recording of overseas vaccinations in AIR, however recent studies in WA, which used a likely more sensitive methodology (telephone contact with parents), identified a higher proportion of overdue children with overseas vaccinations not recorded in ACIR; 7% for children with some vaccinations recorded and 44% for children with no vaccinations recorded on ACIR.[2,8]

In total, 16% (146/905) of the overdue AIR records assessed were identified as truly overdue due to parental refusal or delaying vaccination. This proportion is lower than that in a previous study which showed that around 40% of incomplete vaccination is likely due to vaccination objection, and may be an underestimate.[9]

The multivariate analysis in our study identified four statistically significant variables for whether an overdue AIR record may be actually up to date due to error: transfer to AIR via paper-based methods, living in remote area, being in the age cohort 9 to <12 months old, and transfer to AIR via the online AIR Secure Site. DHS currently identifies providers who regularly use paper-based methods and provides them with information regarding more accurate methods of data transmission; however enhancement of this activity may be of benefit. Issues in remote areas may differ from regional and major city areas and need to be investigated further. The reasons for the age cohort 9 to <12 months having a significant association with an AIR record recorded incorrectly as overdue also require further investigation. While basic text-based instructions are provided on the online AIR Secure Site regarding how to record encounters, more detailed instructions, including examples and screenshots, may be of benefit.

However, the importance of the associations identified in multivariate analysis should not be overemphasised as the numbers of records using a paper-based transfer method or being from remote geographical region are of a smaller proportion in comparison to other identified transfer methods or geographical regions. Given that a large proportion of the Australian population lives in major cities and regional areas, and that PMS is the predominant method of transfer to AIR, initiatives to reduce error rates across these areas also have potential for considerable overall benefit, despite lower baseline levels of error. Supporting all providers with appropriate education and resources on the proper procedures for data entry at all relevant points, including how to avoid common errors, is important.

There are a number of limitations to this study. The ACT and TAS were unable to participate in the study due to resource limitations, and NT data needed to be

excluded from analysis due to major data variation from other jurisdictions. As a result, results from the study are not to be considered nationally representative, as there is likely to be variation within the data from ACT and TAS. A total of 44% (892/2000) of the assigned records from the five participating jurisdictions could not be assessed, mainly due to missing provider contact details within the 11A report data. It is not known whether data from these records might differ from those assessed. As a result, the overall power of the study was reduced and this should be considered when generalising the study results. The power of our study to detect differences at the jurisdictional level was lower than anticipated due to the number of records that were unable to be assessed. Additionally, if these records were able to be assessed, the overall error rate may have been closer to the previously identified rate of 33% in the literature.[5] A total of 18% (203/1108) of records were no longer overdue on AIR at the time of follow-up; it is not known what proportion of these represent children who were vaccinated late versus records that were inaccurate and subsequently updated via provider transfer or DHS intervention, and future studies could investigate this. Among the AIR records that were assessed as actually up to date due to identified error, there were 11 instances where two records relating to the same child were assigned and followed up for overdue antigens usually given in a combination vaccine at the same schedule point. This will have caused duplication of results for these records.

Recommendations

Recommendations to reduce errors in vaccination encounter data in the AIR include:

Initiatives to improve data entry of vaccination encounters

a) Health, in conjunction with DHS, state and territory health departments, and PHNs, should consider collaborative initiatives to support providers to accurately record vaccination encounters. This may include the development of education materials for providers and relevant stakeholders aiming to reduce data entry errors. Education materials or information targeting providers could focus on checking the possibility of an existing record prior to creating a new record, checking patient vaccination history before entering an encounter and using the 'generic' vaccine option when recording overseas vaccination history.

b) Providers who send paper-based records to AIR should continue to be encouraged to transition to electronic methods of transmission where possible, noting that almost 99% of submissions to the AIR are now electronic.

Initiatives to improve data transfer via practice management software

a) Health, in collaboration with DHS, should consider ways to reduce failure of data transfer to AIR via practice management software. DHS, in conjunction with PMS vendors, could consider the possibility of investigating the causes of failure of data transfer to the AIR where no specific error in data entry has been identified.

Initiatives to improve data management

a) Health, in collaboration with DHS, state and territory health departments, and PHNs, should consider ways to improve identification and correction of AIR records that contain errors (e.g. misspelt names, incorrect recording of order of first and surnames, and inclusion of middle names with hyphenation) to assist in reducing the number of duplicate records.

Future studies

a) Health should consider regular future studies of overdue records in the AIR to identify errors in vaccination encounter data. Such studies could be of similar nature to this study, refined with the following potential additions:

   - identifying reason/s for overdue records being up to date on AIR at follow-up (i.e. whether due to delayed vaccination or rectification of previous data transfer error).
   - specific investigation to determine reasoning for the higher error rate in remote areas and in the AIR records of children aged 9 to <12 months
   - excluding 'Baby of' records in the record selection process for the NT; to include valid NT data in analyses
   - interviews of providers and other stakeholders involved in follow up of overdue children and data cleaning to explore their experiences.

Conclusions

Data quality in the AIR database is a critical performance measure for the whole-of-life vaccination register. This study was the first to evaluate the accuracy of AIR data at a national level. This study represents the first attempt at the national level since 2001 to systematically study the accuracy of AIR data. While the error rate was lower than anticipated based on previous studies, there remains room for further improvement. On the basis of our study findings, the most influential areas in which data recording, transfer, and handling could be improved to optimise the effectiveness of data transfer to AIR include:

1) improving data entry for all methods of transfer to AIR;

2) improving processes for transfer of immunisation encounter information to AIR;

3) improving data management to reduce duplicate records; and

4) improving engagement with and enhancing support to immunisation providers, particularly those in remote settings.

Future studies to monitor the effectiveness of vaccination encounter data transfer to the AIR should be informed by lessons learnt in this study, as well as challenges identified during the course of the project (Appendix 2.K).

References

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Appendices

Appendix 2.A: Stata Code for Sample Size Requirements

```
power twoproportions 0.45 0.55, power(.80)

Estimated sample sizes for a two-sample proportions test
Pearson's chi-squared test
Ho: p2 = p1  versus  Ha: p2 != p1

Study parameters:
      alpha =    0.0500
      power =    0.8000
      delta =    0.1000  (difference)
         p1 =    0.4500
         p2 =    0.5500

Estimated sample sizes:
                  N =       784
  N per group =       392
```

Appendix 2.B: Detailed Sample Size Requirements by Jurisdiction, Coverage Level, and Milestone Age

	Low coverage*				Medium coverage†				High coverage‡				Total
	9-<12	15-<18	21-<24	51-<54	9-<12	15-<18	21-<24	51-<54	9-<12	15-<18	21-<24	51-<54	
NSW	39	45	47	69	24	27	28	41	16	18	18	28	400
VIC	40	47	44	69	24	28	27	41	16	18	18	28	400
WA	39	49	48	64	23	29	29	39	15	20	19	26	400
NT	47	41	62	50	28	25	37	30	19	16	25	20	400
QLD	40	40	52	68	24	24	31	41	16	16	21	27	400
SA	37	40	45	78	22	24	27	47	15	16	18	31	400
Total	242	262	298	398	145	157	179	239	97	104	119	160	2400

*50% of all records collected, 200 records per jurisdiction
†30% of all records collected, 120 records per jurisdiction
‡20% of all records collected, 80 records per jurisdiction

Appendix 2.C: Study Questionnaire

Data Transfer Audit 2017 Stage 2

Guidance for Liaising with Provider in NSW, Victoria, South Australia and Western Australia

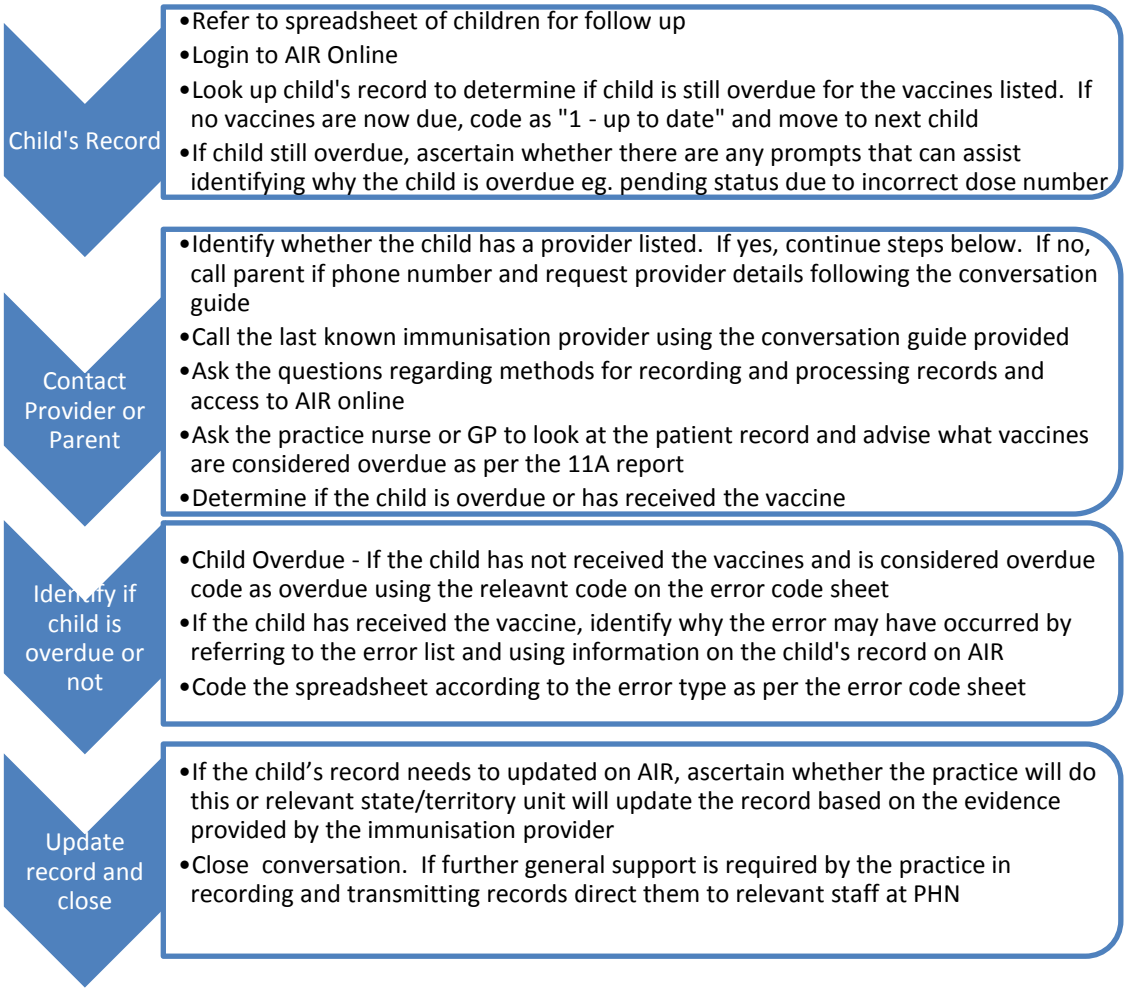
Background

NCIRS is undertaking an audit study to assess the effectiveness of the data recording, handling and transfer of immunisation encounters to the AIR and identify any barriers for the timeliness and accuracy of data. This project is a partnership between NCIRS, the Australian Government Department of Health, the Australian Government Department of Human Services and state and territory Jurisdictional Immunisation Coordinators. On completion of this audit, a report will be produced that will identify the most influential areas in which data recording, transfer and handling could be improved and recommendations on the most practical ways to do so.

Guide

The following information is a guide for site investigators to use to follow up overdue children with their last know immunisation provider or for families who are not linked to a provider.

The following diagram outlines the key step in reviewing the 11A report and following up with the provider. Further detail is provided on the attached conversation guide.



Step	Action	Question/Task
1.	Refer to spreadsheet of overdue children and identify child's record on AIR online to determine if spreadsheet still accurate. Check Immunisation History to see if any encounters are partially processed. If so, use this information to assist in identifying the error when liaising with the provider.	If the spreadsheet is accurate proceed with step 2. If AIR record is now up to date, record date of vaccine given and code error as 1 (see error code attachment). No further action for this child is required
2a.	**If the child is linked to a provider:** Identify how many children are linked to that provider. Call provider, identify yourself and ask to speak to the nurse, GP or Practice Manager who can assist with immunisation records If a practice has more than 3 records to be reviewed, provide an option: to call at another time or fax list (Go to **step 2b** if child is not linked to a provider)	Hello, my name is XX. I am calling from XX. We are currently checking children's immunisation records to determine if the information regarding overdue children is accurate. This is routine follow up for children listed as overdue and is being conducted nationally to determine if there are any common errors in the transfer of information to the AIR. Any information collected regarding errors will be de-identified and contain no patient information. I have x number of children that have been to your practice and are listed overdue for immunisations. I would be grateful if you could check these patient records and we will also just ask your methods for sending immunisation information to the AIR. It will take up to 10 minutes (*estimate 5 minutes per patient*). ***If more than 3 children on list for one provider:*** Do you have some time now to look up the records of the children as it make take a few minutes per child. If not, could you please advise a suitable time to call or whether they would like a list of children faxed to practice and a follow up phone call. If one of these Record outcome in Notes section of spreadsheet. **Continue to Step 3**
2b.	**If the child is not linked to a provider:** A phone call is to be made to the parent/carer if a phone number is listed on the 11A report. • If a phone number is available, call number using script. • If no contact is made after 2 telephone calls, code "no contact made" and no further action.	Hello, my name is XX. I am calling from XX. We are currently checking children's immunisation records to determine if the information regarding overdue children is accurate. This is routine follow up for children listed as overdue and is being conducted nationally to determine if there are any common errors in the transfer of information to the Australian Immunisation Register. Any information collected regarding errors will be de-identified and contain no patient information. We will be following up records with your last

Step	Action	Question/Task
		medical provider. If you would like to participate, could you please provide a name and location of the GP/Council or other immunisation provider that you last visited? If parent/carer gives the provider details record provider details and commence **step 2a** detailed above. If the parent/carer: • does not want to participate • advises they are a conscientious objector or vaccine hesitant • has a language barrier thank them for their time and close call. Record code. If parent/carer advises that immunisation record needs to be updated or they want to catch-up on vaccines, refer the parent/carer to call their local immunisation provider to make an appointment. Record code.
3.	Advise provider: I need to identify how you record and send immunisations to the Australian Immunisation Register. .	**Ask** questions 1- 5 in the questionnaire relating to the recording and transfer systems that are used.
4.	Ask the provider to open the child's record. (Refer to the patient names in the spreadsheet)	**Ask:** Does this patient identify as Aboriginal or Torres Strait Islander. Record yes/no/unknown **Ask:** Has the child had any of the following vaccinations? (list the vaccines that the child is overdue)
5.	If NO to Step 4 regarding vaccinations:	Suggest that they may need to remind the patient that they are overdue and ask provider if they are a known objector or delaying vaccine (mark using error codes in the 'overdue' category). Check next patient if applicable. If no other patients, thank provider for their time. Code spreadsheet accordingly.
	If YES to Step 4 regarding vaccinations:	If yes, ask what date the vaccine was given and insert date in spreadsheet. Try and determine why the encounter has not been transmitted. **Using PMS** • If the record was sent by PMS, try to determine where the error occurred in recording or transmitting the encounter (refer to page 6 for common errors). Useful prompts include missing Medicare number, sequence number missing, wrong vaccine recorded. **Using Paper Based** • Do they have a record of sending the form to AIR? If could not determine

Step	Action	Question/Task
		where error has occurred, code accordingly (error code 7) **Using AIR Secure Site (online)** • Do they have a Claim ID number recorded in the patient notes to confirm the successful entry? If could not determine where error has occurred, code accordingly (error code 8) **List an error code in the spreadsheet Determine whether you or the provider will resend the information to AIR if the patient record needs to be updated.**
6.	Check next patient if applicable. If no other patients, thank provider for their time. Code spreadsheet accordingly.	

Questionnaire for liaising with Provider

Questions identifying how practice records and transfers encounters to AIR.

Provider/Practice Name: **Tel:**

☐ A. General Practitioner	☐ B. Council	☐ C. Aboriginal health service / worker
☐ D. Community health centre	☐ E. No provider listed	☐ F. Other: Public hospital; Private hospital; Public health unit; Flying doctor service; Private hospital

Method of Recording and transmitting encounters

1	What is your primary method for transmitting Immunisation encounters to the Australian Immunisation Registry (AIR)?	**Practice Software (please specify) Go to Q3** ☐ A. Medical Director/PracSoft, version _____ ☐ B. Best Practice, version _____ ☐ C. ZedMed, version _____ ☐ D. MedTech, version _____ ☐ E. IMPS, version _____ ☐ F. Genie, version _____ ☐ G. E-Claims ☐ H. Other _____ specify in version column
		Paper-based – Go to Q2 ☐ I. Immunisation encounter (purple) form **(N/A to QLD)** ☐ J. Immunisation history form ☐ K. Practice letterhead ☐ L. Other (specify) _____
		AIR Secure Site (Online) Go to Q3 ☐ M. AIR Secure Site (online) direct ☐ N. via PRODA ☐ O. via HPOS
		VIVAS (QLD Only) Go to Q3 ☐ P. Send paper forms to VIVAS
		NTIR (NT Only) ☐ Q**.** Send to NTIR
		OTHER Go to Q3 ☐ R. **Other (please specify)** _____
2	If paper-based records are transmitted, what method do you use for sending these records to AIR:	☐ A. Post ☐ B. Fax ☐ C. Email ☐ D. Unsure ☐ E. Other

3.	Does your practice or general practitioners have online access to the AIR Secure Site (Online)	□ A. Yes □ B. No □ C. Don't know
4.	What is your practices method for transferring Overseas History to AIR?	□ A. Complete and send Overseas history form □ B. AIR Secure Site (online) □ C. Telephone AIR □ D. VIVAS (**QLD Only)** □ E. NTIR **(NT Only)** □ F. Unsure □ G. Other
5.	What is your practices method of advising AIR of a medical contraindication or natural immunity to an immunisation?	□ A. Complete & send Immunisation Medical Exemption Form □ B. AIR Secure Site (online) □ C. Telephone AIR □ D. VIVAS **(QLD Only)** □ E. NTIR **(NT Only)** □ F. Unsure □ G. Other

Errors codes by Category

Use this information when identifying errors and recording codes in spreadsheet. If more than one error is identified, you can record up to 3 errors in the data collection spreadsheet

Category	Description	Code
Up to date	AIR record was checked before calling provider and child's record now up to date	1.
Overdue (Followed up with Provider)	Child overdue according to providers record	2.
	Parents/carers have refused vaccination - reported by provider	3.
	Parents/carers delaying vaccination, no medical contraindication - reported by provider	4.
	Provider recommended delaying vaccination due to illness	5.
	Parent/carer delaying vaccination due to illness – reported in patients notes held by provider	6.
Paper based forms	Vaccine given. Practice sent paper record sent to AIR.	7.
AIR Secure Site (Online) entry	Vaccine given. Practice uploaded encounter on AIR.	8.
Data entry error	Wrong vaccine name recorded - eg. Infanrix (Hexa, IPV); MMR instead of MMRV	9.
	Vaccine sequence/dose number incorrect or not recorded	10.
	Vaccine batch number incorrect or not recorded	11.
	Immunisation recorded in notes section of patient record, not immunisation tab and encounter has not been transmitted	12.
	Nurse listed as provider and encounter has not been transmitted	13.
Clinical error	Wrong vaccine given	14.
	Vaccine given too early to be recognised by AIR	15.
	Interval between doses was not accepted by AIR	16.
Practice Software Failure	No Medicare card for child, transmission failed	17.
	Child demographic error (eg DOB or address wrong or postcode missing), transmission failed	18.
	Other Practice Software error, transmission failed	19.
	No error detected. Encounter sent but AIR record not up to date	20.
	Practice could not determine error	21.
Overseas history / schedule	Vaccines given overseas, patient not up to date with NIP	22.
	Overseas history not completed correctly or submitted to AIR	23.
	On catch up – AIR have not been notified	24.
	On catch up – 6 month catch up period has expired	25.
Medical Contraindication/ Natural Immunity	Patient had immunisation medical exemption form completed and sent to AIR.	26.
	Patient has natural immunity recorded (eg varicella) or medical contraindication but no form completed and submitted to AIR	27.

Provider unknown	Current provider is not the provider in which the immunisation is overdue (eg overdue for 2 months, but this provider has only seen the child since 12 months of age)	28.
Duplicate record	Duplicate record - different first name or surname	29.
	Duplicate record – 'Baby of'	30.
	Duplicate record – other	31.
Inactive or Overseas patient	Inactive patient at practice (patient not seen in the last 12 months)	32.
	Child moved overseas, confirmed	33.
	Child moved overseas, speculated	34.
	Child moved within Australia	35.
Not linked to a provider	No contact details available. No contact made	36.
	Parent/carer could not be contacted using phone number available	37.
	Parent/carer called, did not want to participate	38.
	Parent/carer called, advised they were a conscientious objector, vaccine hesitant or delaying vaccine (no illness)	39.
	Parent/carer called, advised they delaying vaccination due to illness	40.
	Parent/carer called, they want to update records or have catch up vaccines, directed to contact their immunisation provider	41.
	Parent/carer called. Language barrier. No progress	42.
Other	Specify	43.
Unknown	Could not determine error	44.

Errors codes by Category

Use this information when identifying errors and recording codes in spreadsheet.

Appendices

AIR	Australian Immunisation Register
AIR Secure Site	Refers to the online website that can be accessed by providers to view and update immunisation records
BP	Best Practice - Practice Management Software Program
HPOS	Health Professionals Online Services - An online platform for providers to login to AIR online
MD	Medical Director. Practice Management Software Program
PRODA	Provider Digital Access – An online platform for providers to login to AIR online

Common Errors in Practice Software

All Software	• Incorrect demographic details ○ Missing postcode

	○ State or Territory appears in Suburb Field ○ PO Box listed as address • Missing or incorrect sequence number • Vaccine recorded in patient notes and not in immunisation tab • Provider details incorrect • Nurse listed as provider (AIR will not accept nurses as provider)
Medical Director specific	• No Medicare Card listed (MD does not transmit without a medicare card)
ZedMed	• Menintorix listed as dose 4

Appendix 2.D: Patient Letter for Mail-out Follow-up

(PRINT ON STUDY SITE LETTERHEAD)

(Insert Date)

Parent/Carer of (insert Child's Name)
(Insert address)

Dear Parent/Carer of (insert Child's name)

Re: Important information regarding Immunisation Records

The (insert study site name) is currently following up children who are listed as overdue for one or more immunisations on the Australian Immunisation Register. This is routine follow up for children listed as overdue and is being conducted nationally to confirm if these records are accurate or identify reasons why vaccines given may not have been successfully recorded on the Register.

We would like to follow up with your last immunisation provider (eg. General practitioner or Council) to confirm these records. If you would like to participate could you please call (Insert Name) on (insert telephone number) to provide the contact details of the last immunisation provider that you visited. We would appreciate it if you contact us within one week of receiving this letter.

If you would like to review your child's immunisation statement you can request this by:

1. Visiting the MyGov website: www.my.gov.au
2. Calling the Australian Immunisation Register: 1800 653 809
3. Visiting a Medicare Service Centre

Thank you for your assistance with ensuring the accuracy of these important immunisation records.

Yours sincerely

(Insert name)
(Insert position)

Appendix 2.E: Weight Calculations

As samples were calculated using 50% weighting to low coverage, 30% to medium coverage, and 20% to high coverage categories, the following post-stratification weights will be applied during analysis for results which are generalisable.

Low- 33/50=.66 (if given equal division in the general population)

465/2714 (proportion of low post codes)

17.13/50= 0.34

Medium- 33/30=1.1 (if given equal division in the general population)

883/2714 (proportion of medium post codes)

32.54/30=1.09

High- 33/20=1.65 (if given equal division in the general population)

1366/2714 (proportion of high post codes)

50.33/20=2.52

Appendix 2.F: NT-specific Error Categories and Rates

NT error rate	
Actually up to date	289
Truly overdue	58
Total	347
Error rate	83.30%
NT records determined to be actually up to date by error category	
Paper form or AIR online error	0
Transfer from practice management software to AIR	6 (2.1%)
'Baby of' record	235 (81.3%)
Other duplicate record	48 (16.6%)
Total	289
NT records determined to be truly overdue by category	
Overdue - no specific reason identified	41 (70.7%)
Overseas vaccines, not NIP up to date	7 (12.1%)
Provider recommended delaying vaccination	0
On catch-up schedule	0
Parent refusing or delaying vaccination	10 (17.2%)
Total	58
NT records lost to follow-up by category	
No contact made/declined participation	4 (14.8%)
Missing or inactive record	3 (11.1%)
Child moved overseas or interstate	20 (74.1%)
Unknown	0
Total	27

Appendix 2.G: Codes Assigned to Each Record by Category Groupings

Code category	Code assigned to records
Overdue	
Truly overdue	
2	Child overdue according to provider's record
14	Wrong vaccine given
15	Vaccine given too early to be recognised by AIR
16	Interval between doses was not accepted by AIR
26	Patient had immunisation exemption form completed and sent to AIR
27	Patient has natural immunity recorded or medical contradiction but no form completed and submitted to AIR
40	Parent/carer called, advised they are delaying vaccination due to illness
41	Parent/carer called, they want to update records or have catch-up vaccines, directed to contact their immunisation provider
47	No vaccines recorded - only on register from Medicare card
50	Other – include as overdue
Overseas vaccines, not NIP up to date	
22	Vaccines given overseas, patient not up to date with NIP
Provider delaying vaccination	
5	Provider recommended delaying vaccination due to illness
Parental refusal or delay	
3	Parents/carers have refused vaccination - reported by provider
4	Parents/carers delaying vaccination, no medical contradiction, reported by provider
6	Parent/carer delaying vaccination due to illness - reported in patients' notes held by the provider
39	Parent/carer called, advised they were a conscientious

	objector, vaccine hesitant, or delaying vaccine (no illness)
On catch-up schedule	
24	On catch-up - AIR have not been notified
25	On catch-up - 6 month catch-up period has expired

Up to Date

Paper form/AIR online error	
7	Vaccine given, practice sent paper record to AIR
8	Vaccine given, practice uploaded encounter on AIR
Failure of transfer from PMS to AIR	
Practice-level data error - vaccination encounter	
9	Wrong vaccine name recorded - eg Infanrix (Hexa, IPV); MMR instead of MMRV
10	Vaccine sequence/dose number incorrect or not recorded
11	Vaccine batch number incorrect or not recorded
12	Immunisation recorded in notes section of patient record, not immunisation tab and encounter not transmitted
13	Nurse listed as provider and encounter not transmitted
23	Overseas history not completed correctly
49	Other
Other documented practice level issue	
17	No Medicare card for record, transmission failed
18	Child demographic error, transmission failed
19	Other practice software error, transmission failed
Unclear whether error related to PMS, AIR receipt or combination thereof	
20	No error detected, encounter sent but AIR record not up to date
21	Practice could not determine error
Duplicate 'Baby of' record	
30	Duplicate record - 'Baby of'
Other duplicate record	
29	Duplicate record - different first name or surname

31	Duplicate record - other

Lost to Follow-up

<u>No contact made/participation</u>	
36	No contact details available, no contact made
37	Parent/carer could not be contacted using phone number available
38	Parent/carer called, did not want to participate
45	Lost to follow-up
48	Record not followed-up by site
<u>Missing/inactive record</u>	
28	Current provider is not the provider in which the immunisation is overdue
32	Inactive patient at practice (patient not seen in the last 12 months)
46	Practice can't find patient's record in the system
<u>Site hasn't reviewed record</u>	
52	Records not followed up by site
<u>Child moved overseas/interstate</u>	
33	Child moved overseas, confirmed
34	Child moved overseas, speculated
35	Child moved within Australia
<u>Unknown</u>	
44	Could not determine error
51	Other- include as lost to follow-up

Excluded

<u>AIR record up to date upon follow-up</u>	
1	AIR record was checked before calling provider and the record is now up to date

Appendix 2.H: Summary of National Descriptive Data, Including NT Data

National frequencies, proportions and error rates, by category, for all participating jurisdictions*

	Up to date n (% of total)	Truly overdue n (% of total)	Error Rate (%)
Coverage level			
Low (<90%)	215 (52.1)	406 (48.4)	34.6
Medium (90 to <95%)	112 (27.1)	250 (29.8)	30.9
High (≥95%)	86 (20.8)	183 (21.8)	32.0
Total	413	839	33.0
ARIA+ remoteness			
Remote	238 (58.3)	49 (5.9)	82.9
Regional	73 (17.9)	151 (18.2)	32.6
City	97 (23.8)	629 (75.9)	13.4
Total	408	829	33.0
Provider type			
General practitioner	92 (22.5)	479 (68.3)	16.1
Local council	9 (2.2)	99 (14.1)	8.3
Aboriginal health worker	25 (6.1)	20 (2.9)	55.6
Community health centre	34 (8.3)	79 (11.3)	30.1
Other†	11 (2.7)	17 (2.4)	39.3
Jurisdictional health department	238 (58.2)	7 (1)	97.1
Total	409	701	36.9
Transfer method			
Practice management software	82 (20.7)	556 (81.6)	12.9
Paper-based	7 (1.8)	6 (0.9)	53.9
Online AIR Secure Site	23 (5.8)	67 (9.8)	25.6
NT Immunisation Register	283 (71.5)	43 (6.3)	86.8

Other‡	1 (0.3)	9 (1.3)	10.0
Total	396	681	36.8
Age cohort			
9 to <12 months	122 (29.5)	140 (16.7)	46.6
15 to <18 months	95 (23)	177 (21.1)	34.9
21 to <24 months	78 (18.9)	237 (28.3)	24.8
51 to <54 months	118 (28.6)	285 (340)	29.3
Total	413	839	33.0

* Participating jurisdictions include: New South Wales, Northern Territory, Queensland, South Australia, Victoria, and Western Australia

† Other provider type included public hospital, private hospital, public health unit, and flying doctor services.

‡ Other transfer method not included in the listed categories; these were not specified.

Appendix 2.I: Categorisation of Records Unable to be Assessed by Jurisdiction, Excluding the NT

Error Category	Jurisdiction					
	NSW	QLD	SA	VIC	WA	Total
No contact made/declined participation	157 (74.4%)	109 (84.5%)	162 (86.2%)	108 (63.5%)	166 (85.6%)	702 (78.7%)
Missing or inactive record	41 (19.4%)	6 (4.7%)	14 (7.5%)	5 (2.9%)	20 (10.3%)	86 (9.6%)
Child moved overseas or interstate	11 (5.2%)	14 (10.9%)	11 (5.9%)	1 (0.6%)	7 (3.6%)	44 (4.9%)
Unknown	2 (1.0%)	0	1 (0.5%)	0	1 (0.5%)	4 (0.5%)
Total	211	129	188	170*	194	892*

*Includes 56 records not reviewed by VIC

Appendix 2.J: Descriptive Analyses by Jurisdiction

New South Wales

	Up to date	Truly overdue	Error rate %
Coverage level			
Low (<90%)	23 (48.9%)	55 (46.6%)	29.5
Med (90-<95%)	17 (36.2%)	33 (28.0%)	34
High (≥95%)	7 (14.9%)	30 (25.4%)	18.9
Total	47	118	28.5
Remoteness status			
Remote	1 (2.2%)	7 (6.1%)	12.5
Regional	5 (10.9%)	16 (14.0%)	23.8
Major Cities	40 (87.0%)	91 (79.8%)	30.5
Total	46	114	28.8
Provider type			
GP	43 (91.5%)	101 (85.6%)	42.2
Council	0	3 (2.5%)	0
AHW	0	5 (4.2%)	0
CHC	0	5 (4.2%)	0
None listed	1 (2.1%)	3 (2.5%)	25
Other	3 (6.4%)	1 (0.9%)	75
State HD	0	0	0
Total	47	118	28.5
Transfer method			
Practice management software	33 (76.7%)	95 (83.3%)	25.8
Paper-based	3 (7.0%)	2 (1.8%)	60
Online AIR Secure Site	7 (16.3%)	17 (14.9%)	29.2
Other	0	0	0
Total	43	114	27.4
Age cohort			
9 to <12 months	11 (23.4%)	24 (20.3%)	31.4
15 to <18 months	11 (23.4%)	37 (31.4%)	22.9
21 to <24 months	15 (31.9%)	28 (23.7%)	34.9
51 to <54 months	10 (21.3%)	29 (24.6%)	25.6
Total	47	118	28.5

Northern Territory

	Up to date	Truly overdue	Error rate %
Coverage level			
Low (<90%)	152 (52.6%)	22 (37.9%)	87.4
Med (90-<95%)	75 (26.0%)	27 (46.6%)	73.5
High (≥95%)	62 (21.5%)	9 (15.5%)	87.3
Total	289	58	83.3
Remoteness status			
Remote	232 (81.1%)	29 (53.7%)	88.9
Regional	54 (18.9%)	25 (46.3%)	68.4
Major Cities	0	0	0
Total	286	54	84.1
Provider type			
GP	1 (0.4%)	7 (12.1%)	12.5
Council	0	0	0
AHW	25 (8.7%)	8 (13.8%)	75.8
CHC	26 (9%)	30 (51.7%)	46.4
None listed	1 (0.4%)	11 (19.0%)	8.3
Other	2 (0.7%)	0	100
State HD	234 (81.0%)	2 (3.5%)	99.2
Total	289	58	83.3
Transfer method			
Practice management software	5 (1.7%)	3 (6.3%)	62.5
Paper-based	0	0	0
AIR Online	0	0	0
NT Immunisation Register	283 (98.3 %)	43 (89.6%)	86.8
Other	0	2 (4.2%)	0
Total	288	48	85.7
Age cohort			
9 to <12 months	86 (29.8%)	3 (5.2%)	96.6
15 to <18 months	71 (24.6%)	6 (10.3%)	92.2
21 to <24 months	50 (17.3%)	34 (58.6%)	59.5
51 to <54 months	82 (28.4%)	15 (25.9%)	84.5
Total	289	58	83.3

Queensland

	Up to date	Truly overdue	Error rate %
Coverage level			
Low (<90%)	10 (52.6%)	97 (47.3%)	9.3
Med (90 - <95%)	5 (26.3%)	63 (30.7%)	7.4
High (≥95%)	4 (21.1%)	45 (22.0%)	8.2
Total	19	205	8.5
Remoteness status			
Remote	0	4 (2.0%)	0
Regional	4 (21.1%)	52 (25.4%)	7.1
Major Cities	15 (79.0%)	149 (72.7%)	9.2
Total	19	205	8.5
Provider type			
GP	13 (68.4%)	91 (44.4%)	12.5
Council	2 (10.5%)	17 (8.3%)	10.5
AHW	0	3 (1.5%)	0
CHC	0	1 (0.5%)	0
None listed	0	89 (43.4%)	0
Other	0	0	0
State HD	4 (21.1%)	4 (2.0%)	50
Total	19	205	8.5
Transfer method			
Practice management software	9 (69.2%)	92 (88.5%)	8.9
Paper-based	3 (23.1%)	0	100
Online AIR Secure Site	0	5 (4.8%)	0
Other	1 (7.7%)	7 (6.7%)	12.5
Total	13	104	11.1
Age cohort			
9 to <12 months	3 (15.8%)	41 (20%)	6.8
15 to <18 months	7 (36.8%)	42 (20.5%)	14.3
21 to <24 months	2 (10.5%)	61 (29.8%)	3.2
51 to <54 months	7 (36.8%)	61 (29.8%)	10.3
Total	19	205	8.5

South Australia

	Up to date	Truly overdue	Error rate %
Coverage level			
Low (<90%)	19 (52.8%)	76 (50.0%)	20
Med (90-<95%)	10 (27.8%)	40 (26.3%)	20
High (≥95%)	7 (19.4%)	36 (23.7%)	16.3
Total	36	152	19.1
Remoteness status			
Remote	1 (2.8%)	4 (2.6%)	20
Regional	5 (13.9%)	19 (12.5%)	20.8
Major Cities	30 (83.3%)	129 (84.9%)	18.9
Total	36	152	19.1
Provider type			
GP	23 (63.9%)	87 (57.2%)	20.9
Council	3 (8.3%)	34 (22.4%)	8.1
AHW	0	3 (2.0%)	0
CHC	3 (8.3%)	3 (2.0%)	50
None listed	2 (5.6%)	22 (14.5%)	8.3
Other	5 (13.9%)	3 (2.0%)	62.5
State HD	0	0	0
Total	36	152	19.1
Transfer method			
Practice management software	17 (56.7%)	108 (83.1%)	13.6
Paper-based	1 (3.3%)	4 (3.1%)	20
Online AIR Secure Site	12 (40.0%)	18 (13.9%)	40
Other	0	0	0
Total	30	130	18.8
Age cohort			
9 to <12 months	14 (38.9%)	23 (15.1%)	37.8
15 to <18 months	2 (5.6%)	31 (20.4%)	6.1
21 to <24 months	6 (16.7%)	29 (19.1%)	17.1
51 to <54 months	14 (38.9%)	69 (45.4%)	16.9
Total	36	152	19.1

Victoria

	Up to date	Truly overdue	Error rate %
Coverage level			
Low (<90%)	2 (50.0%)	76 (50.3%)	2.6
Med (90-<95%)	0	46 (30.5%)	0
High (≥95%)	2 (50.0%)	29 (19.2%)	6.5
Total	4	151	2.9
Remoteness status			
Remote	0	0	0
Regional	2 (50.0%)	25 (16.6%)	7.4
Major Cities	2 (50.0%)	126 (83.4%)	1.6
Total	4	151	2.9
Provider type			
GP	1 (25.0%)	98 (64.9%)	1.0
Council	3 (75.0%)	41 (27.2%)	6.8
AHW	0	1 (0.7%)	0
CHC	0	0	0
None listed	0	8 (5.3%)	0
Other	0	3 (2.0%)	0
State HD	0	0	0
Total	4	151	2.9
Transfer method			
Practice management software	4 (100.0%)	142 (100.0%)	2.7
Paper-based	0	0	0
Online AIR Secure Site	0	0	0
Other	0	0	0
Total	4	142	2.7
Age cohort			
9 to <12 months	2 (50.0%)	28 (18.5%)	6.7
15 to <18 months	0	32 (21.2%)	0
21 to <24 months	0	39 (25.8%)	0
51 to <54 months	2 (50.0%)	52 (34.4%)	3.7
Total	4	151	2.9

Western Australia

	Up to date	Truly overdue	Error rate %
Coverage level			
Low (<90%)	9 (50.0%)	80 (51.6%)	10.1
Med (90-<95%)	5 (27.8%)	41 (26.5%)	10.9
High (≥95%)	4 (22.2%)	34 (21.9%)	10.5
Total	18	155	10.4
Remoteness status			
Remote	4 (23.5%)	5 (3.3%)	44.4
Regional	3 (17.7%)	14 (9.2%)	17.5
Major Cities	10 (58.8%)	134 (87.6%)	6.9
Total	17	153	10
Provider type			
GP	11 (61.1%)	95 (61.3%)	17.7
Council	1 (5.6%)	4 (2.6%)	20
AHW	0	0	0
CHC	5 (27.8%)	40 (25.8%)	11.1
None listed	0	5 (3.2%)	0
Other	1 (5.6%)	10 (6.5%)	9.1
State HD	0	1 (0.7%)	0
Total	18	155	10.4
Transfer method			
Practice management software	14 (77.8%)	116 (81.1%)	10.8
Paper-based	0	0	0
Online AIR Secure Site	4 (22.2%)	27 (18.9%)	12.9
Other	0	0	0
Total	18	143	11.2
Age cohort			
9 to <12 months	6 (33.3%)	21 (13.6%)	22.2
15 to <18 months	4 (22.2%)	29 (18.7%)	12.1
21 to <24 months	5 (27.8%)	46 (29.7%)	9.8
51 to <54 months	3 (16.7%)	59 (38.1%)	4.8
Total	18	155	10.4

Appendix 2.K: Study Challenges

A number of challenges were identified during the conduct of the study as detailed below:

Resource Intensive

Most sites identified during the course of the project that the human resources required to undertake the audit were significant, particularly in jurisdictions where one organisation was solely responsible for the follow-up, with the audit being conducted in addition to normal work duties. Follow up of providers was also identified by sites to be challenging and time consuming. Sites reported that reception staff were often hesitant to refer the call to the nurse or GP, providers were often unavailable for a follow up or return call was required. It was also difficult to find the most appropriate contact where the provider was a hospital.

Disease outbreaks and other compounding factors

A number of factors impacted some sites' capacity to participate and/or complete the audit on time. These included:

- invasive meningococcal disease outbreak
- significant influenza season
- introduction and roll out of the ACWY meningococcal vaccine in high schools

11A reports

The audit required the sites to extract 11A reports and then for a central site to assist with the merge of the raw data. One of the AIR 11A reports from SA did not extract properly, resulting in a large number of records unlinked to providers and affecting 172

out of 400 records. One of the SA sites manually added additional information where available from the AIR. It is not possible to retrospectively extract 11A reports.

The merge of the 11A reports required significant skill and experience to make the output user friendly and to ensure all relevant information regarding each record was provided in a single file.

Follow up

919 records in this study were unable to be followed up; 394 of these were not linked to a provider and either had no parent/carer telephone number listed or the parent/carer was not contactable.

The study challenges identified here provide an opportunity for reflection. Several improvements could be made for similar studies in the future. These include:

- a longer lead-in time to identify appropriate stakeholder for engagement. Staff time could then be properly allocated to include an audit within normal duties
- additional optional training for site staff to properly extract 11A reports
- a sub-analysis of records which were not linked to a provider.

3. Data Analysis Project

Epidemiological review of pneumococcal disease in Australia, 2002-2016

3. Data Analysis Project

Prologue

Background

The Australian Department of Health publishes regular annual and quarterly reports on invasive pneumococcal disease (IPD) trends in the peer-reviewed journal *Communicable Diseases Intelligence*. This project aimed to provide an epidemiological review of IPD trends across a fifteen year timespan. Also of interest was the analysis of pneumococcal hospitalisation data across this same time span, to identify evidence of herd protection within presumptive non-invasive community acquired pneumonia (PnCAP) hospitalisations as a result of IPD immunisation. We were mainly interested in the trends following the 2011 change on the National Immunisation Program (NIP), with the switch to the 13-valent pneumococcal conjugate vaccine (13vPCV). Upon completion of the analyses, the co-authors and I discussed the importance and uniqueness of this piece of work, and agreed upon submitting it to an international infectious disease journal in the first instance.

This study initially included data analysis for IPD notification data and all pneumococcal disease, presumptive PnCAP, non-invasive PnCAP, and invasive PnCAP hospitalisation data. The analysis of this data is included at the end of the chapter as additional analyses.

In addition, this project also compared pneumococcal disease death data and trends across several data sources to assess data completeness as a report of interest for submission to the Enhanced Invasive Pneumococcal Disease Surveillance Working Group (EIPDSWG)(report not included).

My Role

My role in this project started with detailing a data analysis plan. Once completed, I undertook all steps of the analysis, which included: obtaining ethics approval, cleaning data, merging data from different datasets, and data analysis. I calculated rates, incident rate ratios, confidence intervals, and case fatality rates as measures of disease trends, and generated a number of corresponding graphs, figures, and tables to convey results. I completed and submitted a report to the EIPDSWG, which identified death field data completeness in the enhanced National Notifiable Disease Surveillance System (NNDSS) dataset. I also was able to submit my first peer-reviewed publication, as well as prepare an abstract that was accepted for an oral presentation for the 2018 National Immunisation Conference (Appendix 3.A).

Lessons Learnt

I had learned to use statistical programs for data analysis in previous degrees, however, I have never been able to apply my skills to a project from start to completion. This project has taught me an entire spectrum of steps one needs to take to complete a data analysis project. I also learned how to use STATA while undertaking this project, which was sometimes frustrating as well as rewarding. Once my analysis was complete, I also found it challenging to decide which data to present and how, as there were so many options of findings to present. I learned to try to stick to my data analysis plan to keep my project on target. As the focus of this project changed several times while preparing both a conference presentation and a draft for a peer-reviewed publication, I want to emphasise how important this was with each change to keep this project manageable. I enjoyed this project as it was complicated and challenging for

me, and I feel that I improved my data analysis skills along with my confidence to undertake future data analysis projects. It was also exciting for me to be able to learn to write in a more scientific manner, and to prepare a manuscript to submit to a peer review journal on research which previously had not been conducted before. I felt a sense of pride being able to contribute to the scientific community.

Starting this project I knew very little about pneumococcal disease. I did not expect to undertake a project which would include the identification and analysis of several clinical categories of pneumococcal disease, including: all pneumococcal disease, IPD, presumptive PnCAP, non-invasive PnCAP, and invasive PnCAP. Through this experience, however, I was able to gain a greater understanding of the disease burden of pneumococcal disease within Australia, as well as the justifications for the pneumococcal schedule change, as outlined below, for the National Immunisation Program (NIP).

Public Health Implications

This project updated the documentation of national trends of IPD notifications and provided an updated review of the impact of the 13vPCV on national incidence rates. At the time of undertaking this project, a change was proposed to move the 2+1 NIP pneumococcal vaccination schedule to a 3+0 schedule to assist in slowing the increasing rates of pneumococcal disease in the younger population, as well as to provide increased herd protection in older age groups. The results of this study provided additional supporting evidence for the now-implemented national schedule change. In addition, this work provided the first description of annual trends or rates for non-invasive presumptive pneumococcal disease on a national scale. These results

were submitted for publication in an international peer-reviewed journal, to add to the available literature on this topic.

Lastly, this study included a separate report for EIPDSWG which identified the limited usefulness of hospitalisation and mortality datasets in health research involving IPD-caused deaths. The reason for poor quality data within these dataset needs to be investigated further to identify if there are improvements which could be made, whether through death data collection, disease or cause of death classifications, or reporting practices. The report also provided a detailed account of completeness for data within the death data field for NNDSS data by jurisdiction and nationally. This report identified data transfer errors due to differing interpretations by jurisdictions of the definitions for the IPD 'died' field for all codes excluding 'died' (recorded as 'died' [died due to IPD]) , which are: 'not died' (did not die or died of non-IPD causes), 'unknown' (followed up, but status unknown) or incomplete (recorded as 'missing'). As a result of this analysis, investigation began by the Department of Health (DoH) continued into jurisdictional understanding of these codes for not just IPD, but potentially all diseases collected by NNDSS, to improve data quality and completeness of the data collected by the national disease surveillance system.

Acknowledgements

I would like to acknowledge my team members at NCIRS for all of their guidance and contributions in making this study a success, the co-authors involved in all aspects of this project for their support, as well as all of the stakeholders who contributed to this project.

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Abstract

Background

Universal pneumococcal conjugate vaccine (PCV) programs in infants and pneumococcal polysaccharide vaccine (PPV) programs in adults aged ≥65 years began in 2005. We used national invasive pneumococcal disease (IPD) laboratory-based surveillance alongside coded hospitalisations for non-invasive pneumococcal community acquired pneumonia (PnCAP) to evaluate impact of these programs over 12 years to 2016.

Methods

Incidence (per 100,000 population) was estimated for PCV periods defined as pre-universal PCV7 (2002-2004) versus early-PCV7 (2005-2007), pre-PCV13 (2008-mid 2011) and post-PCV13 (mid 2011-2016). Vaccine impact was measured by incidence rate ratios (IRRs) stratified by age group, serotype and Indigenous status.

Results

Total IPD incidence declined from 11.8 pre-2005 to 7.1 post-PCV13 (IRR 0.61, 95% CI 0.59-0.63), varying from 0.20 in infants to 0.68 in adults ≥65 years. Pre-universal PCV, PnCAP incidence was greater than IPD for ≥65 years (36.1 vs 25.2 per 100,000) but in infants less than IPD (18.6 vs 83.2 per 100,000). PnCAP declined pre-2005 to post-PCV13 in infants (18.6 to 6.2; IRR 0.34, 95% CI 0.25-0.45) and 1-4 years (15.9 to 7.9; IRR 0.50, 95% CI 0.43-0.57), but increased significantly ≥5 years (IRRs 1.08 to 1.14). In Indigenous Australians, reductions in PnCAP exceeded IPD, but incidence remained 7.6-fold (PnCAP) and 3.8-fold (IPD) higher than non-Indigenous.

Conclusion

Lack of impact on PnCAP hospitalisations in adults, in contrast to children and all-age IPD, suggests limited direct effects of PPV23 and indirect effects of PCVs and supports monitoring IPD and PnCAP following change to 2+1 PCV infant schedule in 2018.

Introduction

Pneumococcal disease is a major cause of morbidity and mortality globally in different age groups, caused by the encapsulated bacterium *Streptococcus pneumoniae* (pneumococcus) [1]. It causes a spectrum of clinical presentations, the most severe being invasive pneumococcal disease (IPD), which includes potentially life-threatening meningitis, sepsis and pneumonia. Pneumococcus is a leading cause of community acquired pneumonia worldwide and in adults, incidence of non-invasive pneumococcal community-acquired pneumonia (PnCAP) is substantially higher than IPD-associated pneumonia [2, 3]. Since 2000, an increasing number of countries have introduced pneumococcal conjugate vaccines (PCVs) for children, initially 7-valent PCV (PCV7), followed by 13-valent PCV (PCV13), with 10-valent PCV (PCV10) also used [4]. Pneumococcal polysaccharide vaccines, most recently with 23 serotypes (PPV23), have been in use much longer, but are recommended only for adults and older children with an increased risk of pneumococcal disease. In Australia, pneumococcal vaccine was universally funded through the National Immunisation Program in 2005 (PCV7 for children aged 2, 4, and 6 months and PPV23 for adults aged ≥65 years) but selective funded programs were in place earlier. PCV7 was funded for high-risk children from 2001, and PPV23 was funded (for Aboriginal and Torres Strait Islander, hereafter referred to as Indigenous, adults aged ≥50 years) or subsidised (non-Indigenous adults aged ≥65 years) from 1998. Vaccination rates varied by Indigenous status before and after universal funding (Table 1). In 2011, PCV13 replaced PCV7. Australia was unique among high income countries in adopting a PCV schedule of 3 primary doses with no booster (3+0).

Table 1: National vaccination coverage by vaccine type and Indigenous status, Australia [5-8]

	PCV vaccination in children		PPV vaccination in adults	
Indigenous status	Pre-2005	Post-2005	Pre-2005	Post-2005
Indigenous	33%	80-86%	34%	54% (total)
Non-Indigenous	10%	91-92%	20%	

For IPD, Australia introduced national laboratory-based surveillance from 2002. Along with routine quarterly and annual reporting, previous studies have reported trends in the epidemiology of IPD following PCV7 and PCV13 use in children and PPV23 use in adults [6, 9, 10]. However, these studies have been limited to specific regions and populations and/or included shorter time periods. With respect to pneumococcal pneumonia, although previous Australian studies have examined trends in ICD-coded pneumonia hospitalisations, PnCAP has not been examined, unlike similar US studies [11]. PnCAP data are largely limited to coded hospitalisations as, in the absence of IPD, laboratory diagnosis is challenging due to limitations in sensitivity of diagnostic methods [3]. Clinical trial data and international studies using ICD-coded data suggest that direct and indirect impact of PCVs is less against PnCAP than IPD [4, 12-14].

This study aimed to examine Australian IPD incidence over a period of 15 years (2002-2016), examining trends by age, Indigenous status, and PCV13-specific serotypes, with a focus post-PCV13 introduction and on comparisons with PnCAP [15-17]. These data will provide a baseline to assess the impact of the 2018 PCV13 infant schedule change from 3 primary doses (3+0) to 2 primary doses with a 12 month booster dose (2+1).

Methods

Study design and data sources

The study design was cross-sectional and descriptive, both for IPD notifications and coded hospitalisations consistent with PnCAP.

IPD data was sourced from core and enhanced National Notifiable Diseases Surveillance System (NNDSS) datasets between 2002 and 2016. NNDSS core data is derived from cases of IPD notified to the eight Australian State and Territory (jurisdictions) health departments and includes age, date of onset, serotype, and vaccination history, while enhanced data adds clinical category and risk factor status. The case definition for IPD was isolation of *Streptococcus pneumoniae* by culture, or detection by nucleic acid testing, from a normally sterile site [18].

PnCAP data was sourced from the Australian Institute of Health and Welfare's (AIHW) National Hospital Morbidity Database which includes Australia-wide hospital admission and separation data coded by diagnosis. Data from 1 July 2002-30 June 2016 were used. PnCAP cases were defined as hospitalisations assigned ICD-10-AM discharge codes J13 (pneumococcal pneumonia) and J18.1 (lobar pneumonia), together or separately, after excluding cases that also had codes G00.1 (pneumococcal meningitis) and A40.3 (pneumococcal septicaemia). No changes to coding practices occurred during the study period.

Australian Bureau of Statistics mid-year population estimates for 2002-2016 were used as denominators for rate calculations.

Data analysis

Rates per 100,000 population were calculated by calendar year for IPD notifications and by Australian financial year (1 July–30 June) for PnCAP hospitalisations. Changes in rates were compared by age group, Indigenous status, vaccine period, and serotype (IPD only).

Incidence Rate Ratios (IRR) and 95% confidence intervals were estimated assuming a Poisson distribution and used to explore the statistical significance of trends for notification and hospitalisation data by age group, Indigenous status, vaccine period, and for 13v-non7v serotypes in IPD cases. IRRs were calculated using the following formula:

$$\frac{\text{Incidence rate (post-PCV13 introduction)}}{\text{Incidence rate (pre-universal PCV7 or pre-PCV13 introduction)}}$$

Age

For IPD incidence and hospitalisation trends, the age groups of <1, 1-4, 5-49, 50-64, ≥65 years, and all ages, were used for comparisons across vaccine periods.

Vaccine period

Four periods corresponding to the timing of changes in the universal PCV program were used (Table 2). The cut-off between early PCV7 and pre-PCV13 periods was identified as the end of 2007, as serotype replacement, dominated by 19A, significantly increased after 2007, with 2008-2011 used as the baseline for assessment of PCV13 impact.

Table 2: Vaccine periods used for comparison, Australia, 2002-2016

Vaccine period	Inclusion dates	Duration (years)
Pre-universal PCV7	2002 - 2004	3
Early PCV7	2005 - 2007	3
Pre-PCV13	2008 - June-2011	3.5
Post-PCV13	July-2011 - 2016	5.5

Indigenous status

NNDSS records were identified as Indigenous or non-Indigenous if reported; records with unknown Indigenous status were recorded as non-Indigenous. From 2002, Indigenous status was over 80% complete, except in 2003, varying across jurisdictions with greatest completeness in the Australian Capital Territory (ACT), Northern Territory (NT), South Australia (SA), and Western Australian (WA). AIHW provides recommendations for the inclusion of hospitalisation data for analysis based on Indigenous status quality. As per recommendations, data from NT, SA, Queensland (QLD) and WA were used for analysis of PnCAP by Indigenous status, as these jurisdictions held acceptable Indigenous status completeness over our study period [19].

Serotypes

Reference laboratories serotyped *S. pneumoniae* isolates associated with IPD cases. The serotypes included in PCV7 and PCV13 were identified, with serotypes unique to PCV13 (1, 3, 5, 6A, 7F, and 19A) grouped for analysis post-PCV13 vaccine use.

Cases of laboratory confirmed IPD with no established serotype, or which were non-typable, were excluded from serotype-specific analysis but included in total counts.

Analyses were performed using STATA statistical software for Windows, Release 14.2 College Station, TX: StataCorp LP.

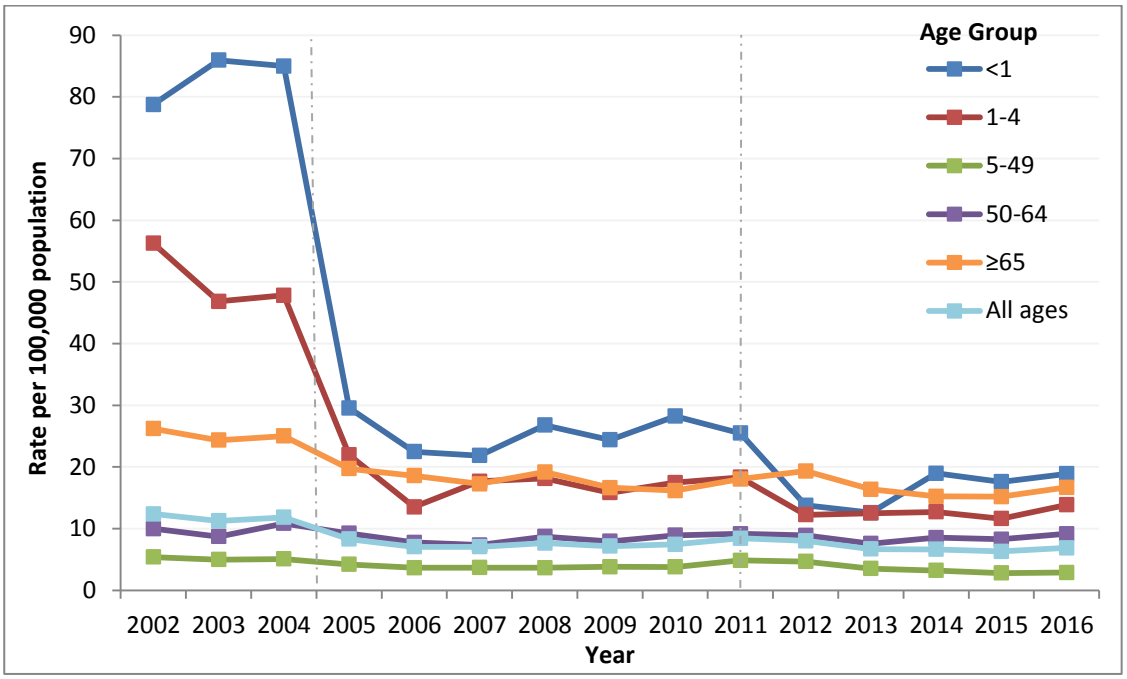
Ethical approval was granted by the Australian National University Human Research Ethics Committee #2017/742.

Results

Total IPD incidence

Annual incidence of total IPD declined in each age group from 2002-2016 (Figure 1). Declines were greatest and similar in children aged <1 (76%) and 1 to 4 years (75%). Notification rates in adults aged ≥65 years showed the next largest decline of 36% from 26.2 to 16.7 per 100,000 population. The lowest all-age IPD incidence was in the 3-year period 2012-2014 (immediately post change to PCV13), but the steepest decline occurred in the 3 years immediately post-PCV7 (2005-2007). IPD incidence increased slightly in 2015 and 2016, but remained lower than 2011.

Figure 1: Total IPD notification rates by age group, Australia, 2002-2016



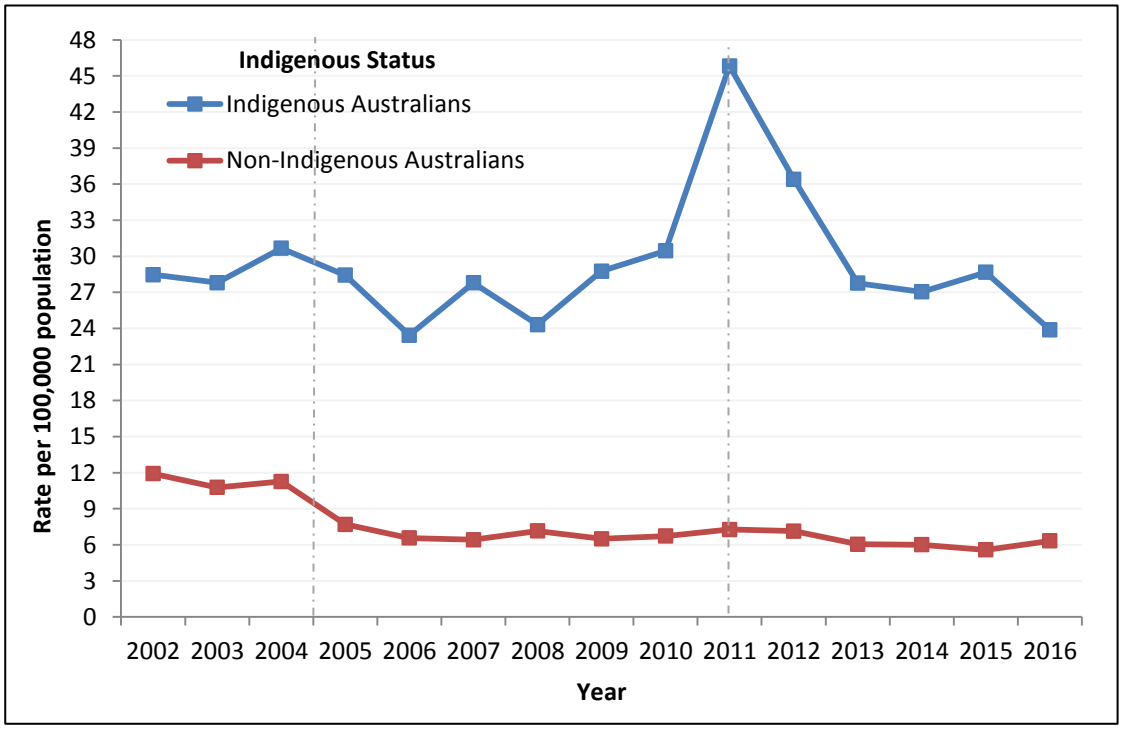
When grouped by vaccine period, the greatest reductions in total IPD occurred in the early PCV7 period and in children, both those <1 year (83.2 to 24.5 per 100,000 population; IRR 0.29, 95% CI 0.25-0.35) and 1 to 4 years (50.3 to 17.7 per 100,000; IRR 0.35, 95% CI 0.32-0.39) (Table 3). From pre-PCV13 to post-PCV13 period, incidence rates decreased, but to a lesser extent, in those aged <1 year from 27.1 to 16.7 per 100,000 population (IRR 0.61, 95% CI 0.51-0.73) and 1 to 4 years (17.2 to 13.1 per 100,000; IRR 0.75, 95% CI 0.67-0.83). However, in those aged 5-49 years, incidence showed little change, and in persons aged ≥50 years there were slight increases between pre- and post-PCV13 periods, such that all-age IPD incidence decreased non-significantly by 2.7% from 7.3 to 7.1 per 100,000 population. In contrast, all-age IPD reduced between pre-universal PCV7 and early PCV7 periods by 36.4% (11.8 to 7.5 per 100,000 population; IRR 0.63, 95% CI 0.61-0.66).

Table 3: Total IPD and presumptive non-invasive PnCAP notification rates by age group and vaccine period, Australia, 2002-2016

Invasive Pneumococcal Disease							
	Rate per 100,000 population				IRR (95% CI)		
Age group (years)	Pre-universal PCV7	Early PCV7	Pre-PCV13	Post- PCV13	Pre-universal PCV7 to Early PCV7	Pre- to Post-PCV13	Pre-universal PCV7 to Post-PCV13
<1	83.2	24.5	27.1	16.7	0.29 (0.25-0.35)	0.62 (0.52-0.73)	0.20 (0.17-0.23)
1-4	50.3	17.7	17.2	13.1	0.35 (0.32-0.39)	0.76 (0.69-0.84)	0.26 (0.24-0.28)
5-49	5.2	3.9	3.8	3.6	0.75 (0.70-0.80)	0.95 (0.89-1.00)	0.70 (0.66-0.74)
50-64	9.9	8.1	8.3	8.7	0.82 (0.75-0.90)	1.05 (0.98-1.13)	0.89 (0.82-0.96)
≥65	25.2	18.5	16.6	17.1	0.73 (0.69-0.79)	1.03 (0.97-1.09)	0.68 (0.64-0.72)
All ages	11.8	7.5	7.3	7.1	0.63 (0.61-0.66)	0.98 (0.94-1.01)	0.61 (0.59-0.63)
Presumptive non-invasive PnCAP							
	Rate per 100,000 population				IRR (95% CI)		
Age group (years)	Pre-universal PCV7	Early- PCV7	Pre-PCV13	Post- PCV13	Pre-universal PCV7 to Early PCV7	Pre- to Post-PCV13	Pre-universal PCV7 to Post-PCV13
<1	18.6	7.5	8.1	6.2	0.41 (0.29-0.56)	0.77 (0.56-1.07)	0.34 (0.25-0.45)
1-4	15.9	6.5	7.7	7.9	0.41 (0.35-0.49)	1.02 (0.88-1.19)	0.50 (0.43-0.57)
5-49	5.6	3.9	4.3	6.0	0.70 (0.65-0.75)	1.39 (1.31-1.47)	1.08 (1.02-1.15)
50-64	13.8	9.2	11.1	16.5	0.67 (0.61-0.73)	1.48 (1.39-1.58)	1.19 (1.11-1.27)
≥65	36.1	25.5	26.3	41.2	0.71 (0.67-0.75)	1.57 (1.50-1.65)	1.14 (1.09-1.20)
All ages	11.6	7.8	8.7	13.1	0.68 (0.65-0.70)	1.50 (1.46-1.55)	1.13 (1.10-1.17)

In 2002, all-age IPD incidence in Indigenous Australians was 28.5 per 100,000 population, 2.4 times higher than in non-Indigenous Australians (11.9 per 100,000, Figure 2). In 2010, a serotype 1 outbreak of IPD began among Indigenous people living in the NT, WA, and parts of QLD), which, together with increasing incidence of serotype 19A, resulted in all-age total IPD incidence in Indigenous Australians increasing to 45.8 per 100,000 population [20-22]. Between 2012 and 2013, IPD incidence in Indigenous Australians declined to pre-outbreak levels (27.8 per 100,000), decreasing to the lowest-recorded incidence of 23.9 in 2016 (Figure 2), still 3.8 times higher than non-Indigenous Australians (6.3 per 100,000 population).

Figure 2: IPD notification rates by Indigenous status, Australia, 2002-2016



Serotype-specific IPD incidence

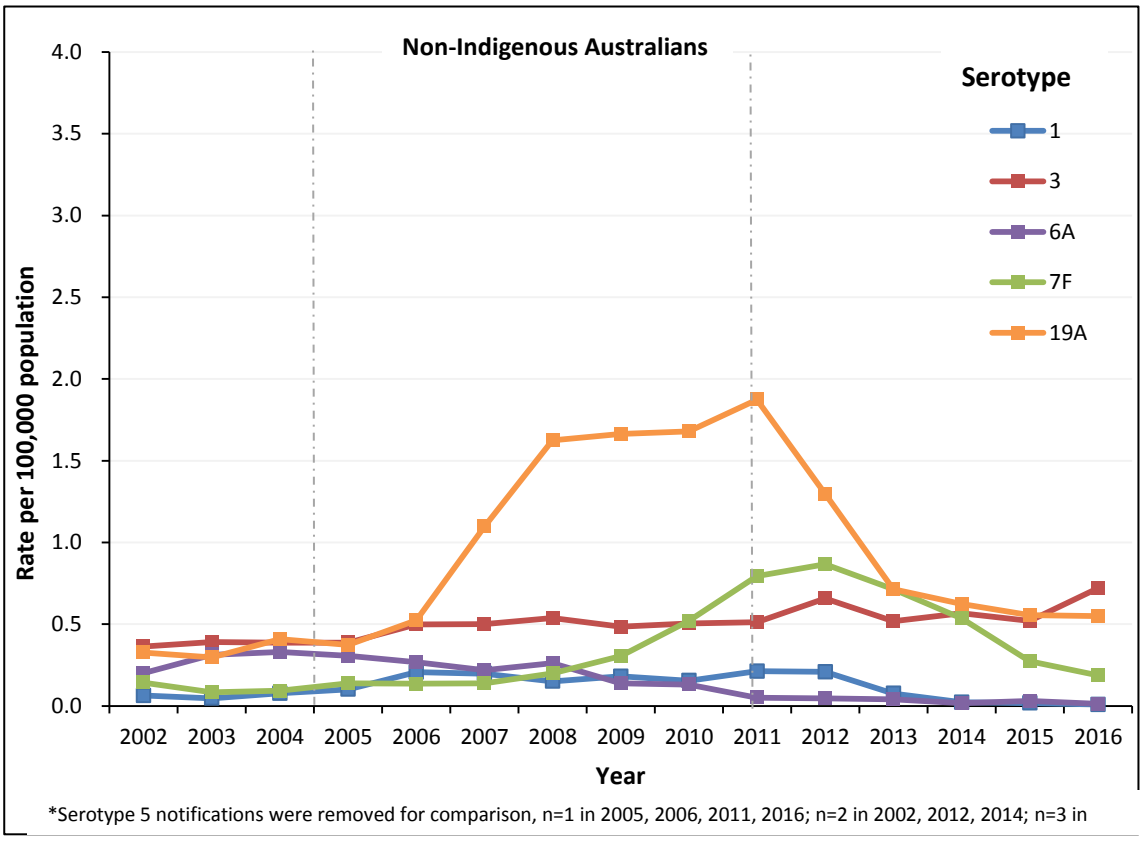
Of the six serotypes unique to PCV13 (13non-7v), there were reductions in all-age IPD incidence (data not shown) for serotypes 1, 6A, 7F, and 19A following PCV13

introduction; serotype 5 IPD had always been rare, and incidence remained <0.1 per 100,000 population, with no cases identified among Indigenous Australians. However, timing of these reductions differed, with incidence increasing three to fourfold for serotype 1 from 2008 to 2011 (0.2 to 0.7 per 100,000 population) and serotype 7F from 2007 to 2012 (0.2 to 0.9 per 100,000). Serotype 19A IPD increased almost five-fold from 0.4 in 2005 to 1.9 per 100,000 population in 2011, but also decreased most steeply post-PCV13 introduction [23].

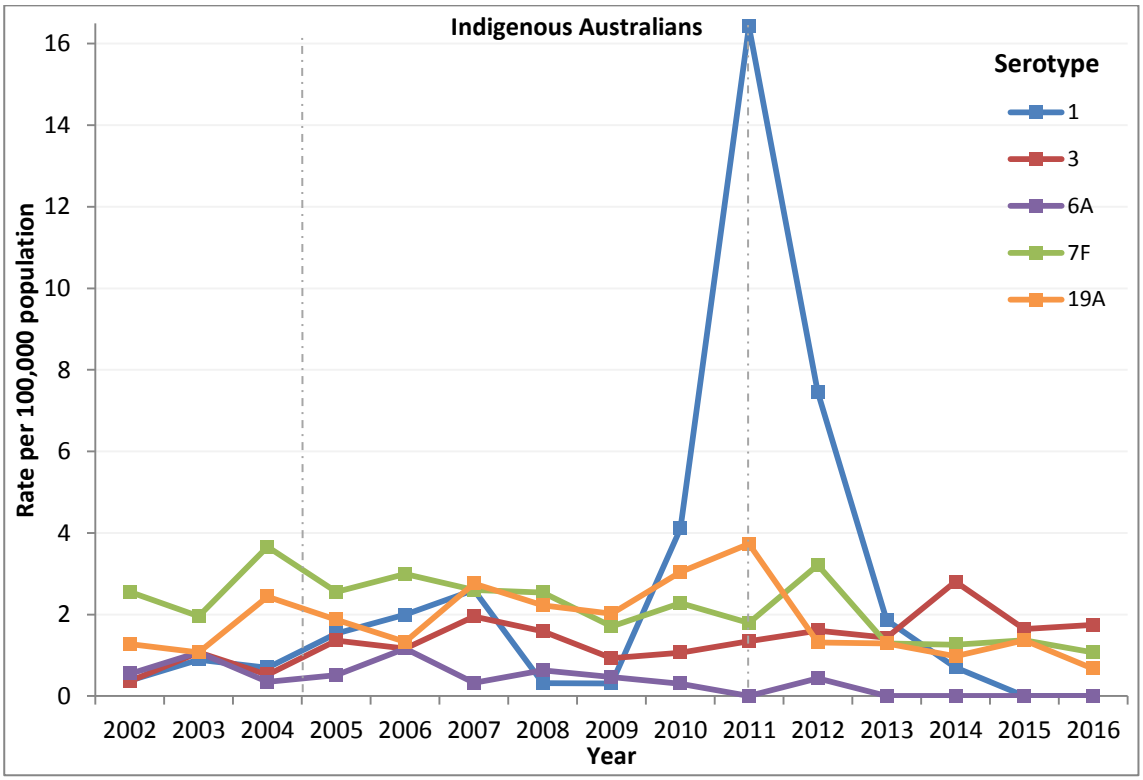
For serotype 3 IPD, we observed a small but significant rise in incidence from the pre-PCV13 to post-PCV13 periods (IRR 1.18, 95% CI 1.05-1.33), representing continuation of trends since 2005 (Figures 3a and 3b). The increase in all-age incidence of serotype 3 IPD from 0.6 to 0.8 per 100,000 population between 2015 and 2016 was driven by increases in children aged <5 years (data not shown).

Incidence of all 13vnon-7v serotypes was higher among Indigenous Australians (Figures 3a and 3b). Serotypes 7F and 19A were most common pre-2005, with incidence three to fourfold higher than non-Indigenous. Strikingly, incidence of serotype 1 IPD in Indigenous Australians in 2011, at 16.4 notifications per 100,000 population, was about 80 times that in non-Indigenous Australians (0.2 per 100,000). Incidence of serotype 19A IPD also peaked in 2011, with 3.7 and 1.9 notifications per 100,000 population for Indigenous and non-Indigenous Australians respectively.

Figure 3a & 3b: All-age incidence of IPD due to 13v-non-7vPCV serotypes, non-Indigenous* and Indigenous Australians, Australia, 2002-2016



*Serotype 5 notifications were removed for comparison, n=1 in 2005, 2006, 2011, 2016; n=2 in 2002, 2012, 2014; n=3 in



PnCAP hospitalisations

When examined by year, PnCAP hospitalisations decreased in the pre-universal PCV period (2003/4 and 2004/5 compared with 2002/3) in persons aged ≥5 years, most strikingly in those ≥65 years, but not in those <5 years (Figure 4). After universal PCV7 introduction in 2005, annual incidence declined in all age groups, reaching its nadir in 2006/7, with variable increases thereafter. After PCV13 introduction in mid-2011, age-specific rates continued to increase, especially in those ≥65 years, but declined from pre-2011 levels in all age groups by 2014/5. In 2015/16, PnCAP incidence had decreased in all age groups compared with 2002/3, but when compared with the post-PCV7 nadir in 2006/7, decreased only in those aged <5 years.

Figure 4: National incidence of hospitalisations coded as non-invasive PnCAP by age group, Australia, 2002/03-2015/16

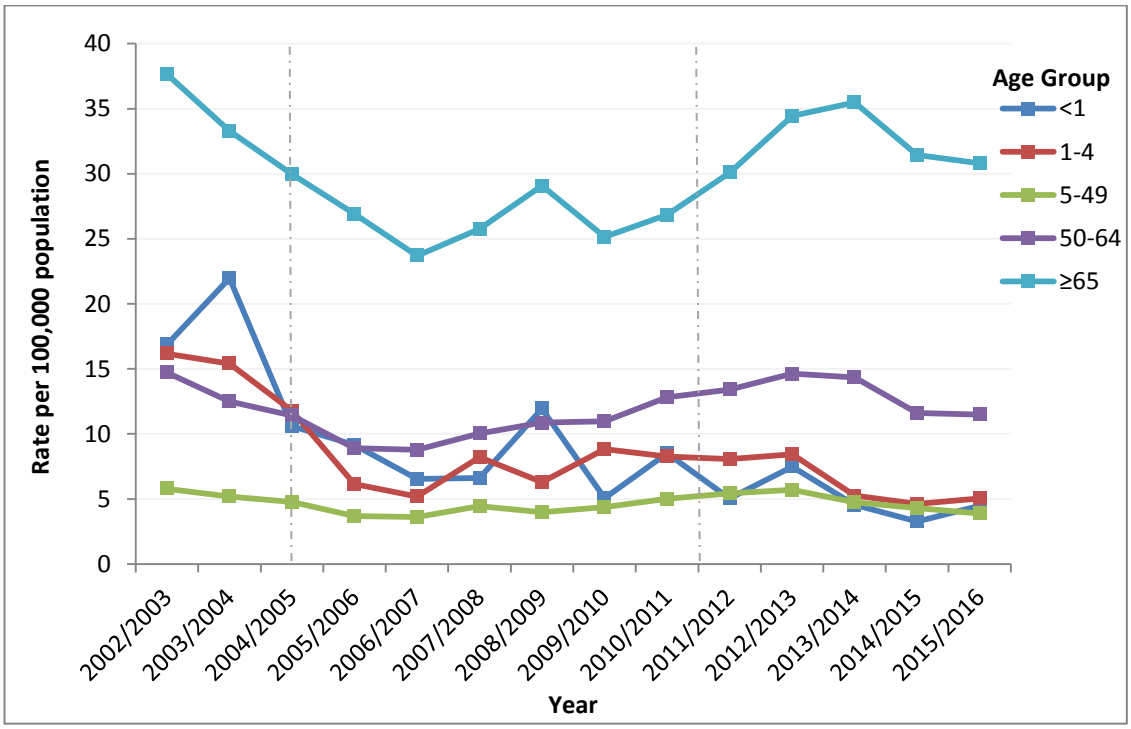
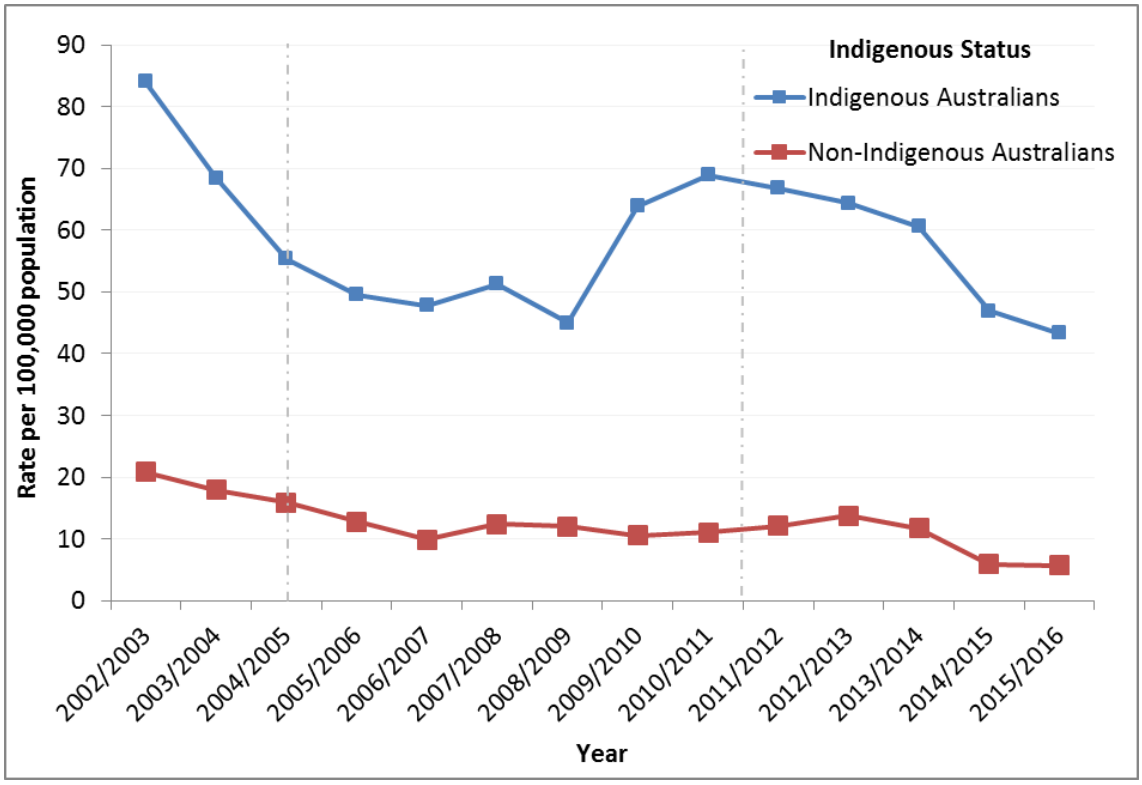


Table 3 shows average age-specific incidence of PnCAP hospitalisations over years, grouped by vaccine periods corresponding to those in Table 2. When examined by

vaccine period, there was a significant decrease in incidence of PnCAP hospitalisations between pre-universal PCV7 and post-PCV13 periods only in children aged <1 year (18.6 to 6.2 per 100,000 population; IRR 0.34, 95% CI 0.25-0.45) and 1-4 years (15.9 to 7.9 per 100,000; IRR 0.50, 95% CI 0.43-0.57). For all age groups ≥5 years, there was a small but statistically significant increase in PnCAP hospitalisation incidence between pre-universal PCV7 and post-PCV13, and (more marked) between pre- and post-PCV13 periods, greatest in adults ≥65 years (IRR 1.57, 95% CI 1.50-1.65).

Figure 5 shows all-age PnCAP hospitalisation incidence by Indigenous status. A significant reduction in the incidence of PnCAP hospitalisations was observed in Indigenous Australians comparing 2006/7 with 2002/3, especially in those aged <1 year (177.1 to 52.9 per 100,000 population; IRR 0.29, CI 0.09-0.85) and ≥65 years (272.4 to 121.7 per 100,000; IRR 0.45, 95% CI 0.20-0.93) (age-specific data not shown). After PCV13 introduction, the incidence of PnCAP hospitalisations in Indigenous Australians declined from 66.8 per 100,000 population in 2011/12 to 43.3 in 2015/16 (IRR 0.65, 95% CI 0.53-0.79). In non-Indigenous Australians, incidence in 2015/16 was lower than any preceding year, with a decrease from 2011/12 from 12.1 to 5.7 per 100,000 population; IRR 0.47, 95% CI 0.42-0.52). In 2015/16, the hospitalisation rate in Indigenous Australians was 7.6 times that of non-Indigenous Australians, compared to 4.0 times higher in 2002/3.

Figure 5: All-age non-invasive PnCAP hospitalisation incidence by Indigenous status, Australia, 2002/03-2015/16



Discussion

In this study we review Australian trends in of all laboratory-confirmed IPD by Indigenous status over fifteen years and IPD due to vaccine serotypes post PCV13 introduction, and compare IPD data with ICD-coded PnCAP hospitalisations. The all-age IPD notification rate in Australia decreased by 39% (IRR 0.61, 95% CI 0.59-0.63) from 2002 to 2016, reflecting an overall declining trend. In the 2-3 years following PCV13 introduction, total IPD declined to its lowest rate, in concordance with previous reports from Australia, the United Kingdom (UK), and US [10, 24, 25]. All-age rates varied non-significantly in 2015 and 2016, but statistically significant age-specific reductions were documented in infants (80%) and 50-64 year olds (11%). The small increases in total IPD incidence in 2015 and 2016 may be due to increases in non-

vaccine type IPD as observed, particularly in older age groups, in the UK [26]. This study provides the most recent baseline data to monitor IPD rates after the July 2018 change to a national 2+1 infant PCV schedule and evaluate whether expected benefits (i.e. reduction in IPD incidence overall and during the second year of life) are achieved [27].

Trends in IPD incidence due to 13v-non7v serotypes are of particular significance. Serotype 19A was the main replacement serotype following PCV7 introduction, as found in similar high vaccine coverage settings. However, 19A IPD incidence stabilised from 2008 to 2010 after three years of PCV7 use in Australia, in contrast to most other settings where increases continued [28]. The decline in serotype 19A IPD post-PCV13 introduction was consistent with pre-licensure studies, but breakthrough cases in older children, associated with waning vaccine effectiveness, meant that declines were not sustained [29-32]. Australia experienced an outbreak of serotype 1 among Indigenous Australians between 2010 and 2012. Continued use of PCV13 may prevent future outbreaks, with short-term effectiveness of PCVs suggested by lower incidence during the 2010-12 outbreak among NT children who received PCV10 through their jurisdictional program [33].

We documented increasing rates of serotype 3 IPD in recent years, on a background of less steep increases in previous years. Similar findings have been reported even in settings where a booster dose was implemented, resulting in no substantial changes for serotype 3 [34-36]. It is important to continue to monitor this trend following the 2+1 schedule change.

We also examined data for PnCAP hospitalisations, although we were unable to confirm they were not IPD cases as data were not linked. These coded hospitalisations represent a small proportion of all-cause pneumonia, with about 85% of hospitalised

CAP coded as 'aetiology not specified' [37, 38]. However, in our data, incidence of PnCAP was substantially higher than IPD in adults aged ≥50 years and so represents a potentially preventable disease burden from which valid conclusions can be drawn [37, 38].

The declines of PnCAP hospitalisations found in all age groups post-PCV7 introduction are consistent with direct impact among children <5 years, indirect impact in persons ≥5 years, and earlier Australian studies of all-cause pneumonia, but were short-lived, with hospitalisation rates increasing during pre- and post-PCV13 periods [37, 38]. These trends are similar, but less pronounced, to reductions in IPD in those aged <5 years and similar to other studies [39]. Incidence of PnCAP is higher at older ages, with increases up to 57% between pre- and post-PCV13 periods, contrary to the IPD declines observed. This suggests no indirect benefit from the infant PCV13 program and limited direct effects from PPV23.30-40% of those aged ≥65 years were receiving PPV23 prior to PCV introduction and so any related decline may have occurred previously [40, 41]. Similar findings from the UK have been reported, with reductions in coded pneumonia hospitalisations in younger groups and increases in older groups, although the UK uses a 2+1 PCV schedule [42].

More specific laboratory tests would be needed to confirm if the trends we observed in presumptive ICD-10-AM codes represented a true vaccine effect [43]. In the Australian context, there may be greater justification for an adult PCV13 program, although indirect impact of the 2+1 schedule change would have to first be assessed [12, 14, 44].

Indigenous Australians have historically had a higher burden of pneumococcal disease, similar to First Nations populations in North America. All-age IPD incidence in

Indigenous Australians decreased markedly post-PCV13 introduction, particularly for serotype 19A and 7F disease. Steep decreases in serotype 1 disease are likely outbreak-related, however it is important to evaluate whether PCV13 is protective against future outbreaks [20]. In contrast to non-Indigenous Australians, we found that reductions in PnCAP in Indigenous Australians in the post-PCV13 period were greater than for IPD. Differing vaccine programs, with a 3+1 PCV13 schedule routinely recommended for Indigenous children in high-incidence regions, may have played a role in this.

This study had several limitations. First, annual data were aggregated into periods related to vaccine use, with the aim of enhancing available numbers and relating analysis to policy context, but averaging may have concealed IPD trends if later years post-PCV13 differed from earlier years, or if decreasing annual trends existed before PCV7 introduction. Although time-series analysis would have better accounted for pre-existing trends, it is also limited by case numbers and was out of scope for our study. Similarly, we were unable to separately identify cases detected by nucleic acid testing of specimens from sterile sites, but these are small in number and unlikely to impact on overall results.

In conclusion, our study identified Australian-wide trends in IPD and PnCAP over the longest period reported to date, with baseline data for more than 3 years, as recommended for impact analyses [28]. Our findings extend those from previous studies finding lesser impact post PCV13 than post PCV7, and both support the decision to move to a 2+1 schedule and provide an important baseline for impact assessment [10]. In the absence of assays to detect serotype-specific pneumococcal pneumonia, our data on PnCAP hospitalisations are also important for evaluation of

herd protection from the schedule change and considerations around any incremental value of PCV13 use in persons aged ≥65 years currently eligible for PPV23 [13].

Funding: This study was conducted at the NCIRS, which receives funding from the Australian Government Department of Health.

Keywords: Australia, pneumococcal disease, epidemiological review, community acquired pneumonia, mortality data

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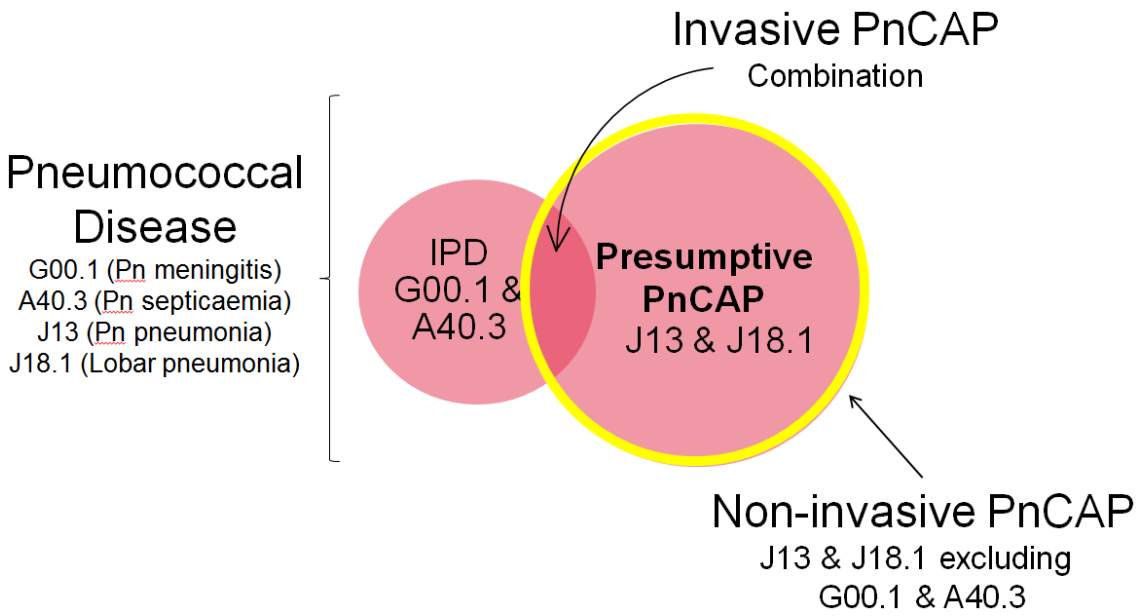
Additional Analyses and Results

This study included data analysis for IPD notification data and all pneumococcal disease, presumptive PnCAP, non-invasive PnCAP, and invasive PnCAP hospitalisation data (Figure 6). The submitted article on this project reviewed non-invasive PnCAP, while the presentation focused on presumptive PnCAP. Results for all pneumococcal disease and invasive PnCAP were not included in the submitted publication, but are included below.

Figure 6: Visual representation of the relationship of ICD-10-AM coded clinical disease classifications of illnesses analysed.



Pneumococcal Disease and Invasive PnCAP

Rates of hospitalisations decreased between all vaccine periods for all pneumococcal disease, IPD, presumptive PnCAP, non-invasive PnCAP, and invasive PnCAP, as described in Figure 7 and Table 4 below. With respect to the impact of the 13vPCV vaccine on hospitalisations defined as all-cause pneumococcal disease, incidence

decreased from 17.2 to 15.9 per 100,000 population (IRR 0.93, 95% CI 0.91-0.95). Presumptive PnCAP and non-invasive PnCAP showed statistically significant decreases of 5% in rates from 14.6 to 13.9 and 13.6 to 12.9 per 100,000 population respectively. While invasive PnCAP also showed a decrease in rates of 6.8%, this did not reach statistically significance (IRR 0.94, 95% CI 0.85-1.03).

Figure 7: Rate of pneumococcal disease per 100,000 population by clinical category and vaccine period

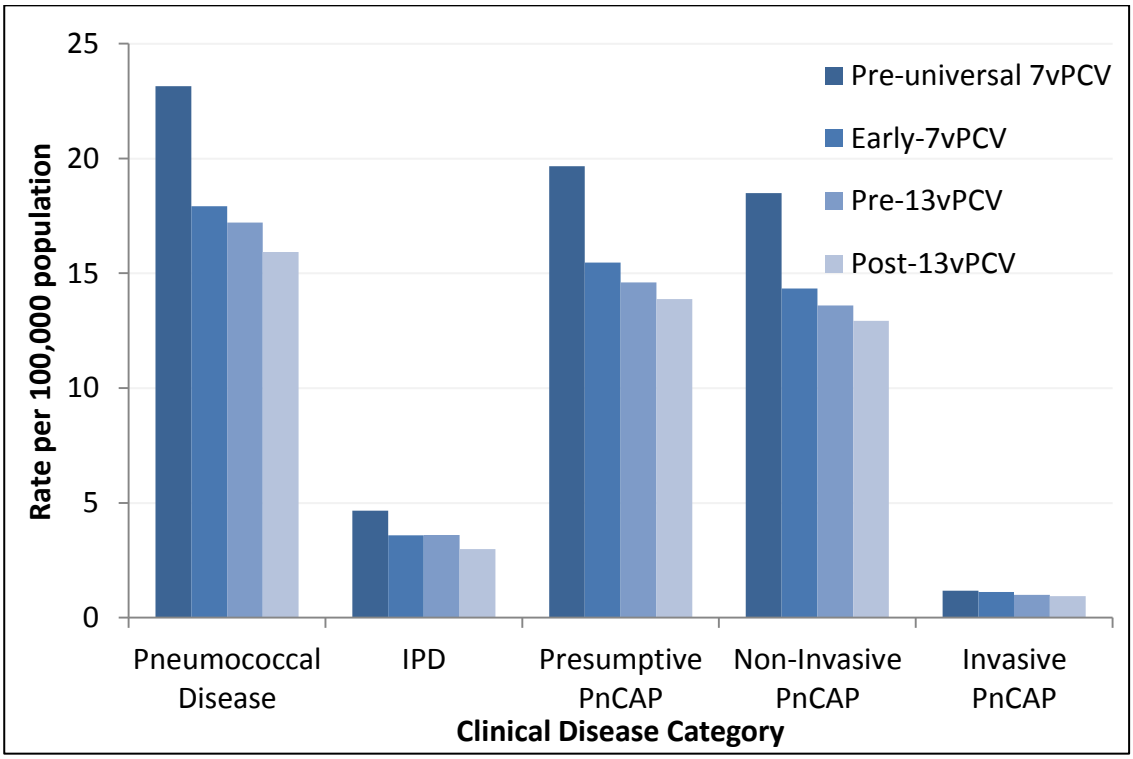


Table 4: Rate of pneumococcal disease per 100,000 population by clinical category and vaccine period and Pre-Post 13vPCV Period IRR

Disease clinical category	Pre-universal 7vPCV 2002-2004	Early-7vPCV 2005-2007	Pre-13vPCV 2008-June 2011	Post-13vPCV July 2011-2016	IRR	95% CI	P-value
All Pneumococcal	23.1	17.9	17.2	15.9	0.93	0.91-0.95	<0.001
IPD	4.7	3.6	3.6	3.0	0.83	0.79-0.87	<0.001
Presumptive PnCAP	19.7	15.5	14.6	13.9	0.95	0.93-0.97	<0.001
Non-invasive PnCAP	18.5	14.3	13.6	12.9	0.95	0.93-0.98	<0.001
Invasive PnCAP	1.2	1.1	1.0	0.9	0.94	0.85-1.03	0.077

Appendices

Appendix 3.A: 16th National Immunisation Conference (NIC) 2018 conference presentation, Adelaide, June 2018

Pneumococcal disease trends in Australia, 2002-2016.

Ms Kelley Meder
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National Centre for Immunisation Research and Surveillance
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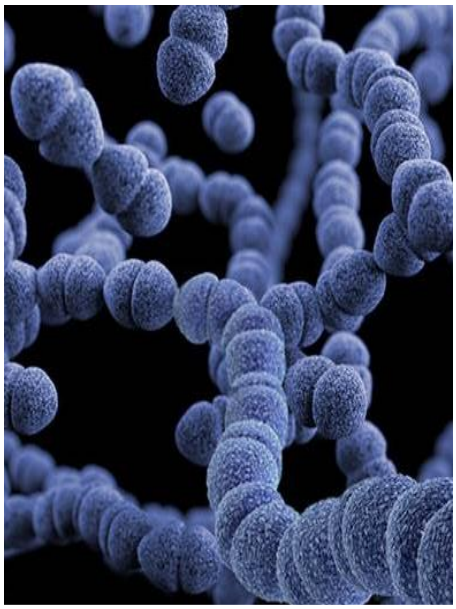
S. Jayasinghe, F. Beard, A. Dey, K. Pennington, H. Cook, C. Giele, B. Howden, V. Krause, V. Sintchenko, H. Smith, J. Strachan, P. McIntyre

NCIRS
National Centre for Immunisation Research and Surveillance

Background

- Pneumococcal disease
  - Bacterium *Streptococcus pneumoniae*
- Invasive pneumococcal disease (IPD)
- Pneumococcal Community Acquired Pneumonia (PnCAP)
  - Invasive
  - Non-Invasive



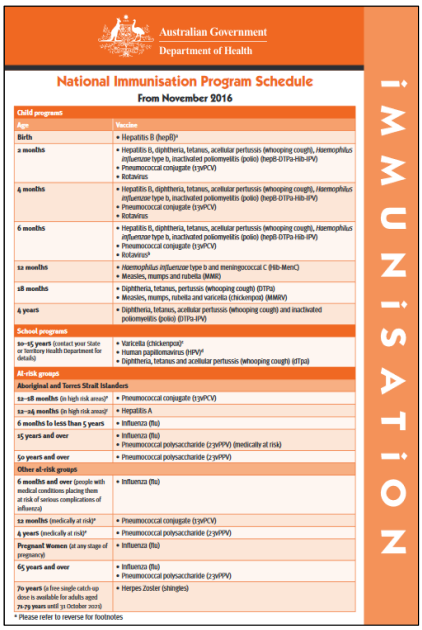
National Immunisation Program

1999
23vPPV for Indigenous adults ≥50y & 15-50y with underlying condition

Mid-2001
7vPCV for Indigenous infants & at-risk children

2005
7vPCV for infants with catch-up in ≤2y & 23vPPV for adults ≥65y

Mid-2011
13vPCV replacement for 7vPCV



Australian Government
Department of Health

National Immunisation Program Schedule
From November 2016

Age	Vaccine
Child programs	
Birth	• Hepatitis B (hepB)*
2 months	• Hepatitis B, diphtheria, tetanus, acellular pertussis (whooping cough), *Haemophilus influenzae* type b, inactivated poliomyelitis (polio) (hepB-DTPa-Hib-IPV) • Pneumococcal conjugate (13vPCV) • Rotavirus
4 months	• Hepatitis B, diphtheria, tetanus, acellular pertussis (whooping cough), *Haemophilus influenzae* type b, inactivated poliomyelitis (polio) (hepB-DTPa-Hib-IPV) • Pneumococcal conjugate (13vPCV) • Rotavirus
6 months	• Hepatitis B, diphtheria, tetanus, acellular pertussis (whooping cough), *Haemophilus influenzae* type b, inactivated poliomyelitis (polio) (hepB-DTPa-Hib-IPV) • Pneumococcal conjugate (13vPCV) • Rotavirus[3]
12 months	• *Haemophilus influenzae* type b and meningococcal C (Hib-MenC) • Measles, mumps and rubella (MMR)
18 months	• Diphtheria, tetanus, pertussis (whooping cough) (DTPa) • Measles, mumps, rubella and varicella (chickenpox) (MMRV)
4 years	• Diphtheria, tetanus, acellular pertussis (whooping cough) and inactivated poliomyelitis (polio) (DTPa-IPV)
School programs	
10–15 years (contact your State or Territory Health Department for details)	• Varicella (chickenpox)* • Human papillomavirus (HPV)* • Diphtheria, tetanus and acellular pertussis (whooping cough) (dTpa)
At-risk groups	
Aboriginal and Torres Strait Islanders	
12–18 months (in high risk areas)*	• Pneumococcal conjugate (13vPCV)
12–24 months (in high risk areas)*	• Hepatitis A
6 months to less than 5 years	• Influenza (flu)
15 years and over	• Influenza (flu) • Pneumococcal polysaccharide (23vPPV) (medically at risk)
50 years and over	• Pneumococcal polysaccharide (23vPPV)
Other at-risk groups	
6 months and over (people with medical conditions placing them at risk of serious complications of influenza)	• Influenza (flu)
12 months (medically at risk)*	• Pneumococcal conjugate (13vPCV)
4 years (medically at risk)*	• Pneumococcal polysaccharide (23vPPV)
Pregnant Women (at any stage of pregnancy)	• Influenza (flu)
65 years and over	• Influenza (flu) • Pneumococcal polysaccharide (23vPPV)
70 years (a free single catch-up dose is available for adults aged **71-79 years** until 31 October 2021)	• Herpes Zoster (shingles)

* Please refer to reverse for footnotes

IMMUNISATION

Aims

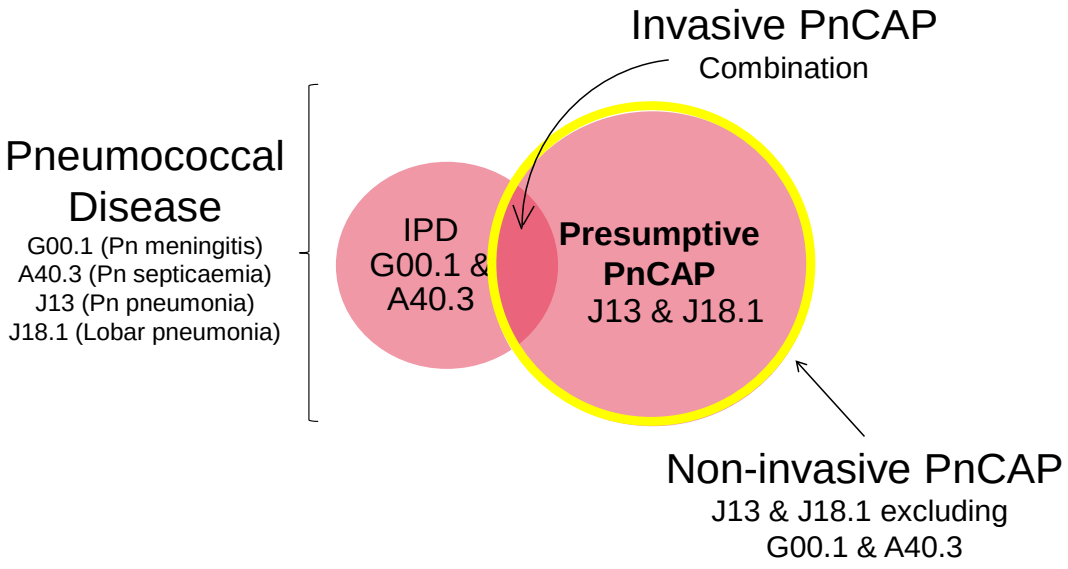
- To identify trends of IPD notifications and PnCAP hospitalisations by Indigenous status, age, and IPD serotype from 2002-2016

- To explore the impact of 13vPCV on trends of IPD notifications and PnCAP hospitalisations by Indigenous status, age, and IPD serotype

Methods

- Study period: 2002-2016
- Datasets:
  - National Notifiable Disease Surveillance System (NNDSS) core & enhanced databases
  - Australian Institute of Health and Welfare (AIHW) National Hospital Morbidity Database
  - Australian Bureau of Statistics (ABS) population data

Presumptive pneumococcal pneumonia based on ICD-10-AM codes



Analysis

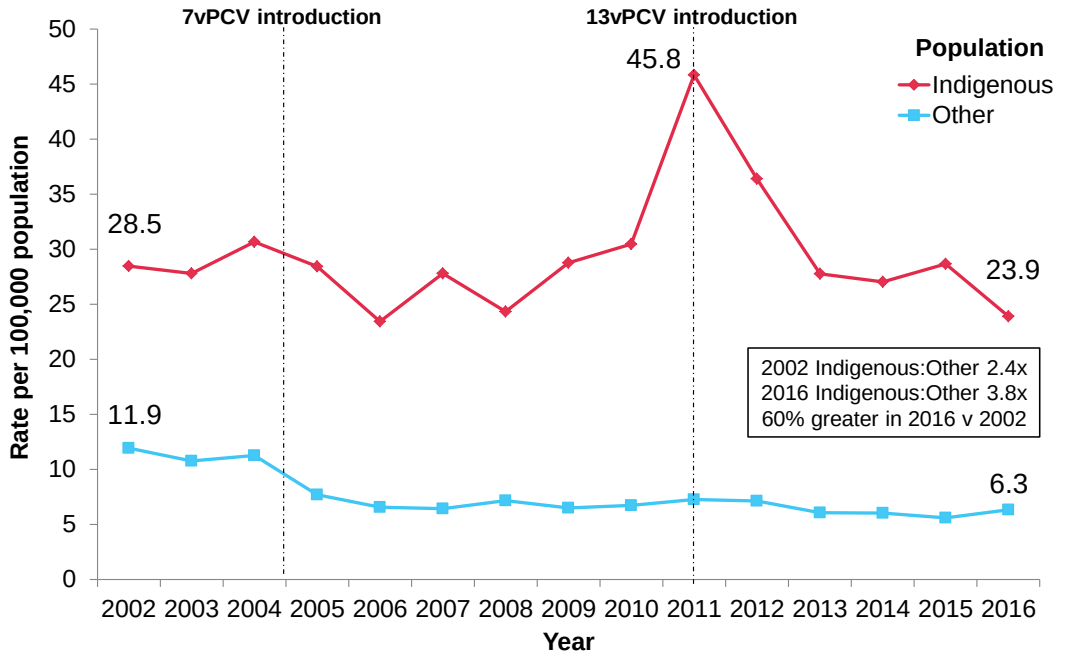
Calculated incidence rates and incident rate ratios (IRR) to assess trends and vaccine impact by:

- Indigenous status
  - Indigenous Australians/Other Australians
- Age Group
  - IPD: <1, 1-4, 5-49, 50-64, ≥65 years
  - Presumptive PnCAP: <5, ≥5 years
- Vaccine period
  - Pre-universal 7vPCV (2002 - 2004)
  - Early-7vPCV (2005 - 2007)
  - Pre-13vPCV (2008 - mid-2011)
  - Post-13vPCV (mid-2011 - 2016)
- Serotype
  - 13v non-7v serotypes (1, 3, 5, 6A, 7F, 19A)

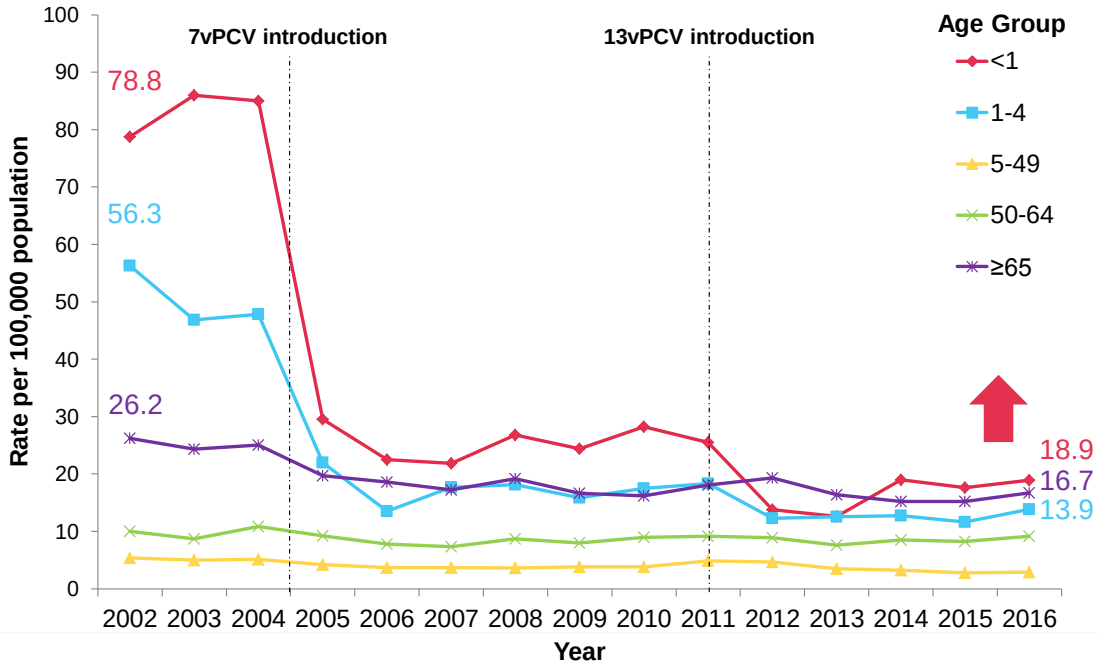
IRR= Incidence rate (post-13vPCV introduction) / Incidence rate (pre-13vPCV introduction)

Invasive Pneumococcal Disease

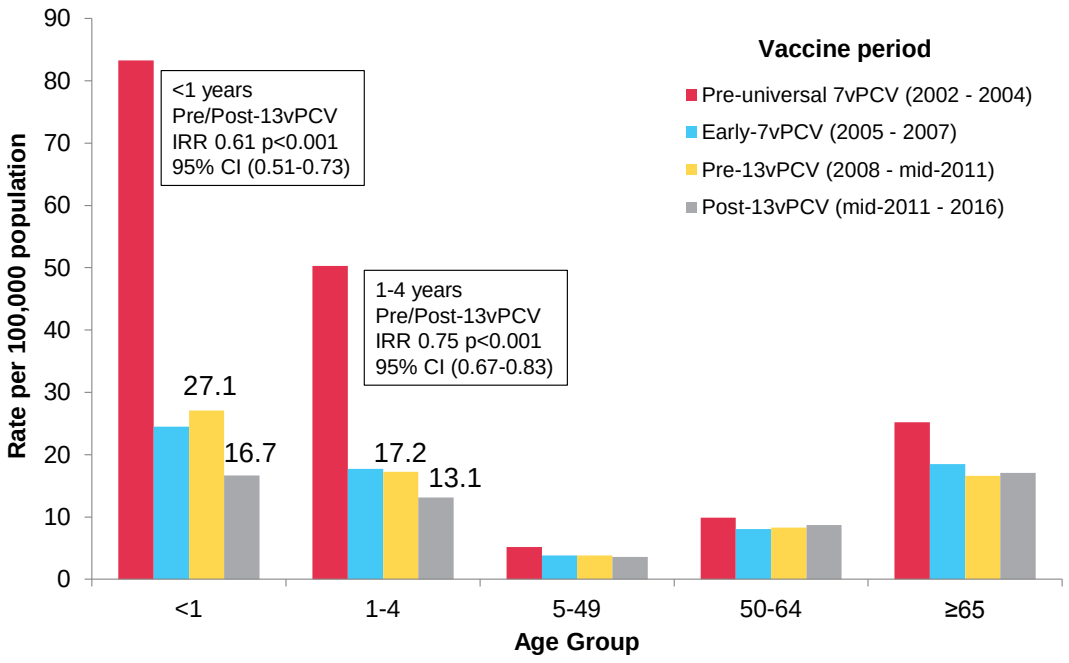
Trends of total IPD notifications by Indigenous status, 2002-2016.



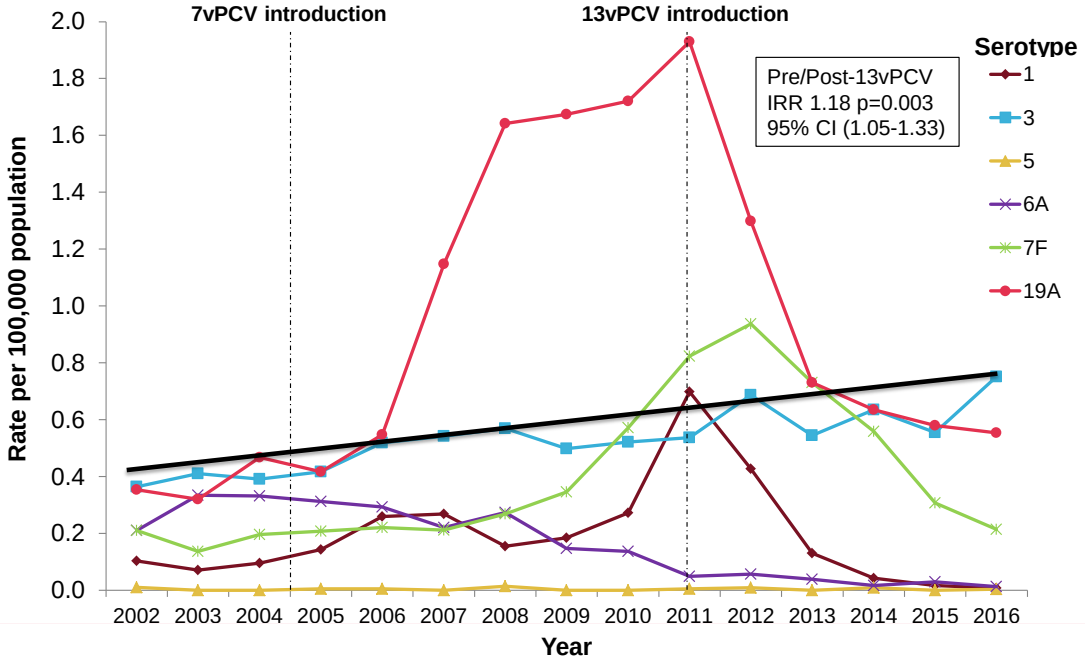
Trends of total IPD notifications by age group in Australia, 2002-2016.



Trends of IPD notifications by vaccine period and age group in Australia, 2002-2016.

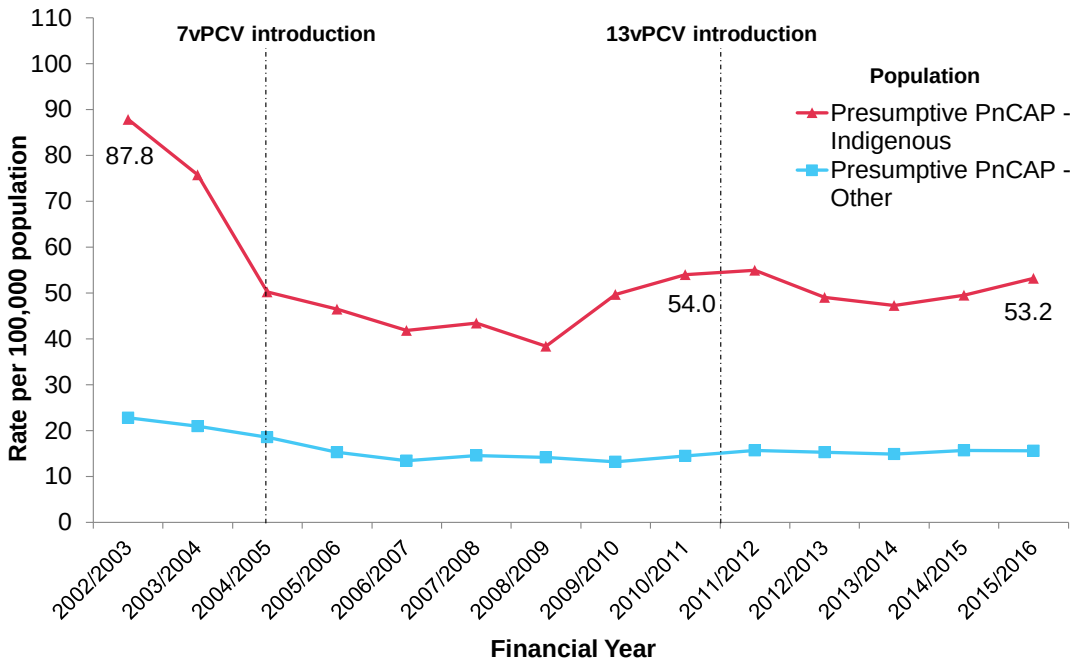


Trends of IPD notifications by 13v non-7v serotypes in Australia, 2002-2016.

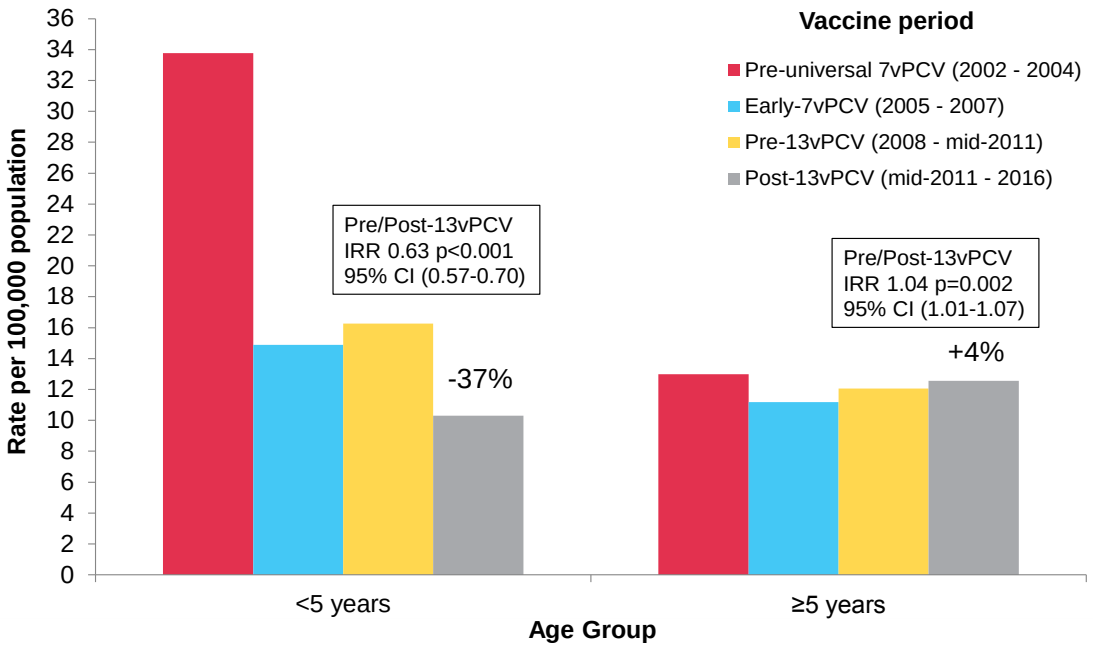


Presumptive Pneumococcal Community Acquired Pneumonia

Trends of presumptive PnCAP hospitalisations by Indigenous status, 2002/2003-2015/2016.



Trends of presumptive PnCAP hospitalisations by age group and 13vPCV period in Australia, 2002/2003-2015/2016.



Conclusions

- Decrease in Indigenous IPD notifications since 13vPCV introduction
  - Disparity has increased since 2002 – non-vaccine types, underlying medical conditions
- IPD notification rates in the total population decreased or stabilised in all ages between pre- and post-13vPCV periods
  - Slight increases in all ages 2015-2016
  - Greatest increase in <5y
- NIP schedule change 3+0 to 2+1 may help control increasing notifications

Conclusions

- Rise in serotype 3 IPD notifications should be monitored
- Rates of presumptive PnCAP decreased 37% in <5y & increased 4% in ≥5y between pre- and post-13vPCV periods
- In 2015/2016, relative burden of presumptive PnCAP:IPD 4.6x

Acknowledgements

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Enhanced Invasive Pneumococcal Disease Surveillance Working Group members

Communicable Diseases Network Australia

Australian Institute of Health and Welfare

4. Evaluation of a Surveillance System

Evaluation of the *Haemophilus influenzae* type b (Hib) Case Surveillance Scheme

4. Evaluation of a Surveillance System

Prologue

Background

One of the four major projects contributing to this thesis is the evaluation of a surveillance system. I evaluated the *Haemophilus influenzae* type b Case Surveillance Scheme (HCSS) which is currently coordinated by the National Centre for Immunisation Research and Surveillance (NCIRS). The HCSS provides supplementary information to data that are routinely and passively collected by the National Notifiable Diseases Surveillance System (NNDSS) including *H. influenzae* type b (Hib) vaccination status and history, underlying medical conditions, clinical manifestations, and laboratory confirmation method. Since its establishment in 1994, the HCSS has yet to undergo an evaluation of whether the system is achieving its aims and objectives.[1]

My Role

I was responsible for all aspects of the evaluation of the HCSS. To begin, I developed a project proposal which was reviewed and endorsed by the National Surveillance Committee (NSC). I then obtained both the NNDSS and HCSS datasets for analysis. To collect all of the required data to conduct the evaluation, I developed participant information sheets to accompany questionnaires which contained questions aimed at assessing the key attributes for review during a surveillance system evaluation, as per the Centers for Disease Control and Prevention (CDC) guidelines.[2] Questionnaires were distributed to identified key stakeholders for completion. I conducted an interview with the HCSS Data Custodian at NCIRS using the questionnaire as the basis for the line of questioning. Once all data were collected, I started with conducting an

epidemiological review of Hib disease from 2000 to 2016 to summarise the epidemiology of the disease in Australia. I then evaluated the HCSS across each attribute and compiled results to produce recommendations, which if implemented, would aid the HCSS in achieving its objectives.

In addition to completing the evaluation, I produced an update to the NCIRS Fact Sheet on Hib disease, which is published on the NCIRS website (Appendix 4.A).

Lessons Learned

This project was the first evaluation of a surveillance system that I have undertaken. I learned how to approach an evaluation, and how to utilise the nine key attributes to successfully complete one. I learned how to prepare a participant information sheet and compile questionnaires for various stakeholders. During this evaluation, I gained an understanding of the HCSS and its aims and objectives, in addition to its historical adaptations.

In addition to learning about the HCSS and the process of undertaking a surveillance system evaluation, I learned about Hib disease and its history and epidemiology in Australia, and the vaccine and vaccination schedule changes on the National Immunisation Program (NIP).

Public Health Implications

As a result of this evaluation, several recommendations were made for consideration. Acting on these recommendations would improve the quality of the data collected,

simplify the system and its tools, and provide epidemiological reports of the collected data to expand upon the literature available on Hib disease trends in Australia. As a result, while the HCSS may not exist in the same capacity as a stand-alone surveillance system, the usefulness and quality of any enhanced data collected would be improved.

Acknowledgements

I would like to acknowledge those who contributed to the successful completion of this evaluation, especially those who provided expert knowledge and guidance on many aspects of the HCSS.

National Centre for Immunisation Research and Surveillance

Han Wang

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Aditi Dey

Frank Beard

Helen Quinn

National Surveillance Committee

Jurisdictional members

Abstract

Introduction

Nationally-funded vaccination for Hib disease was introduced into Australia in 1993 to reduce rates of infection. Shortly following, the *Haemophilus influenzae* type b Case Surveillance Scheme was established in 1994, managed by the Commonwealth Department of Human Services and Health (DoH), to collect enhanced case data including vaccination details, risk factors, clinical manifestations, and laboratory testing methods. The management of the HCSS was transferred to NCIRS in 1996, reportedly due to a lack of resourcing at DoH, and has yet to be evaluated as to whether the system is achieving its main aim of collecting enhanced data on Hib disease cases to monitor trends of disease in Australia.

Methods

The usefulness of the HCSS was evaluated based on the Centers for Disease Control and Prevention's key applicable attributes including: simplicity, flexibility, data quality, acceptability, sensitivity, representativeness, timeliness, and stability.[2] Stakeholders were engaged to complete a questionnaire or undertake an interview in August 2018. In conjunction with qualitative and quantitative responses, the 2000-2016 HCSS and NNDSS datasets were reviewed for descriptive and summary statistics, including counts and percentages, to review the performance of the HCSS based on these key attributes. Ethical approval was granted by Australian National University protocol #2017/909.

Results

The HCSS was found to be flexible, acceptable, timely, and stable. To improve simplicity, it is necessary to improve the methods of data collection. Data completeness ranged from 73-96% for reviewed variables. Completeness was found to be above 90% for demographic variables (sex, state, date of birth, and Indigenous status), however completeness for variables including laboratory information and vaccine brand/type need improvement. It was also found to be important to have a clearer definition of 'reference laboratories' used for typing to ensure data specificity. When compared to records contained in the NNDSS database, 3.2% (10/311) of HCSS records were found to be unique i.e. not in the NNDSS. Of the records that did align between the datasets by date of birth, state, and diagnosis date, additional variables included in both dataset were reviewed and found to match with over 90% accuracy.

Conclusion

This evaluation assessed the current usefulness of the HCSS in monitoring Hib disease in Australia by collecting supplementary Hib disease case data. The importance of the continued collection of these data lies in the option to identify increasing trends of Hib disease due to decreasing vaccine effectiveness or vaccine failure. While this evaluation endorses the continued collection of enhanced data, it is recommended that further consultation be undertaken with DoH and NSC on whether the HCSS should transition to an enhanced data collection process similar to that used for invasive pneumococcal disease and invasive meningococcal disease, coordinated by DoH, to improve data quality, simplicity and frequency of reporting.

Introduction

Haemophilus influenzae is a gram-negative bacterium, either non-encapsulated or polysaccharide encapsulated. There are six serotypes of encapsulated strains, characterised into serotypes a-f. *Haemophilus influenzae* bacteria are ordinarily transmitted via the inhalation of infected respiratory droplets or discharges from the nose and mouth from asymptomatic carriers. *H. influenzae* type b, commonly referred to as Hib, presents clinically as meningitis, epiglottis, cellulitis, pneumonia, septicaemia, and/or septic arthritis, with an incubation period of 2 to 4 days and an infectious period lasting between 48 to 72 hours.[3]

Prior to 1993, the annual incidence rate of Hib disease infection in Australian children under 5 years of age was 25 per 100,000 population for non-Indigenous children, and 150 per 100,000 population for Indigenous children, showing a disproportionately higher incidence rate in Aboriginal and Torres Strait Islander populations.[4-6] The overall case fatality rate was 5%.[5] In 1993, a vaccine against Hib disease was introduced onto the NIP with an acceptable estimated cost per quality adjusted life year (QALY), for the 3-dose PRP-OMP at 2, 4, and 12 months of age, of $1965.[7] The introduction resulted in decreases in incidence rates to 0.07 per 100,000 population by 2010 for non-Indigenous children and 1.4 per 100,000 population for Indigenous children, with an overall rate of 0.09 cases per 100,000 population.[3,8]

While annual rates of Hib disease have stabilised as shown through the analysis of NNDSS data, the continued monitoring of Hib disease in Australia remains significant. As Hib disease has a high case fatality rate and mainly effects the younger population with up to 60% of cases being preventable, it is important to be able to identify any

increasing trends in the epidemiology of Hib disease in Australia.[9,10] Since the introduction of Hib vaccination in 1993, several changes have been made to the vaccines used on the Australian NIP with PRP-OMP (polysaccharide capsule polyribosyl-ribitol phosphate linked to a mutant diphtheria toxin carrier protein) and HbOC (polysaccharide capsule polyribosyl-ribitol phosphate linked to an outer membrane protein of meningococcus) previously used.[6,10,11] Since late 2005, the PRP-T (polysaccharide capsule polyribosyl-ribitol phosphate linked to tetanus toxoid carrier protein) vaccine type has transitioned into use on the NIP in hexavalent (Infanrix® hexa – at 2, 4, and 6 months of age) and monovalent (ActHIB® - at 18 months of age) forms.[6,10,11] The NNDSS and HCSS provides routinely collected and enhanced information on cases, allowing for specific analyses on the epidemiology of the disease in Australia.[10,12]

The HCSS is an enhanced surveillance system for Hib disease in Australia which collects risk factor, clinical diagnostic, and detailed vaccine brand/type and dose information, allowing for the evaluation of the effectiveness of immunisation strategies and control measures, as well as being able to influence future immunisation programs in Australia.[3] Since its establishment in 1994, the HCSS has yet to undergo an evaluation to determine whether it is achieving its aims and objectives.[1] This evaluation assessed the usefulness of the HCSS.

Aim

The aim of evaluating the HCSS was to determine its usefulness and to ascertain any improvements that would facilitate the monitoring of Hib disease using enhanced notification data from jurisdictions.

Objectives

The objectives for this evaluation were to:

- evaluate the effectiveness of the HCSS in identifying the current public health importance of Hib disease in Australia
- review key surveillance system attributes: simplicity, flexibility, data quality, acceptability, sensitivity, positive predictive value, representativeness, timeliness, and stability
- provide a report to key stakeholders which includes recommendations on improvements to the HCSS

Current Hib Surveillance Systems in Use

National Notifiable Diseases Surveillance System

The Communicable Diseases Network Australia (CDNA) began routinely collecting notification data on invasive Hib disease in 1991 via the NNDSS. NNDSS does not collect enhanced data on Hib notifications. Notifications are required to be reported within one working day.[3]

Haemophilus influenzae type b (Hib) Case Surveillance Scheme

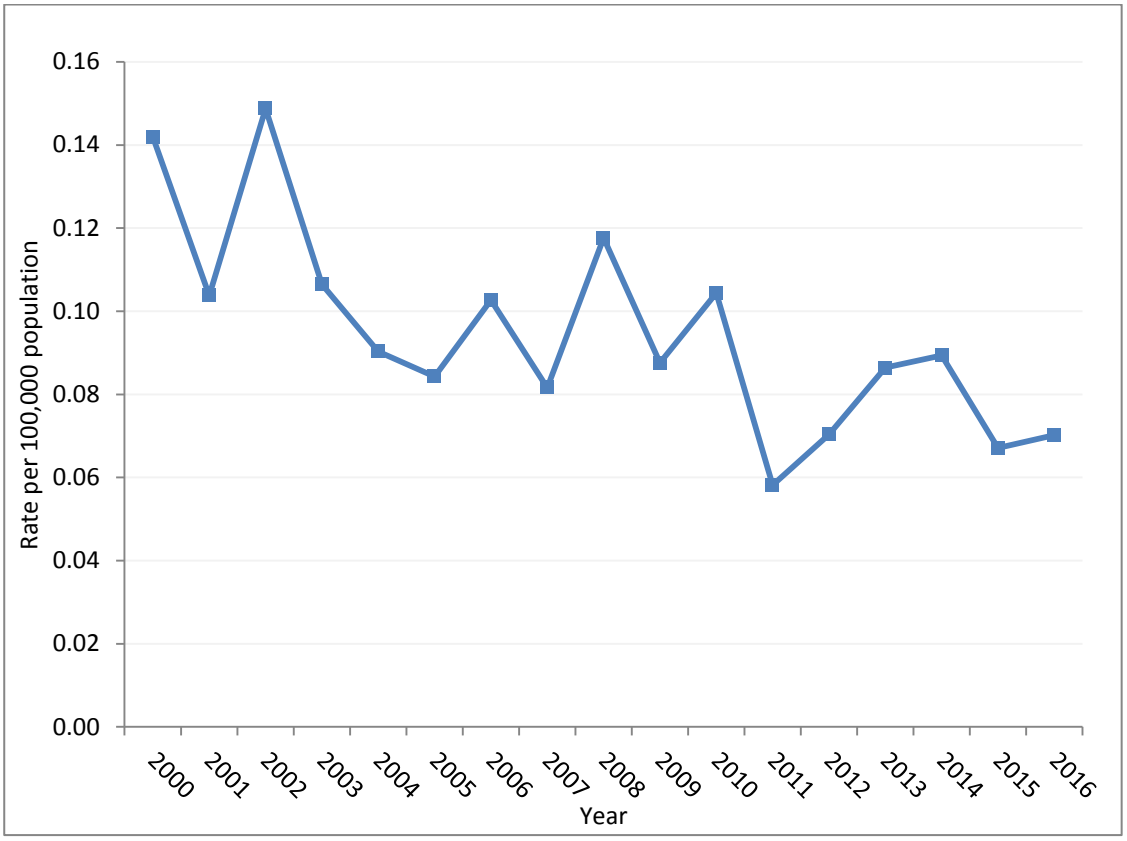
The HCSS was established in January 1994 and managed by the Commonwealth Department of Human Services and Health (DoH) as an adjunct to the NNDSS, following the introduction of the Hib vaccine on the NIP in 1993.[13] In 1996, NCIRS was requested to take over the management of the HCSS. Information on treating doctor,

vaccine brand/type, dates of vaccination, symptom onset date, clinical diagnoses, underlying medical conditions, past medical history, laboratory confirmation method, and reference laboratory are collected by state and territory health department staff on paper or digital surveillance forms which are mailed or emailed to NCIRS for data entry and management.[1]

Epidemiological Summary of Hib Disease in Australia

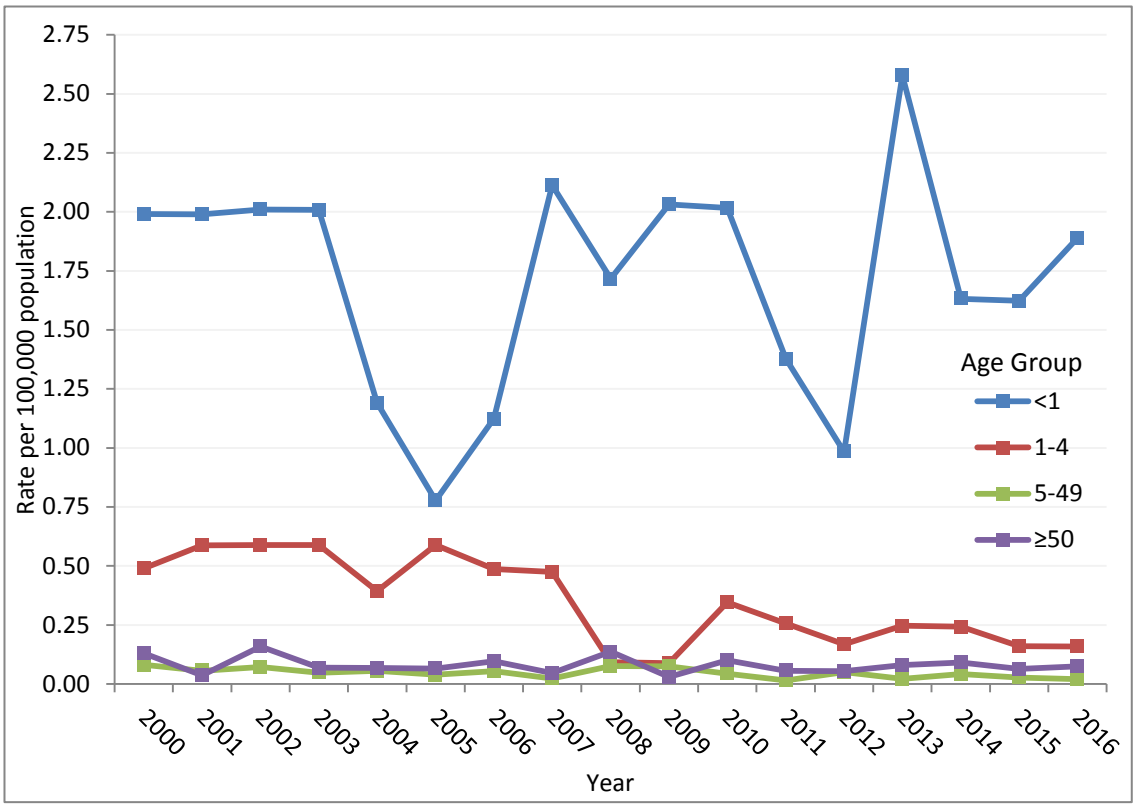
From 2000 to 2016, total counts of invasive Hib disease notifications in the NNDSS dataset ranged from 27 in 2000 to 17 in 2016, with an average of 20 per year. Rates of all-age Hib disease in Australia varied from a high in 2002 at 0.15 per 100,000 population to a low of 0.06 per 100,000 population in 2011 (Figure 1). Overall, rates have reduced across the timeframe, stabilising from 2012 to 2016 at between 0.07 and 0.09 notifications per 100,000 population.

Figure 1: NNDSS annual rate of invasive Hib disease notifications per 100,000 population in Australia, 2000-2016



Infants aged <1 year of age have the highest disease burden annually with between 0.78 and 2.58 notifications per 100,000 population, followed by children aged 1-4 years with 0.09 to 0.59 notifications per 100,000 population (Figure 2). Persons aged 5-49 years old had notification rates ranging from 0.01 to 0.08 cases per 100,000 population, while people ≥50 years of age experienced rates between 0.03 to 0.16 cases per 100,000 population per year.

Figure 2: NNDSS annual rate of invasive Hib disease notifications per 100,000 population in Australia by age group, 2000-2016



Methods

Case definition

Invasive Hib disease is notifiable if a case is confirmed by laboratory definitive evidence. This includes the isolation or detection of *H. influenzae* type b from a normally sterile site, where typing has occurred and been confirmed at a jurisdictional or regional reference laboratory.[14]

System Attributes:

This evaluation of the HCSS was conducted utilising the CDC's *Updated Guidelines for Evaluating Public Health Surveillance Systems* (Table 1).[2] All attributes were assessed in this evaluation except for predictive value positive. The total number of samples sent to laboratories for assessment was unable to be determined, resulting in the inability to asses this attribute for the HCSS. Representativeness was unable to be assessed as intended, by comparing the characteristics of reported events to all such actual events.[2] As it is a national requirement to report any case of invasive Hib disease to CDNA, so as to collect data in the NNDSS, data in the HCSS was compared to that in the NNDSS, as a proxy of the true measure of disease occurring in Australia. Detailed questionnaires and interviews for stakeholders were used in conjunction with the analysis of both NNDSS and HCSS databases in the review of each system attribute.

Table 1: System attributes and methods used for assessment of the *Haemophilus influenzae* type b Case Surveillance Scheme

Attribute	Methods
Simplicity	Methods for assessing simplicity included a stakeholder questionnaire or interview and a review of HCSS and NNDSS datasets. A process flow chart of the notification of a confirmed Hib case was developed. Considerations for assessing simplicity included: integration with other systems, data collection methods, data management, data analysis for reporting, staffing requirements, and system maintenance.
Flexibility	A review of any adaptations the HCSS may have undergone was conducted through a stakeholder questionnaire or interview, assessing the possibility for the system to adapt in the future to collect new information.
Data Quality	An examination was conducted for the completeness of nine essential and two optional variables in the HCSS database and case report form (Appendix 4.B).
Acceptability	The willingness of persons and organisations to participate in the HCSS was assessed through stakeholder questionnaires and interviews.
Sensitivity	Sensitivity was assessed by comparing total NNDSS and HCSS notifications as well as assessing stakeholder views on Hib disease data reporting through questionnaires.
Predictive Value Positive	Unable to be evaluated.
Representativeness	Analyses comparing HCSS and NNDSS records determined the representativeness of the data collected by the HCSS. Questionnaire and interview input from stakeholders was also reviewed.

Timeliness	Timeliness was assessed via data analysis of the time from date of lab confirmation to receipt of notification by NCIRS. Stakeholder responses on the HCSS reporting timelines were also reviewed from a questionnaire or interview.
Stability	Based on the objectives of the HCSS to collect enhanced notifiable data, stability was assessed, via a stakeholder questionnaire or interview, based on the desired and actual time requirement to manage data, and an investigation into historical periods of system down-time.

Stakeholder Engagement and Consultation

Identified stakeholders were engaged from the design stage of this evaluation through approval and consultation during a meeting of the National Surveillance Committee. Feedback on the study design and methodologies, and either the completion of a questionnaires or interview, were requested from the eleven identified stakeholders. In addition, stakeholders were engaged for clarification where required for this study.

Identified stakeholders included:

- HCSS Data Custodian (n=1)
- Jurisdictional members of the National Surveillance Committee (n=9)
- Personnel involved in the establishment of the HCSS (n=1)

Questionnaire

A questionnaire was developed to obtain information on all attributes being assessed. A number of quantitative and qualitative questions were generated to evaluate the usefulness of the HCSS and whether it has been fulfilling its purpose. Areas for free text were available for each attribute to collect detailed information. The questionnaire served as the basis for conducting an interview with the HCSS Data Custodian.

Data Analysis

Study Population

The population for this study includes all confirmed cases of invasive Hib disease in Australia with a disease onset date from 1 January 2000 to 31 December 2016.

Data Sources

- HCSS enhanced dataset (2000 – 2016)
- National Notifiable Diseases Surveillance System dataset (2000 – 2016)

Analyses

Summary statistics were calculated, including counts and percentages, from the HCSS and NNDSS datasets where relevant, for a number of variables including: sex, state, date of birth, Indigenous status, date of disease onset, outcome, date of laboratory specimen, name of confirmation lab, immunisation status, 1st vaccine given, brand/type of 1st vaccine, the least frequently reported 4th vaccine given and

brand/type of 4th vaccine, and date of report. A full list of variables by dataset is listed below in Table 2. All analyses were conducted using STATA statistical software for Windows, Release 14.2 College Station, TX: StataCorp LP.

Table 2: Variables contained in NNDSS and HCSS Hib disease datasets

Common variables to both HCSS and NNDSS
State/Territory notification unique ID
Sex
Date of birth
Postcode of residence
State of residence
Indigenous status
Date of disease onset
Place of acquisition (postcode, state, or country)
Outcome
Date of laboratory specimen
Method of Hib confirmation (blood culture, CSF culture, antigen CSF, nucleic acid testing, other sterile site, other)
Dates of all Hib vaccinations
Type/brand of all Hib vaccinations
Variables unique to HCSS
Surname (first 2 letters)
First name (first 2 letters)
Treating doctor name
Treating doctor phone number
Clinical diagnosis (meningitis, epiglottis, septicaemia without focus, cellulitis, other)
Risk factors (premature, no underlying illness, splenectomy, immunosuppressive drug, immunosuppressive condition, congenital or chromosomal abnormality, other)

Name of performing laboratory
Laboratory address
Name of reference laboratory (ICPMR, MDU, QHFSS, Other, not sent, not known)
Vaccination status
Source of vaccination information
Batch numbers of all Hib vaccinations
Name of person reporting notified case
Telephone or reporting person
Email of reporting person
Date of report
Variables unique to NNDSS
Disease code
Organism name
Serogroup subtype
Additional typing information
Confirmation status of the disease defined by case definition
Resident location
Notification date
Notification received date
Age at onset
Outbreak reference
Case found by
Hospitalised

Ethics

The Human Research Ethics Office at the Australian National University approved the conduct of this evaluation (protocol #2017/909). Stakeholders were provided a participant information sheet detailing the study parameters and requirements of

participation. Participation was voluntary and informed consent was collected prior to stakeholders beginning a questionnaire or interview. All quantitative results were pooled and qualitative responses were kept anonymous to ensure confidentiality.

Results and Discussion

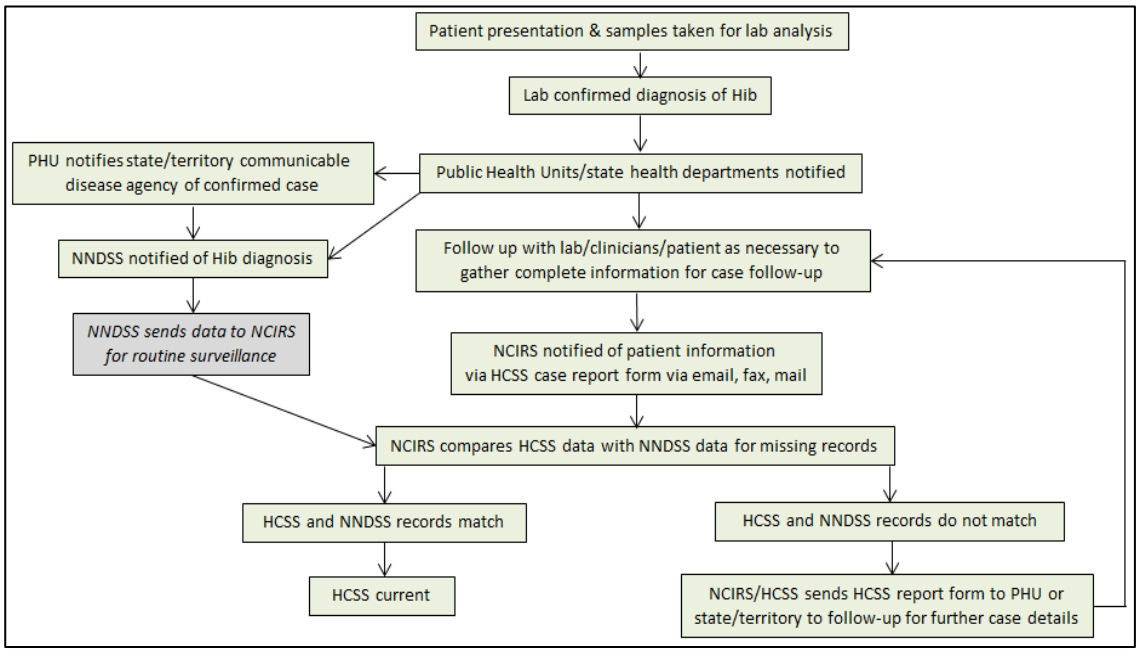
Simplicity

The simplicity of the HCSS was evaluated on its reporting structure and process, the clarity of the case report form, data collection methods, and the resources needed to maintain the surveillance system.

Reporting process

A detailed flow-diagram of the reporting process of Hib notification to the HCSS is provided below in Figure 3. Overall, respondents (members of the NSC, the NCIRS data manager, and personnel involved in the establishment of the HCSS) found the reporting process to be simple, with 89% (8/9) indicating the system as simple and 11% (1/9) unsure. While the process was reported to be simple, 80% (4/5) of respondents indicated that the manual process of filling out a paper form and transferring it to NCIRS via email, mail, or fax was an area for improvement. Suggestions to replace the paper form included an online PDF version of the form, in addition to two respondents suggesting that the enhanced data collected should be automatically submitted to NNDSS, bypassing the HCSS system altogether.

Figure 3: Flow diagram of the Hib notification reporting process from lab-confirmed Hib diagnosis to the receipt of a HCSS case report form at NCIRS



Data collection methods

Case report form

Survey responses indicated that 89% (8/9) of respondents found the HCSS case report form to be simple to use, with 11% (1/9) unsure of its simplicity. Despite the majority of respondents identifying the form as simple to use, 33% (3/9) respondents identified several areas requiring change. Several fields on the case report form were questioned on their usefulness and overall benefit of collection, including outcome (died, discharged well, or discharged with abnormality; due to limited timing of illness onset until report submission), treating doctor, address of diagnostic laboratory, with the place of acquisition field identified as being vague. One respondent commented on the need to expand the Indigenous field options from 'Yes', 'No', or 'Unknown' to the Australian Bureau of Statistics recommended categories. One respondent also commented on the overall layout of the form being cramped.

NNDSS dataset

Records in the HCSS are compared on a regular basis to those in the NNDSS to ensure enhanced data are collected for all notified cases. Thirteen fields are duplicated between the two databases, with 44.8% (13/29) of HCSS variables and 52% (13/25) of NNDSS variables currently duplicated. Given the high percentage of identified duplicate variables, stakeholders questioned the need to collect the repeated fields via the HCSS case report form. It is important to note that from 2012 onwards, vaccination status, vaccine dose count, vaccination validation, and date of last vaccination are no longer being collected by NNDSS and have been replaced by vaccine fields listed in Table 2.

The comparison of the two systems is manual in nature. However, with limited numbers of reported Hib disease cases annually, this process is currently manageable on a per-record basis. Improvements could be made to reduce the number of duplicate fields collected, resulting in fewer fields needing to be compared for consistency. The small numbers of annual Hib disease cases makes this process currently feasible, although it could be streamlined further to reduce the workload required for enhanced data collection.

System resourcing requirements

Staffing and time

Given the low incidence of Hib disease cases annually reported, the management of the HCSS only requires one staff member – the data custodian. The length of time it takes to manage a new notification in the HCSS database varies for the data custodian depending on the completeness of the case report form received and the availability of

an updated NNDSS dataset to use for comparison. However given the nature of Hib disease being minimally contagious with few annual notifications, there is currently no urgency for completing a new entry, resulting in a simple system in regards to staff resources and time required.

Flexibility

Case report form

The HCSS was established in 1994. Since its inception, there have been several changes to the HCSS case report form. There have been five versions of the form, the most recent occurring in 2005, 2010, and 2014, to reflect changes in the NIP-funded Hib vaccines available, clinical diagnoses, reference laboratories, and updates to laboratory testing. Currently, a change on the HCSS case report form is required due to the 2018 change on the NIP from a booster dose of Hib-MenC (Menitorix®) at 12 months of age to a fourth monovalent booster dose of ActHIB® at 18 months of age.[15] Changes to the HCSS case report form have previously been driven by NCIRS. At the time of each change, there have been no formal review processes to assess the appropriateness of the changes to the form.

During an interview with the HCSS data manager and discussing the possibility for future changes to the case report form, the importance of keeping the form as consistent as possible to the previous version in regards to the fields collected and question ordering was stressed. This is to ensure a seamless transition for data collection, database management, and reporting purposes. Given the rationale behind keeping the question field ordering and case report form to one double-sided page for

simplicity, any significant changes to the fields on the case report form may cause problems in the future if all fields are to remain on the form. This would include the fields duplicated in the NNDSS dataset. Supporting this, 63% (5/8) of respondents identified that there were unsure whether the HCSS case report form would allow for future changes if required. However, in regards to the vaccine schedule change, there is currently an 'other' option with free text space in all four vaccine dose fields to ensure all vaccine brand information is recorded. With the recent Hib immunisation schedule change, it was identified through consultation with the data manager that there is adequate space on the current form to include the fourth dose of monovalent ActHIB® as a specified vaccine option.[15]

HCSS database

Any changes to the fields collected on the case report form would need to be reflected within the HCSS database. Modifications may include the removal of duplicate fields (although data can be retained in the database for historical records and analysis), the addition of new fields, or editing previous records to produce data for the new fields, if applicable. Additionally, knowledge of which data fields are no longer in active use for assessment would be required. As a result, the HCSS database is moderately flexible given the relatively small number of records included within it which would need adaptation.

Communication of the changes

Upon making previous adjustments to the case report form, changes were not

communicated nationally. Rather, changes were communicated with state and territory data managers to update relevant website resources, and updated case report forms were sent via email attachment at the time of a newly identified case of Hib disease being reported. Despite attaching the most current version of the form, old versions were, and continue to be, used and submitted to NCIRS for data collection.

Upon the implementation of updated case report forms, all documentation and web resources linking to the form were to be updated to the current version of the document. However through investigation, New South Wales (under 'Case Management' and in the Appendix) and Queensland (under 'Enhanced surveillance for public health units') control guidelines link to the 2010 version of the form. These links require immediate amendment. It is evident that updates are not routinely communicated or reviewed, given the near eight-year gap between the 2010 form version and this evaluation. This is an identified area for improvement which requires the management of available resources.

Data Quality

The HCSS database contains variables derived directly from the HCSS case report form. The assessment of data quality included the review of a selected number variables; fields on the form which are applicable to all identified cases of Hib disease. Several variables on the form may not apply to all cases and may be left blank upon completion, such as risk factor data. Nine variables were selected for review, with two

of these additional 'if applicable' variables selected for review. The variables selected were:

- Sex
- State
- Date of birth
- Indigenous status
- Date of disease onset
- Outcome
- Date of laboratory specimen
- Name of confirmation lab
- Vaccinated (Y/N)
- Identified brand/type if 1st vaccine was given (n=126) – if applicable field
- Identified brand/type if 4th vaccine was given (n=27) – if applicable field

Results from the analysis of 311 records from 2000-2016 can be found in Figure 4. One-hundred percent (311/311) of records contained data for sex, state, date of birth, and disease onset date. Only 1 record was missing an identified Indigenous status with a blank entry, however 17 records did contain an 'unknown' entry. Ninety-one percent (284/311) of the records had an entry for outcome, with 27 blank entries, and 9 'unknown' entries. Ninety-six percent (300/311) of records were identified as being vaccinated or not, with 10 'unknown' and 1 blank entry. While 'unknown' is considered

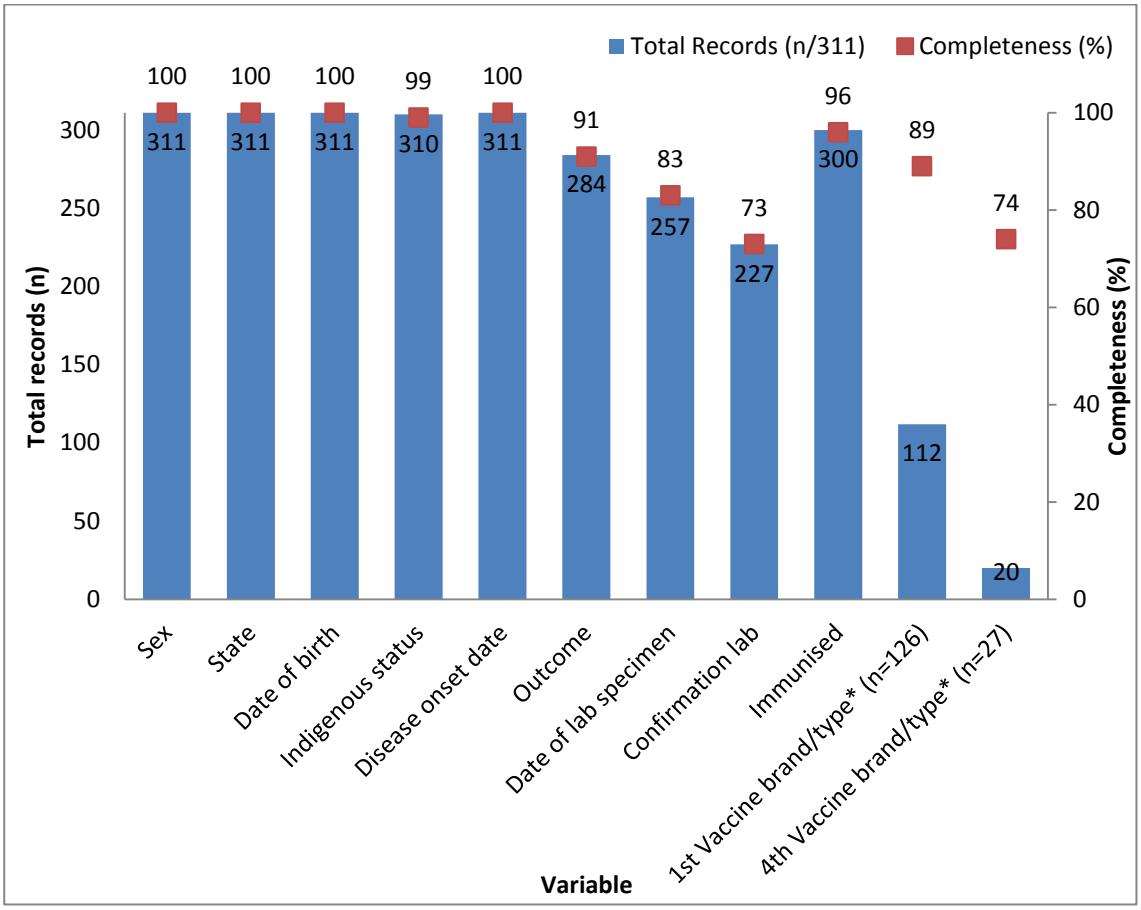
complete in the above variables, it is considered incomplete here as vaccination information is critical to collect on identified cases of Hib disease for identifying vaccine failures. While demographic, outcome, and vaccination status variables had quite high completeness percentages, data completeness was lower for variables related to laboratory-specific information. Only 83% (257/311) of records contained data which specified the date of laboratory specimen testing, and only 73% (227/311) specified the name of the confirmation lab. The current case definition for Hib disease includes disease confirmation 'at a jurisdictional or regional reference laboratory'; however, this definition is vague. While there are numerous laboratories across the country which perform initial testing, only a handful of laboratories are identified as jurisdictional or regional reference laboratories on the case report form, including the Institute for Clinical Pathology and Medical Research (ICPMR), the Microbiological Diagnostic Unit (MDU), and the Queensland Health Forensic and Scientific Services (QHFSS). Of the 227 records with data for specified confirmation lab, 13 were recorded as 'unknown', 14 as the nonspecific 'state reference lab', 5 as 'not sent', 7 as 'local lab', and a large proportion, 110, as 'other lab (not specified)'. 84 records were blank. It is unclear whether states and territories consider additional labs as meeting this definition. The missing information identified supports the need for more detailed information to be collected on this variable and a consistent definition to be identified and used to ensure the specificity of the typing results for identified cases of Hib disease.

Additionally, while reference laboratories test for serotype b antigens, it is not currently national practice in Australia to identify serotypes a, c-f, or non-typable serotypes.[16] The Northern Territory (NT) and South Australia (SA) are exceptions to this

generalisation, as samples have been serotyped at ICPMR or South Australia (SA) Pathology (formerly the Institute of Medical and Veterinary Science (IMVS).[16] Since the introduction of national immunisation in Australia against Hib disease, rates have decreased to their lowest levels. Other countries with national immunisation and Indigenous populations, such as the United States, have identified an increase in *H. influenzae* type a (Hia) notifications, particularly in Indigenous populations, identifying the occurrence of serotype replacement.[18] This increase is of concern as Hia disease has similar clinical presentations and severity as to serotype b disease.[18] Previously NT and SA data have been reviewed for indications of serotype replacement but no evidence was found of this occurring in Australia.[16] However, with serotype replacement in similar, high-income countries occurring, it is important to consider testing for all invasive *H. influenzae* serotypes. It is suggested that typing be conducted at laboratories currently undertaking typing of other diseases such as invasive pneumococcal disease (IPD).

In conjunction, running whole genome sequencing of all isolates and linking the results to a national genomics database would allow for richer insights into the epidemiology of Hib disease over successive years and allow for international comparisons.

Figure 4: Total records with complete data and completeness percentage for the HCSS database, by variable, 2000-2016



*For records with an identified 1st or 4th vaccine administered, completeness of identified vaccine brand was assessed.

Of the optional fields selected for review, identified brand/type for 1st and 4th vaccine given if applicable, records with an identified date of a 1st or 4th dose of Hib-containing vaccine were included. One hundred and twenty-six records were identified as having a 1st dose given (of 129 total records recorded as being vaccinated – 97.7% complete), and 27 records as having a 4th dose given. Of those with a 1st dose recorded as given, 89% (112/126) of records detailed a vaccine brand/type, with 14 blank entries. Of the 27 records with a date entered for a 4th dose given, only 74% (20/27) detailed a vaccine brand/type. While vaccine brand/type may not have yet been completed on the case report form, efforts should be made to revisit these records at a later date or

follow up with the Australian Immunisation Register (AIR) record, immunisation provider, or parent/case to identify the brand/type of vaccine to improve data completeness. This information is important for collection to identify any increasing trends of vaccine-specific failures within the population.

Based on the variables selected for review, the overall completeness of the HCSS is quite high, with a minimum of 73%. Seventy-one percent (5/7) stakeholders believed that the database was over 80% complete. One stakeholder identified that "cases are not followed-up after an extended period of time after a case report form is submitted",[18] supporting the need to consider establishing a follow-up process on case status to increase data completeness.

Acceptability

The HCSS should be acceptable to all stakeholders to ensure support in its use. When asked whether the system is acceptable, 57% (4/7) of respondents indicated that it was, however 43% (3/7) were unsure. Identified strengths of the HCSS included its simplicity, longevity and consistency, and the collection of supplementary Hib disease data to that of the NNDSS. In contrast, limitations included the use of paper forms, as previously indicated, timeliness of reporting, and absence of feedback.

When asked whether the HCSS should continue to be used for enhanced Hib disease surveillance, only 14% (1/7) of stakeholders reported 'yes', 57% (4/7) were 'unsure', and 29% (2/7) reported 'no'. Reasoning provided in support of the use of the HCSS included its collection of data not routinely collected by NNDSS. However, several

stakeholders suggested that the enhanced data fields should collected within the NNDSS dataset, as there are so few case notifications, in conjunction with the lack of regular reporting on the enhanced data collected. The merger of the enhanced data fields on to the NNDSS core dataset has previously been discussed within the National Surveillance Committee, however it was reportedly agreed that this option was not feasible due to the complex adjustments the database would require in adding the enhanced fields (personal communication Aditi Dey, National Centre for Immunisation Research and Surveillance, August 2018). It is recommended that further consultation be undertaken with DoH and NSC on whether the HCSS should transition to an enhanced data collection process similar to that used for invasive pneumococcal disease (IPD) and invasive meningococcal disease (IMD), coordinated centrally by DoH. This would require DoH to manage the Hib disease NNDSS dataset and, in conjunction, coordinate an enhanced data collection program to produce an enhanced Hib disease dataset.

Sensitivity

Sensitivity of the HCSS was evaluated by assessing the ability of the system to identify significant public health events, and the sensitivity of the HCSS dataset compared to the NNDSS dataset, which is considered to be the most accurate and complete Hib disease dataset.

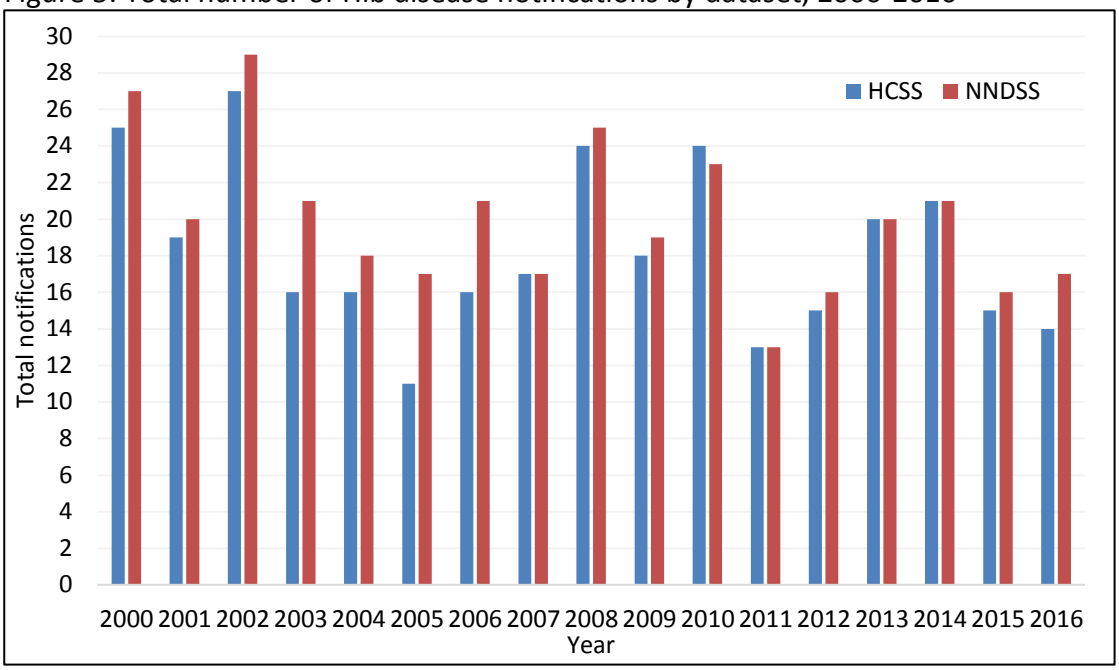
Identification of public health events

The purpose of the HCSS does not include the timely identification of public health events of concern, but rather that is role for the NNDSS data. However, it does collect detailed supplementary information to the NNDSS including vaccination status and risk factor data, which may impact upon vaccine effectiveness and vaccine failure data; thus making dissemination of its collected data essential to understanding the current status of Hib disease in Australia. To date, there have been three peer-reviewed publications using HCSS data, but no regular reporting has been established.[6,10,12] One-hundred percent (7/7) of stakeholders identified that regular reports should be produced from HCSS data. Forty-three percent (3/7) of stakeholders would like to see reports annually, while 29% (2/7) would like to see them bi-annually. Annual data summary reports would greatly assist in assessing the vaccine effectiveness of Hib disease in Australia and increase the academic literature available.

Dataset sensitivity

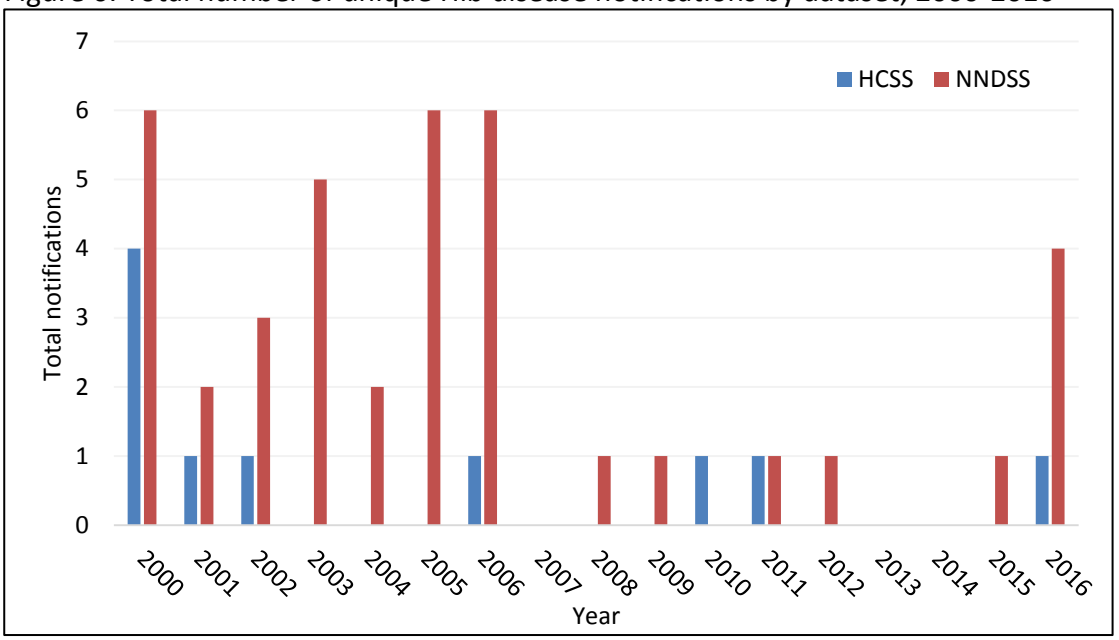
Data was reviewed between 2000–2016, identifying 340 NNDSS records and 311 HCSS records in total (Figure 5). Records were then compared in parallel by the variables Date of Birth, Diagnosis Date and Onset Date, State, and Sex to identify any records unique to one dataset (Figure 6). Eleven percent (39/340) of records in NNDSS were not found in HCSS, 8 of which were under 15 years of age (HCSS only followed up cases under 15 years of age in the earlier years of its use). Three percent (10/311) of records in HCSS were not found in NNDSS, 4 of which were under 15 years of age. Overall, 301 records were compared between the two databases, more consistently since 2007.

Figure 5: Total number of Hib disease notifications by dataset, 2000-2016*†



*Note that in the earlier years, records where onset age <15 were followed-up by HCSS.
†NNDSS data contains 4 records in 2016 which are unique. 2016 records in HCSS have not been finalised and are to be updated

Figure 6: Total number of unique Hib disease notifications by dataset, 2000-2016*



*Note that in the earlier years, records where onset age <15 were followed-up by HCSS.
†NNDSS data contains 4 records in 2016 which are unique. 2016 records in HCSS have not been finalised and are to be updated

The NNDSS dataset is considered the most accurate and complete dataset for Hib disease case data collection. As such, the process for data collection for the HCSS involves the comparison of records of enhanced notifications with records of the

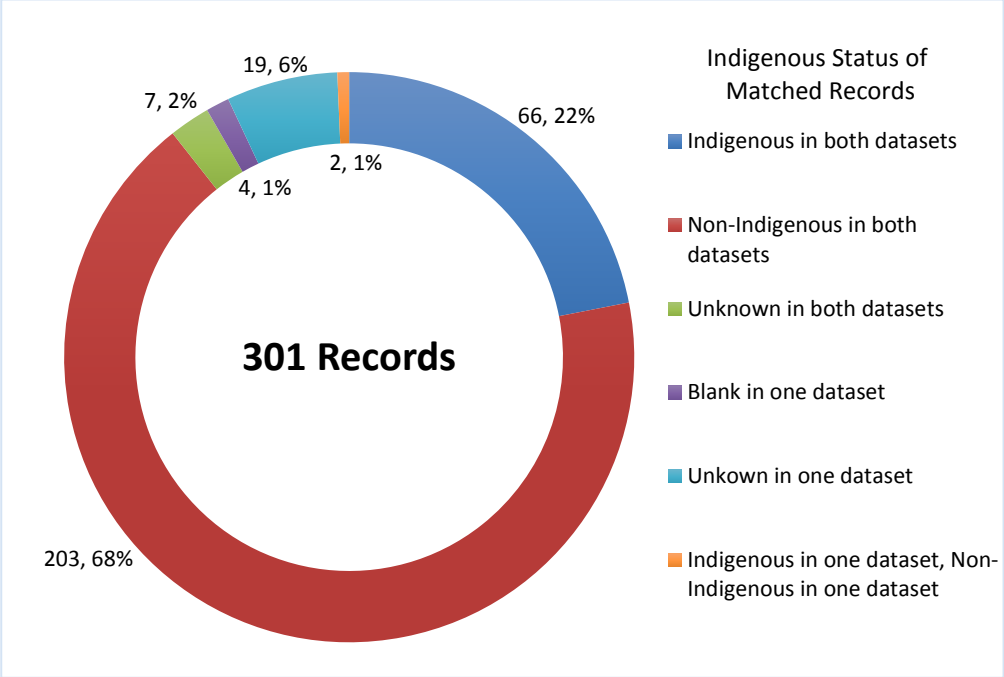
NNDSS to ensure completeness. However, this evaluation has identified a number of records within each dataset which are unique to each. Overall, with 340 records identified in the NNDSS dataset and 311 records identified in the HCSS for the same reporting period, the overall sensitivity of the HCSS is 91%. One reason for the possible discrepancy is that in the earlier years of the HCSS, data on those aged over 15 years of age was not collected. Another possible explanation is that the NNDSS dataset is continually being refreshed, including records from previous years. Notifications of these updates may not reach the HCSS data custodian for amendment of the HCSS database. A review should be conducted between the NNDSS and HCSS data managers of the 49 unique records between the two databases to improve data completeness.

Representativeness

Stakeholders were mostly unsure of the representativeness of the HCSS data, as in how well HCSS data compares to NNDSS data, with 71% (5/7) indicating they 'neither agree nor disagree' that the data was representative, and 28% (2/7) indicating they 'strongly agree' or 'agree'. Comparisons included study factors of Aboriginal and Torres Strait Islander status and sex.

Overall, 301 records were compared between the two datasets, as noted previously. Of those, 92% (276/301) of records reviewed were comparable for Indigenous status, with 8% (25/301) of records containing differing Indigenous statuses between the two datasets (Figure 7).

Figure 7: Breakdown of the representativeness of Indigenous status between 301 compared HCSS and NNDSS records, 2000-2016.



Comparing records on the data field 'sex' 99% (298/301) of records contained identical data between the two datasets. One percent (3/301) of records differed.

Overall the level at which the HCSS dataset is representative of data in the NNDSS dataset is very high, at over 90%. However, follow-up could be conducted to identify the correct Indigenous status and sex of the records identified as differing to improve representativeness.

Timeliness

Immediate public health response is not required with the notification of a new case of Hib disease to the HCSS, as its purpose is to collect additional data to the NNDSS. While strict timelines are required to be adhered to for the initial reporting of a confirmed Hib disease case to jurisdictional health departments, the timeframes to

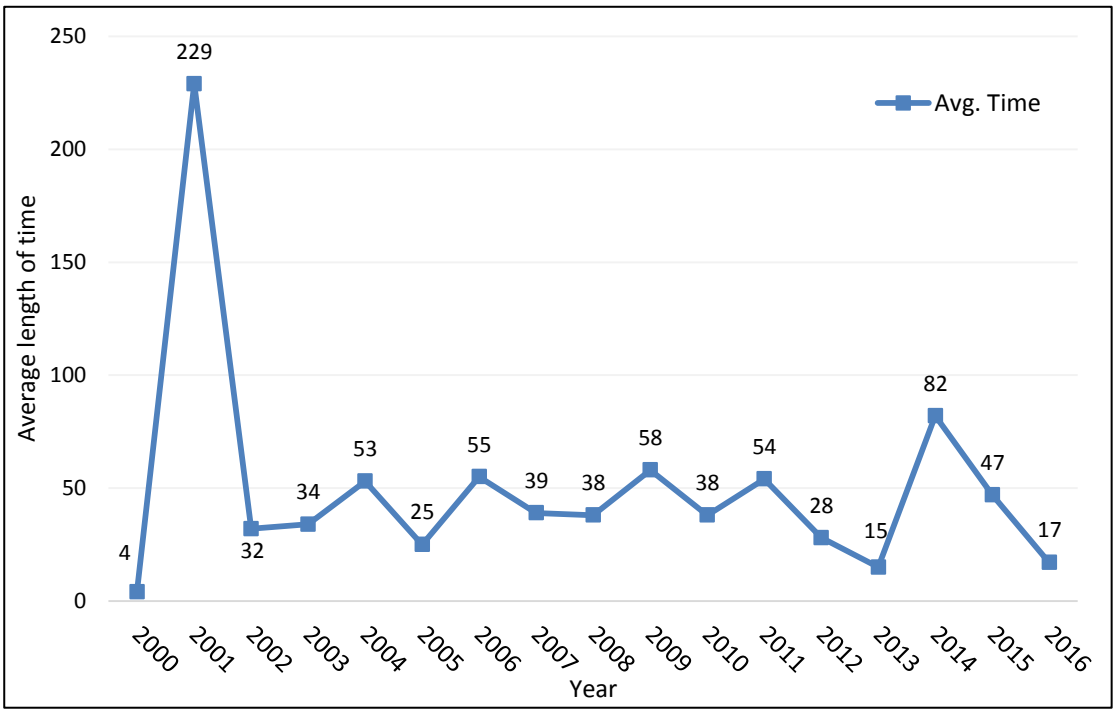
follow-up and collect enhanced data are not firm. Despite this, it is still important to identify and state within policy documents reporting timelines for enhanced data.

Unlike the requirement to report to jurisdictional health department systems within one working day for NNDSS data collection and initial case follow up, timelines for reporting to the HCSS are currently not found on the national CDNA Series of National Guidelines (SoNGs) or the case report form. The Hib SoNG and jurisdictional Hib disease control guidelines indicate only that a HCSS case report form should be submitted to NCIRS upon case follow up. Jurisdiction health control guidelines note the same wording, or refer back to the national SoNG. Eighty-six percent (6/7) of stakeholders could not identify reporting timelines to the HCSS. Noting the absence of timelines, 50% (4/8) of stakeholders indicated a period of one month to less than two months would be an acceptable timeframe for reporting enhanced data to the HCSS, while 38% (3/8) stakeholders indicated a period of time less than one month. Urgent reporting is not required to identify an upsurge in cases, as the NNDSS would identify any event of public health significance. In addition, the likelihood of outcome data being available increases the longer the interval between initial notification and HCSS case report form completion and submission to NCIRS, making the HCSS data more complete. It is recommended that a timeline of two months be included in relevant guidelines to allow time for case outcomes to be documented while ensuring efficient collection of enhanced data.

HCSS records were reviewed for timeliness of reporting from date of lab confirmation. Sixty-eight percent (211/311) of records were complete for both fields 'Q7_DateLabConfirm' and 'Date of Report' to assess timeliness (Figure 8). Three percent (8/311) of records were further excluded due to implausible dates (date of

report was prior to date of lab confirmation) or data error in one or both fields. Sixty-five percent (203/311) of records were in the final review. Upon assessment, the average time from date of lab confirmation to receipt at NCIRS was 46.3 days; the quickest was 0 days, and longest was 722 days.

Figure 8: Average length of time in days from lab-confirmed Hib diagnosis to receipt of HCSS case report form by NCIRS, 2000-2016



The average timeliness of reporting falls within a 2-month window for all years except for 2001 and 2014. However, outliers may present issues in producing representative data summaries. It is important to reduce similar out-dated notifications in the future with the implementation of a 2-month reporting timeframe, as the data collected may influence research on vaccine effectiveness studies.

Stability

The stability of the HCSS was assessed on the time required to manage the database, in addition to the evaluation of any historical periods of down-time, and the potential for future periods of down-time.

Database management

A focus of this evaluation was to assess the documentation of the historical knowledge surrounding the establishment of, changes made to, and management of, the HCSS and its data. Upon consultation, the majority of this knowledge lies within the data custodian and NCIRS staff who were responsible for the management of the HCSS. Limited information can be found within published reports in *Communicable Diseases Intelligence*, however what is recorded is not sufficient to pass the management of the HCSS to a new data custodian, or to reproduce the HCSS, if either were required.[13] No documentation on the HCSS management processes are recorded or published.

In addition, the use of paper forms to send notifications and enhanced case data to NCIRS was reviewed and found to be an unstable practice. One stakeholder noted that there are few cases of Hib disease annually, making paper forms an efficient way to collect and transfer data. However, it was identified that when follow-up is required for a case report form with missing information, there are gaps within the process of the data custodian sending an email with an attached form for completion to jurisdictional health department or PHU contacts for follow-up. Issues identified include:

- Turnover of jurisdictional staff and not being able to identify a contact person

- Postal mailed and faxed forms being sent to an incorrect address and getting lost

The identification of these issues supports the need for a more streamlined method and transfer process.

Down time

Interviews with the data custodian and an original developer of the HCSS detailed that there was a period of down-time for the HCSS, but this and its effects pre-date the assessment period for this evaluation. There are no current negative effects from this incident.

Despite one data custodian managing the HCSS database, there have been no periods of down time due to illness, personal leave, or staff turnover. This is due to the flexible length of time given in following up a case of Hib disease and subsequently submitting a case report form to NCIRS and its processing. Updating the HCSS is not an urgent task, and as a result, can be managed at different time points throughout the year. Supporting this, the release of updated NNDSS notification data to NCIRS is required to cross-check records to identify inconsistencies between the two databases. The release of the NNDSS updates were limited to several times a year, currently once a year, and thus not supporting the immediate updating of case report form data into the HCSS database.

Summary

This evaluation assessed the current usefulness of the HCSS in monitoring Hib disease in Australia. Through reviewing key attributes of a surveillance system, it was identified that it is essential to gather additional data to which the NNDSS collects, specifically risk factor data and vaccination status. The importance of the collection of these fields, through the continued use of the HCSS, lies in the option to identify increasing trends of Hib disease due to decreasing vaccine effectiveness or vaccine failure. The HCSS is the current system in place fulfilling this need; however, a number of areas requiring adjustment were identified. While the HCSS was found to be useful in collecting enhanced Hib disease data, areas for improvement were identified which include to: provide an update to, and simplify, the case report form and its method of transfer; establish a process to follow-up incomplete records to improve data quality; and publish annual reports summarising enhanced data. As NCIRS does not have capacity to undertake all improvements required, it is recommended that further consultation be undertaken with DoH and NSC on whether the HCSS should transition to an enhanced data collection process similar to that used for IPD and IMD, coordinated by DoH. With a more streamlined process in place, the collection of enhanced data for Australian Hib disease cases could continue with improved data quality and reliability.

Recommendations

1) Establish protocols for the following:
    a. A review and approval process for any future changes to the case report form by the National Surveillance Committee
    b. A communication pathway to inform jurisdictional data managers of a case report form update. Jurisdictional data managers should be responsible for updating all corresponding web links to the newest version of the form, including NSW and QLD control guidelines online
    c. Inclusion of a 2-month reporting timeline for completion and submission of the case report form in relevant guidelines
2) Update the case report form to include the most recent NIP Hib immunisation schedule change and to consider the removal of variables not required including: treating doctor, address of diagnostic laboratory, and the place of acquisition field (postcode and state only). Consider the expansion of the Indigenous status field. Removal of duplicate variables where possible is also recommended
3) Consider the replacement of the paper form with an online PDF version for automated electronic transfer to DoH systems
4) Establish a nationally agreed-upon definition for 'reference laboratory'
5) Consider establishing national serotyping for all invasive *H. influenzae* isolates, with the possibility of establishing recommendations to conduct whole genome sequencing of isolates and to store data in a national genomic library. If increases are identified for any serotype, indicative of serotype replacement,

consider adding enhanced surveillance of the identified serotype(s) to the existing enhanced surveillance system

6) Investigate the identified 49 unique records, and the inconsistencies between 25 Indigenous status and 3 sex field entries to improve completeness and representativeness
7) Publish annual reports summarising enhanced Hib disease data
8) Produce a report or publication detailing the establishment of the HCSS inclusive of historical changes and decisions affecting the HCSS and its database to date
9) As NCIRS lacks capacity to progress all the recommendations above, it is recommended that further consultation be undertaken with DoH and NSC on whether the HCSS should transition to an enhanced data collection process similar to that used for IPD and IMD, coordinated by DoH

Conclusion

In conclusion, the HCSS performs an important role in collecting enhanced Hib disease data in Australia, however improvements could be made to increase its usefulness. The supplementary data collected to that of the NNDSS provides additional insight into the effectiveness of Hib-containing vaccines and possible vaccine failures. With the recent change on the NIP to include a fourth monovalent booster dose of Hib at 18 months of age, an identified method to collect enhanced case data becomes even more crucial, allowing for future assessment of this change. The included recommendations will be brought forward to the NSC for discussion, in regards to further actions which may be taken. Action on the recommendations provided in this report would optimise enhanced Hib disease surveillance in Australia and make it more fit for purpose.

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Appendices

Appendix 4.A: NCIRS Hib Factsheet – a Lay-person Published Document

FactSheet

Haemophilus influenzae type b

ncirs NATIONAL CENTRE FOR IMMUNISATION RESEARCH & SURVEILLANCE

HAEMOPHILUS INFLUENZAE TYPE B (HIB) VACCINES FOR AUSTRALIAN CHILDREN: INFORMATION FOR IMMUNISATION PROVIDERS

This fact sheet provides information on Hib disease and the available vaccines to assist immunisation providers in the delivery of Hib vaccinations to children.

Disease and epidemiology

- *Haemophilus influenzae* type b (Hib) is a bacterium that causes a range of clinical syndromes such as meningitis, pneumonia and epiglottitis, particularly among young children.
- Introduction of Hib conjugate vaccines into routine vaccination programs has led to a dramatic decline in the incidence of Hib disease in many regions of the world.
- In Australia, Hib conjugate vaccines were first introduced into the routine vaccination schedule in 1993, leading to a more than 95% reduction in the reported incidence of Hib disease.

Who should be vaccinated?

- Hib-containing vaccine is recommended for all infants from 2 months of age and also for people with special vaccination requirements, such as people with asplenia and people who have received haematopoietic stem cell transplants.
- Infants should be given 3 primary doses of Hib vaccine at 2, 4 and 6 months of age and a booster at 18 months of age.

Vaccines

- The current Hib conjugate and monovalent vaccines used in the National Immunisation Program are PRP-T vaccines. These vaccines contain the capsular polysaccharide of Hib, polyribosyl-ribitol phosphate (PRP), linked to a tetanus toxoid carrier protein.
- Previously used PRP-OMP vaccines are no longer available and have been discontinued for use in Australia since 2017.

The disease

Causative agent

Haemophilus influenzae is a bacterium that has two forms: capsular and non-capsular. Capsular (typable) forms have a polysaccharide covering that is responsible for the organism's virulence and stimulation of immunity. There are 6 distinct capsular serotypes: a to f. Of these, type 'b' is almost always responsible for serious disease in children, such as meningitis, pneumonia and septicaemia (i.e. invasive Hib disease). Non-capsular (non-typable) forms of *Haemophilus influenzae* mostly colonise the upper respiratory tract without causing illness. However, non-typable *Haemophilus influenzae* (NTHi) can also cause middle ear infection (otitis media) in young children. *Haemophilus influenzae* vaccines provide protection specifically against infection by the 'b' capsular type (Hib).[1-3]

Clinical features

There is a range of clinical syndromes caused by Hib. The most common manifestation of Hib disease is meningitis (52%) followed by pneumonia (12%) and epiglottitis (10%).[4] Meningitis and pneumonia are responsible for most cases of Hib-related mortality and morbidity. Hib can also infect other organ systems and cause septic arthritis, pericarditis, osteomyelitis, bacteraemia or septicaemia, and cellulitis. Many other organisms can also cause these infections and there are no specific signs that indicate infection by Hib.

The classic clinical features of meningitis are fever, neck stiffness and photophobia. However, young infants with meningitis may present with vague and non-specific symptoms such as lethargy, poor feeding and irritability. Even with appropriate antibiotic treatment, Hib meningitis can be fatal. Long-term complications, such as mental retardation, cerebral palsy, hearing loss and seizure disorders, are often reported in children with Hib meningitis after acute illness.

Epiglottitis is the inflammation of the epiglottis and the surrounding structures. Patients with epiglottitis present with soft stridor, high fever, dysphagia and drooling. If appropriate treatment, including antibiotic therapy and airway management, is not started, the swollen epiglottis can rapidly cause respiratory obstruction, leading to death. Hib was responsible for over 95% of cases of epiglottitis in the pre-vaccination era.

Transmission

The only reservoir of Hib is humans and the organism is mostly carried as a commensal (present without causing symptoms) in the nasopharynx of healthy individuals.

Hib enters the body through the upper respiratory tract via droplets, after direct contact with either asymptomatic carriers or patients with Hib disease. When the organism enters the bloodstream or the lungs, it causes serious disease. The incubation period of the disease is short, around 2–4 days.

Many children will come into contact with Hib at some time in the first 2 years of life, mostly by being around asymptomatic children or adults who have the organism (carriers).

Immunity to Hib

Age-dependent susceptibility is an important feature of Hib disease. Most newborns initially have passive protection from Hib disease due to antibodies transferred from their mother. When maternal antibody levels decline in the first few months of life, children become susceptible to Hib infection until they acquire their own immunity. As a result, peak Hib disease attack rates occur at 6–7 months of age.

Children start to progressively acquire immunity through natural exposure to Hib from about 2 years of age. Older children have adequately mature immune systems and develop immunity to Hib infection when nasopharyngeal colonisation with Hib or similar (cross-reacting) organisms occurs. Because of naturally acquired immunity, Hib disease was not common beyond 5 years of age even before the introduction of Hib vaccines. Hib vaccination programs mainly target infants and children up to 5 years of age, the group at highest risk of Hib disease.

Epidemiology

Hib is mainly a childhood disease with over 80% of cases worldwide occurring in children aged <5 years. Before Hib vaccination started, Hib was one of the most common bacterial causes of pneumonia and meningitis in children aged between 4 and 18 months, with a high case fatality rate the world over.[4,5]

Before Hib vaccines were introduced, Hib was the most common cause of bacterial meningitis in Australian children. Aboriginal and Torres Strait Islander children, especially in remote and rural areas, had a much higher incidence of Hib infection and presented at a younger age than non-Indigenous children.[6-9] Hib epiglottitis was particularly rare among Indigenous children. A similar pattern is described among other indigenous populations, such as American Indians and Alaskan Natives in the USA and Maori and Pacific children in New Zealand.[10,11]

Introduction of Hib vaccines led to a remarkable decrease in the incidence of Hib disease in Australia and other countries with vaccine programs.[4] Hib vaccine was first added to the National Immunisation Program in Australia in 1993.[12] The sharp decline in Hib disease incidence since then is seen among both Aboriginal and Torres Strait Islander and non-Indigenous populations. In the pre-vaccination era, there were at least 500 cases of Hib disease and 10–15 deaths annually among Australian children aged <6 years. At present, the number of cases reported in Australia for all ages is around 20 per year, a reduction of over 95% from the pre-vaccination period.[5,13]

Who should be vaccinated?

National Immunisation Program

Hib-containing vaccine is recommended for all infants from 2 months of age under the National Immunisation Program. The recommended schedule is 3 primary doses at 2, 4 and 6 months of age and a booster at 18 months of age. For the booster dose, a single dose of any registered Hib monovalent vaccine is recommended, regardless of previous Hib vaccine type given.

The 1st dose of a Hib-containing vaccine can be given as early as 6 weeks of age. If the 1st dose is given at 6 weeks of age, the next scheduled doses should still be given at 4 months and 6 months of age.

Children aged >18 months and up to 59 months of age at presentation who have not received a primary course of a Hib or Hib-containing vaccine will only require 1 dose of vaccine as catch-up, irrespective of the number of previous doses administered. There should be a minimum 2-month interval between their last dose and the catch-up dose.

High-risk patients

Hib is not a common cause of sepsis among patients who have undergone a splenectomy. Children >2 years old who have completed their Hib vaccination do not require a further booster dose after splenectomy. A single dose of Hib vaccine is recommended for those splenectomised patients who have not been vaccinated in infancy or are incompletely vaccinated. These patients should preferably receive the vaccine 2 weeks before the planned splenectomy. If not received then, they should receive the Hib vaccine 2 weeks after the splenectomy. No further booster doses of Hib vaccine are required in these patients.

Functional and autologous HSCT recipients should receive 3 doses of Hib conjugate vaccine at 6, 8 and 12 months post-transplant. All solid organ transplantation recipients should receive Hib vaccination at least 6 weeks before their procedure or, if that is not possible, within 6–12 months post transplantation.

Women who are pregnant or breastfeeding

Women who are pregnant or breastfeeding are not routinely recommended to receive Hib vaccine. However, for women who have functional or anatomical asplenia, refer to *High-risk patients* above.

Vaccines

Vaccine types

Protection against Hib disease is provided by antibodies produced against Hib polysaccharide capsule polyribosyl-ribitol phosphate (PRP). The first generation of Hib vaccines had purified PRP.[14] These purified PRP vaccines failed to induce an adequate immune response in children younger than 18 months, the age group most susceptible to Hib disease. Combining the PRP with a 'carrier' protein (conjugation) enhanced the immunogenicity of the vaccine and generated a protective response to Hib disease in young infants as well.[15]

Four different carrier proteins have been used to develop conjugated Hib vaccines. They are all conjugated to PRP: diphtheria toxoid (PRP-D), tetanus toxoid (PRP-T), a mutant diphtheria toxin (HbOC) and an outer membrane protein of meningococcus (PRP-OMP).[4] PRP-T conjugates achieve protective antibody levels only after the administration of the 2nd dose of the vaccine.[16,17]

The Hib-containing vaccines that are currently used in the National Immunisation Program (NIP) are: Act-Hib and Infanrix hexa.

Act-Hib is a monovalent Hib PRP-T vaccine.

Infanrix hexa (DTPa-HepB-IPV-Hib) contains Hib PRP-T in combination with diphtheria and tetanus toxoids and acellular pertussis (DTPa), hepatitis B (HepB) and inactivated poliomyelitis (IPV) antigens.

Hib-containing vaccines registered for use in Australia but not currently used in the NIP:

Hexaxim (DTPa-HepB-IPV-Hib) contains Hib PRP-T in combination with diphtheria and tetanus toxoids and acellular pertussis (DTPa), hepatitis B (HepB) and inactivated poliomyelitis (IPV) antigens.

Menitorix (Hib-MenC) contains Hib PRP-T in combination with meningococcal serogroup C – tetanus toxoid conjugate.

Hiberix is a monovalent Hib PRP-T vaccine.

Dose and route

The dose of all Hib-containing vaccines is 0.5 mL given by intramuscular injection.

Vaccine efficacy and effectiveness

Several prospective randomised studies have reported a protective efficacy of over 94% for Hib conjugate vaccine following the primary vaccine schedule.[18] In Australia, vaccine effectiveness was estimated to be between 83% and 90% when adjusted for under-reporting.[5] Hib conjugate vaccines have been shown to not only reduce the rate of disease in people who have been vaccinated but also reduce the prevalence of Hib carriage. Because of this effect on the 'reservoir of infection', Hib vaccines reduce disease incidence even among the non-vaccinated people (herd immunity).[19-21]

Since 2000, every state and territory in Australia has achieved Hib vaccine coverage rates of over 90% for the primary series by 12 months of age in Aboriginal and Torres Strait Islander as well as non-Indigenous children. Hib vaccine coverage among children at 24 months of age for the primary series plus the booster is slightly lower than at 12 months of age but is still over 90%.[12,22]

Vaccine safety

Hib is not a live vaccine and, therefore, there is no risk of the vaccine causing Hib disease. Adverse reactions that have been reported following Hib vaccination have been mild and transient. 5%-30% of children may have local reactions such as pain, swelling or redness at the injection site, most commonly presenting after the 1st dose. These reactions generally appear within 3–4 hours of injection and resolve completely within 24 hours. A slightly raised temperature that is short-lived in 2% of vaccinated children has been reported as well.

Anaphylaxis is a rare possibility following Hib vaccination as with all other vaccines. However, anaphylaxis following Hib vaccination is exceptionally rare in comparison to most other vaccines.

Interchangeability

Ideally the same Hib conjugate vaccine type should be used for all doses of the complete schedule. However, studies have shown that schedules combining different types of Hib conjugate vaccines are safe and provide adequate protection against Hib disease.[23-25]

Concomitant administration

Children can be safely vaccinated with pneumococcal conjugate vaccines, hepatitis B vaccines, DTPa-containing vaccines, inactivated poliomyelitis (IPV or IPV-containing) vaccines, and monovalent meningococcal C vaccine in separate sites at the same visit.

Contraindications and precautions

The only contraindications to any of the Hib vaccines are a history of anaphylaxis following a previous dose of Hib vaccine or anaphylaxis following any component of the vaccine.

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Appendix 4.B: Current HCSS Case Report Form

NCIRS ID:_____

NCIRS *Haemophilus influenzae type b*

Enhanced surveillance notification (amended January 2014)

To be completed for:

1. **Isolation of H. influenzae type b from any normally sterile site, OR**
2. **Identification of Hib antigen in cerebrospinal fluid, with other laboratory parameters consistent with meningitis.**

Note: Diagnosis of epiglottitis by direct vision, laryngoscopy or X-ray without a positive sterile site culture is now NOT notifiable.

Patient Information

State/Territory Notification (Unique) ID: .....

Surname: (First 2 Letters) |___|___| First name: (First 2 Letters) |___|___|

Sex: (M / F) |___| Date of Birth: __ __|__ __|__ __ __ __

Postcode of Residence: |___|___|___|___| State of Residence: |___|___|___|

Aboriginal or Torres Strait Islander: ☐ Yes ☐ No ☐ Unknown

Treating doctor: ..... Phone No: .....

Clinical Data

1. Date of onset: __ __|__ __|__ __ __ __

2. Place of acquisition:
   Either Australian Postcode |___|___|___|___| *or* Australian State |___|___|___|
   (if postcode not known)
   or, ☐ Other Country (specify): .....
   or, ☐ Unknown

3. Clinical diagnosis:
   ☐ Meningitis ☐ Epiglottitis ☐ Septicaemia without focus
   ☐ Cellulitis ☐ Other - please describe .....

4. Outcome:
   ☐ Discharged apparently well
   ☐ Discharged with abnormality please specify .....
   ☐ Died

Risk Factors

5. ☐ Premature (< than 37 weeks gestation)..... weeks
6. Does the case have an underlying illness requiring regular medical supervision?
   ☐ No underlying illness
   ☐ Splenectomy
   ☐ Immunosuppressive drug (specify): .....
   ☐ Immunosuppressive condition (specify): .....
   ☐ Congenital or chromosomal abnormality (specify): .....
   ☐ Other (specify): .....

Microbiology Data

7. Date of laboratory specimen __ __|__ __|__ __

8. Method of confirmation (if blood and another site, please indicate both):

☐ Blood culture ☐ CSF culture ☐ Other sterile site..... (Please specify)

☐ Antigen CSF ☐ Nucleic acid testing ..... (Please specify specimen site) ☐ Other.....

9. Laboratory performing microbiology: .....

Address (if known): .....

..... Telephone: .....

10. Confirmation as type b:

☐ ICPMR (Sydney) ☐ MDU (Melbourne) ☐ QHFSS (Brisbane)

☐ Other laboratory, specify ..... ☐ Not sent ☐ Not known

Note: All isolates should be confirmed as type b by an approved reference laboratory

Vaccination Data

11. Was the child vaccinated against Hib?

☐ Yes ☐ No ☐ Unknown ☐ NA (Adult or born before Jul 1988)

12. Source of information:

☐ Australian Childhood Immunisation Register

☐ Other written record (Please specify) .....

☐ Verbal report from provider

☐ Verbal report from parent, self or other (Please specify).....

13. **Dates of Hib Vaccination** (Approximate if Necessary)	**Type/Brand** (If Available)		**Batch Numbers** (if Available)
1st __ __|__ __|__ __	☐ HibTITER ☐ Pedvax	☐ *Comvax*	
	☐ *Infanrix hexa*	☐ Other..... (Please specify)	.....
2nd __ __|__ __|__ __	☐ HibTITER ☐ Pedvax	☐ *Comvax*	
	☐ *Infanrix hexa*	☐ Other..... (Please specify)	.....
3rd __ __|__ __|__ __	☐ HibTITER ☐ Pedvax	☐ *Comvax*	
	☐ *Infanrix hexa*	☐ Other..... (Please specify)	.....
4th __ __|__ __|__ __	☐ HibTITER ☐ Pedvax	☐ *Comvax*	
	☐ *Infanrix hexa*	☐ Other..... (Please specify)	.....

Reported by:.....

Telephone: (.....) .....

Email:.....

Date of report: __ __|__ __|__ __

Please return this form to:
Hib Enhanced Surveillance
NCIRS, Kids Research Institute
at The Children's Hospital at Westmead
Locked Bag 4001, Westmead NSW 2145
or fax to **NCIRS: 02 9845 1418**

5. Response to an Acute Public Health Incident

Ultra-high Risk Patient Exposure to an Active Tuberculosis Case: An Epidemiological and Risk Assessment from a Baseline Contact Investigation and Follow-Up

5. Response to an Acute Public Health Incident

Prologue

While New South Wales (NSW) and National guidelines exist for the risk categorisation and management of tuberculosis (TB) index case contacts, these guidelines only identify high, medium, and low risk categories.[1-3] The nature of this incident where over 100 immunosuppressed patients were exposed to an active case of TB in a renal clinic waiting room, resulting in the need to re-assess the guidelines to produce a more targeted approach based on this specialised population and their complex clinical management needs.

There is very limited literature on the contact investigation and follow-up of TB in immunocompromised patients.[4-6] Without national or jurisdictional guidelines for this type of incident and a lack of published literature, it was essential for experts to meet to discuss the creation of an ultra-high risk group and redefine existing risk groups as required. To contribute to the response effort, I developed a database to generate contact investigation and clinical summary reports. I produced a risk assessment report (Appendix 5.A) detailing the initial management and decision making processes undertaken. The production of this database and risk assessment report will allow for a future peer-reviewed manuscript to be published using the data collected, adding to the available national and international literature available, which may help guide responses to similar incidents should they occur in the future.

My Role

My involvement in this acute public health response was time-limited, however the efforts are ongoing. My role revolved around the management of the data and evaluation of the response. At the time I was brought into the response, another team member had developed an initial database to collect contact and clinical data. However upon review, I determined it was not adequately capturing the clinical and patient data required. I re-developed the pre-existing database to meet the needs of the complex contact investigation and follow-up screening pathways. I was able to implement skip logic functionality to create a more seamless user experience for those entering data, as well as develop the question and answer combinations to not only collect the required data and clinical results, but to easily extract data to produce contact tracing and clinical summary reports for multidisciplinary team (MDT) meetings to review current statuses of all contacts, and manage clinical pathways and decisions. I developed templates for the contact investigation and clinical summary reports, which were used while formatting the question and answer combinations in the database, to ensure seamless data extraction. I coded these reports into the database based on contact risk level and/or specific dates. I extracted and analysed baseline contact investigation and clinical summary reports for review at a MDT meeting.

In addition to managing the development and design of the database, I engaged with response partners to identify areas for improvement in the form of a risk assessment. Given this was a rare occurrence of a TB exposure incident within a large population of immunocompromised patients in New South Wales, a review of the processes and timelines that occurred during the early decision-making period was considered

necessary to maximise efficiency should a similar event occur again. As contacts were immunocompromised, timeliness was essential to the proper management and healthcare of these patients to ensure no serious adverse events occurred.

Lessons Learned

Working with the Western Sydney Public Health Unit (WSPHU) exposed me to a more practical side of epidemiology, compared to the majority of research-based work at my field placement. The Infectious Diseases team allowed me to attend a number of morning briefing meetings, which exposed me to cases of less commonly observed infectious diseases in New South Wales including malaria, Zika virus infection, hepatitis E infection, typhoid, and dengue. I was able to review case follow-up questionnaires and listen to phone calls with cases to understand the steps required in case follow-up and investigation. I gained a greater understanding of the role of the Public Health Unit (PHU) in protecting the health of the local population and enforcing public health legislation.

My role in the contact investigation and follow-up of a case of tuberculosis amongst ultra-high risk patients taught me about the proper steps and management during a contact investigation exercise for tuberculosis. I learned about the importance of stakeholder identification and engagement through clear communication in time sensitive situations such as this. In addition as a result of my role, I gained a greater understanding of where the weak points are in bringing together a team and undertaking such an exercise when available protocols do not fit the specific situation. In time sensitive situations, the ability to think quickly and identify proper experts to

consult with to generate new protocols, and as well as the importance of role assignment, are lessons I will take with me into the future.

Additionally, I learned about complex clinical interactions and the severe and possibly life-threatening consequences of both the mismanagement of, or improper treatment of, active or latent tuberculosis in immunocompromised patients. I also learned about the screening pathways, clinical tests required, and treatment options for high, medium, and low-risk contacts.

More practically, I learned how to use and write code for data storage software which I hadn't worked with previously, REDCap, to create a database. My role in the response to this incident allowed me to exercise my ability to foresee unknown outputs, document them, and build functionality into the database to capture fields and variables to produce such outputs. This exercise challenged me as there were different opinions on the purpose of the database including the ability to provide contact investigation summaries, to store and review clinical histories, results, and treatment pathways, and to capture information in an easily extractable way for data analysis and publication production once follow-up is complete. I learned how to assess each of the competing needs and assemble a database, which suited all of the requirements in the final system.

Public Health Implications

As a result of my involvement in this piece of work, I was able to contribute to the control and prevention of the spread of tuberculosis in Western Sydney, NSW. The

interventions provided as a result of response efforts may have saved a number of lives, especially of those who were immunocompromised.

I was able to leave a legacy in the form of a working database for continued use in the screening and testing of potential contacts identified in this investigation. This database can be continued to be used for early detection of infections in contacts for the entirety of the potential 27-month follow-up period. This database can act as a model for future incidents similar in nature with complex screening algorithms. In addition, the reports generated in REDCap for extraction are able to be continually exported by WSPHU staff at future time points to review the current status of contacts and their clinical management.

The risk assessment of incident management provides areas for improvement and suggested methods for such. In the event of a secondary incident similar in nature, this risk assessment identifies procedural changes and processes, which should be put in place and explored from incident onset, for the most efficient and appropriate response possible.

Lastly, the building and implementation of a REDCap database allowed for the extraction of summary reports of the contact investigation and clinical management of index case contacts. As a result, contacts were able to be identified as active and latent tuberculosis cases and proper decisions about their management were made, potentially avoiding clinical complications and negative health consequences. In addition, the data collected within the database will be used to produce a peer-reviewed publication, which will add to the literature on complex tuberculosis contact investigation and management in Australia.

Acknowledgements

I would like to acknowledge the staff at the WSPHU for providing me with the opportunity to be involved in this response. In particular, the leadership given by Dr Shopna Bag and the epidemiological expertise of Ms Sophie Norton were integral in the WSPHU's role in this response. I would also like to acknowledge the efforts of the following response partners who assisted with this response:

The following groups with Western Sydney LHD:

- Renal team
- TB service (Parramatta Chest Clinic)
- Respiratory team
- Infection Prevention and Control (Westmead Hospital)
- Infectious Diseases team
- Microbiology team

NSW Health TB Program Manager and team

NSW Clinical TB expert panel – assembled by request through the NSW Health TB program team

I would lastly like to acknowledge the Infectious Diseases team at the WSPHU for allowing me to spend time learning and attending a number of their internal meetings, giving me exposure to the responsibilities and requirements of a public health unit.

Abstract

Introduction

A confirmed case of active tuberculosis (TB) was reported in Western Sydney, New South Wales, on 2nd May 2018. Upon investigation, the case had attended to Westmead Hospital's Renal Department multiple times over several months, resulting in the exposure of over three hundred contacts, one-third of whom were immunocompromised. This study details the epidemiology of the baseline period of follow-up screening and assesses the management and handling of a large public health response to a rare incident.

Methods

A contact tracing exercise was initiated which included the identification of potential case contacts, the re-classification of risk categories of individuals (ultra-high, high, medium, and low), appropriate clinical examinations and testing for TB based on appropriate risk category, and the review of clinical results by a multidisciplinary team. A database was developed to capture the complex contact tracing pathways and clinical outcomes for contacts by risk category. Contact tracing and clinical summary reports were developed and extracted from the database. Report data was analysed to provide epidemiological snapshots of follow-up activities to key response partners, informing clinical decision making and treatment options for identified secondary cases.

A risk assessment was produced through consultation with risk partners to identify, describe, and propose solutions for the key risks and challenges in the management of TB contact tracing investigation and screening in a healthcare facility involving immunocompromised patients.

Results

There were 317 contacts were identified as be exposed to the index case. Over 100 contacts were determined to be immunocompromised and of ultra-high risk being either a renal transplant patient, an immunocompromised renal non-transplant patient, or an immunocompromised urology patient. An additional 21 ultra-high risk contacts were identified from a second index case.

Contact tracing and clinical summary reports were extracted for the baseline period of follow-up, however results varied from those within internal stakeholder meetings due to delays in database development and data entry. Fourteen cases of TB were identified by response partners and multidisciplinary teams through clinical review, requiring further screening and treatment.

Results from the risk assessment showed areas for improvement including stakeholder engagement, human resourcing, data management, contact management, and communication.

Conclusion

As a result of an examination into the processes undertaken during the baseline contact tracing and screening phase of follow-up to an active case of TB, the identification and documentation of several areas of improvement were produced. Key NSW stakeholders should consider expanding upon current TB contact tracing guidelines to include large and uncommon incidents such as this in preparation for possible future events.

Introduction

Tuberculosis is a disease caused mainly by *Mycobacterium tuberculosis* complex in Australia, with fewer cases caused by *M. bovis, M. africanum, M. caneti,* and *M. caprae*.[3] TB is transmitted via aerosol transmission of infected air droplets of infectious individuals with pulmonary or laryngeal TB, most commonly spread through coughing, sneezing, or talking. Infection can also occur during medical procedures including sputum induction, bronchoscopies, autopsy, or similar. Upon inhalation, the incubation period can range from 2-10 weeks. [3] Only 5-10% of immunocompetent individuals exposed develop active tuberculosis; however the disease can remain in a latent state within the body for life without presenting symptoms or being infectious.[3] Symptoms for active pulmonary TB include cough, fever, night sweats, weight loss, and malaise. Those with drug-sensitive TB have a 95% recovery rate after treatment with antibiotic therapy.[3]

In Australia there were 1,425 new TB cases in 2017, 542 of which were in NSW alone, with those born overseas, being of Aboriginal or Torres Strait Islander origin, living in overcrowded conditions, those <5 years of age or in the elderly population, or being immunocompromised at higher risk of illness.[7,8] In the event of an identified case of TB, contact tracing activities are initiated by jurisdictional health departments and PHUs. Contact tracing is used to monitor for active disease for early diagnosis and treatment and to identify secondary cases with latent TB Infection (LTBI) in order to prevent the development of active TB disease by utilising prophylactic antibiotics.

On 2nd May 2018, a confirmed case of active tuberculosis was reported to the local tuberculosis service and PHU in Western Sydney, NSW. During follow-up with the case, medical history was collected which detailed the case's immunocompromised status, recent travel to a TB-endemic country and current symptoms. Upon further investigation, the case was identified to have attended Westmead Hospital's Renal Department on multiple occasions while infectious. It was estimated that close to 317 patients were exposed to the case while infectious. This was determined to be between 19th March 2018 and 2nd May 2018.

Contact tracing was facilitated by obtaining patient appointment lists, as well as contact information for the identified potential contacts through the hospital's medical records system. Due to the number of immunocompromised patients attending the Renal Department, contact tracing was prioritised based on risk, according to the NSW guidelines for TB management, and the work was divided between the Parramatta Chest Clinic (PCC) and the Renal Department of Westmead Hospital. Detailed letters (Appendix 5.B) were mailed to patients' home addresses, indicating the need for urgent TB testing. Testing included a clinical examination, interferon gamma release assay (IGRA) blood testing and/or tuberculin skin test (TST).

During this contact tracing and screening process, an additional case of TB was identified, which was determined to be a contact of the index case, however molecular typing determined the individual bacterium were genetically distinct. As a result, contact tracing exercises were expanded to include contacts of this second case. An additional 95 contacts were identified, 21 of whom were considered to be of ultra-high risk due to being immunocompromised, and also followed-up.

Aim

The aim of this project was to provide an epidemiologic summary and a risk assessment of the baseline phase of screening for contacts to an active case of tuberculosis in a hospital waiting room, and their management.

Objectives

The objectives of this response were to:

1. develop and manage a REDCap database system for collecting patient data from contacts of the index case for epidemiological analysis and fortnightly reporting purposes;
2. produce an epidemiological summary of the results from the baseline screening for dissemination to key stakeholders;
3. produce a risk assessment after the baseline wave of screening and patient assessment to identify key risks, barriers, and areas for improvement for amendment regarding the management of and screening process which was undertaken, prior to beginning the second wave of patient screening.

Methodology

Case Definition

A confirmed case of tuberculosis required either laboratory definitive evidence or clinical evidence, and the diagnosis must be accepted by the Director of Tuberculosis Control (or equivalent) in the associated jurisdiction.[9]

Laboratory definitive evidence consists of either the isolation of *Mycobacterium tuberculosis* complex (*M. tuberculosis, M. bovis,* or *M.africanum,* excluding *M. bovis* var BCG) by culture or the detection of *M. tuberculosis* complex by nucleic acid testing except where detection may be due to previously treated or inactive disease. [9]

Clinical evidence was a diagnosis of tuberculosis by a clinician experienced in tuberculosis, which includes a clinical follow-up assessment to ensure a consistent clinical course. [9]

Confirmed cases of tuberculosis are notifiable to the NSW Notifiable Conditions Information Management System (NCIMS) initially, and subsequently nationally notifiable to the Nationally Notifiable Disease Surveillance System (NNDSS).

Response Partners

This response was a joint collaboration and partnership between various actors and public health bodies across the Western Sydney Local Health District (LHD) and NSW Health. The following response partners assisted with this response:

The following groups with Western Sydney LHD:

- Renal team
- TB service (Parramatta Chest Clinic)
- Respiratory team
- Infection Prevention and Control (Westmead Hospital)
- Infectious Diseases team
- Microbiology team

NSW Health TB Program Manager and team

NSW Clinical TB expert panel – assembled by request through the NSW Health TB program team

Contact Investigation and Screening

Risk Level Development

In response to the incident, the Western Sydney team and TB expert panel consulted and began a contact investigation exercise to identify all possible contacts of the index case. The subsequent screening of identified contacts of the index case was a multi-stage process dependent on degree of infectiousness, level and duration of contact, immune competency of contacts, and other environmental factors (ventilation, humidity, air flow). These factors influence the risk of a contact becoming infected with tuberculosis.

In the NSW Health contact investigation guidelines, cases and contacts of TB patients are categorised into high, medium, and low risk categories based on duration of exposure, clinical history, and whether or not the contacts fall into a special category including: Multi-drug resistant TB infection, TB-HIV co-infection, children, resident of a health care facility, having travelled on an airline, or contact being in an educational facility, child care setting, special school, or prison.[3] However in this incident, a large number of immunocompromised patients were exposed to the index case, resulting in the need to review, and ultimately redevelop, the risk levels and categories specifically to fit this incident.

In redefining the risk levels, several key issues were considered including: the immune competency of patients, exposure period, relationship to the index case, complex medical histories, and medication usage (e.g. renal transplant patients are on numerous medications including immune-suppressive agents to ensure transplants are not rejected). Table 1 details the redefined risk levels and corresponding categories used to assist in the prioritisation and management of the contact investigation and follow-up screenings.

Table 1: Identified risk levels and categories for contact follow-up for ultra-high risk patient exposure to an active tuberculosis case in New South Wales, 2018

Ultra-High Risk
• Renal transplant patient • Renal non-transplant patient, immunocompromised • Urology patient, immunocompromised
High Risk
• Workplace contact • Renal non-transplant patient with >8 hours of exposure, non-immunocompromised • Urology patient with >8 hours of exposure, non-immunocompromised
Medium Risk
• Renal patient with 4-8 hours of exposure, non-immunocompromised • Urology patient with 4-8 hours of exposure, non-immunocompromised • Healthcare worker
Low Risk
• Renal patient with <4 hours of exposure, non-immunocompromised • Urology patient with <4 hours of exposure, non-immunocompromised • Ophthalmology patient • Radiology patient

Due to potential adverse outcomes of a delayed positive diagnosis, including adverse medication interactions, especially those which may interact with the recommended first-line LTBI prophylaxis, rifampicin, or the risk of an adverse event occurring including the loss of renal graft, contacts deemed to be at ultra-high risk of developing

TB were prioritised for follow-up and screening. Immunocompromised patients are also at a higher risk of developing TB from exposure, supporting the need for rapid follow-up.[10,11] Those identified as high or medium risk were prioritised next, followed by those of low-risk if required, as per NSW Tuberculosis Contact Investigation Guidelines.[2]

Contact Investigation and Screening Algorithms

Electronic Microsoft Excel lists of potential patient contacts were obtained by the WSPHU from relevant clinics, including the PCC and the Renal Clinic in Westmead Hospital. The NSW Health TB Contact Tracing Questionnaire (Appendix 5.C) was used to identify background symptoms, travel, and health history via phone conversation prior to patient screening at either clinic. The following algorithms were used as a guide for the screening and treatment management for the ultra-high risk contacts (Figure 1) and the high, medium, and low contacts (Figure 2).[12] Contacts were then asked to attend their relevant clinic as soon as possible for a clinical examination, QuantiFERON TB Gold Plus (QFT-Plus) blood test, and/or TST to identify acquisition of the *M. tuberculosis* complex, using the NSW Health TB case definition.

If found to be positive, contacts were referred for chest x-ray and consultation with specialist physicians to determine appropriate course of care and preventative therapy. If found to be negative, testing was to be repeated in 3 months' time to assess status. Potential cases were informed of any diagnosis by their renal and/or respiratory physician.

Figure 1: Algorithm for ultra-high risk contact screening and management for contact follow-up for ultra-high risk patient exposure to an active tuberculosis case in New South Wales, 2018[12]

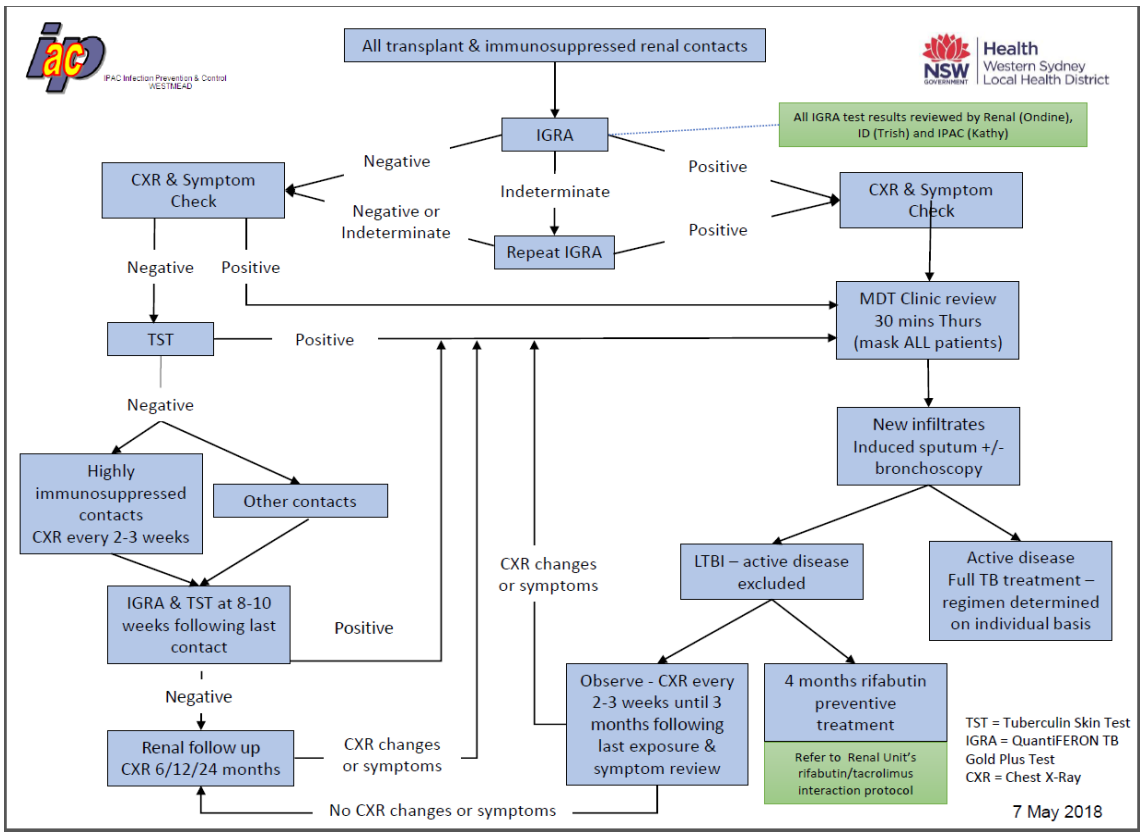
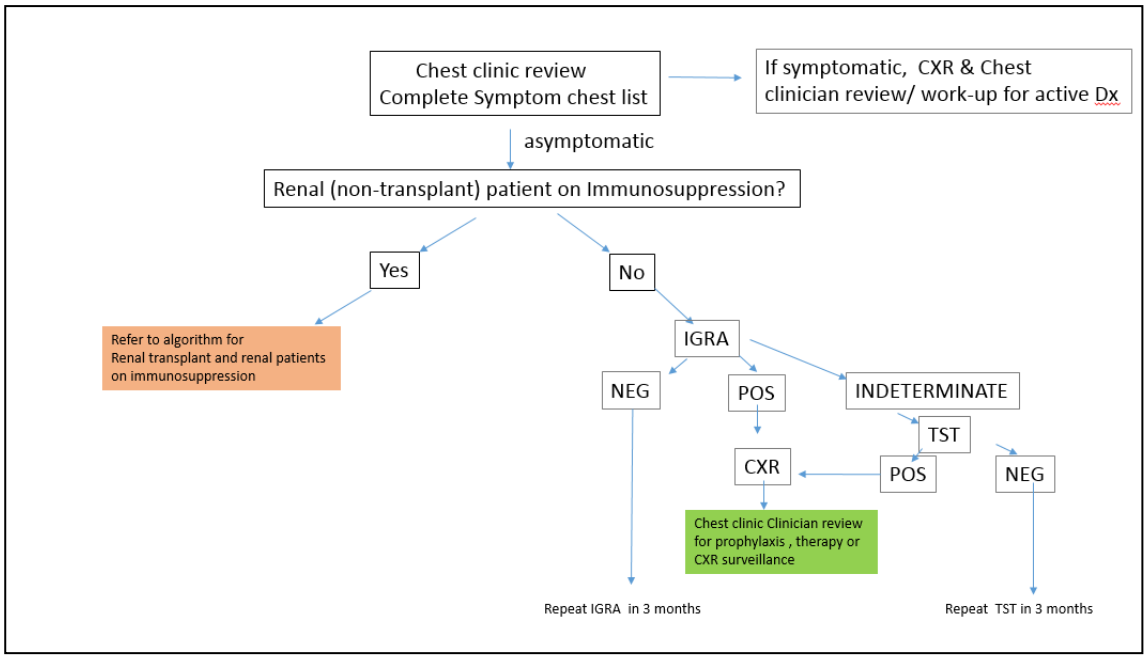


Figure 2: Algorithm for high, medium, and low contact screening and management for contact follow-up for ultra-high risk patient exposure to an active tuberculosis case in New South Wales, 2018[12]



Data Collection and Handling

REDCap Database

I re-designed a REDCap database, a secure web application for building and managing online surveys and databases, to capture and analyse patient information for epidemiological reporting (samples provided in Appendix 5.D). The initial database would not record the necessary data or produce summary reports with specific contact investigation and clinical data. During the re-development of the database, skip logic functionality was incorporated to allow for a simple user interface while detailing specific information for each contact to reflect their individual screening pathway, based on the complex screening algorithms in use. The database and questions were developed with the concept of being able to easily pull out either summary data reports for use in MDT meetings, or detailed data reports to use in future research outputs. The database was reviewed and approved by key response partners prior to implementation and the commencement of live data entry.

Data collected on all potential contacts included the following variables (with accompanying relevant dates):

- Exposure dates and risk category
- Current symptoms upon initial phone follow-up
- Background and travel history
- Medical history, including previous TB history
- Any current medications or treatments
- Clinical consultation results

- Laboratory testing results
- Chest x-ray results
- Calculation between exposure date and date of first testing to inform if a secondary screening is required if <56 days
- Case status (positive/negative)
- Recommended treatment from specialist physicians
- Any clinical notes from specialist physicians

Current symptom, background, and travel history data was initially collected on paper-based NSW Health TB Contact Investigation Questionnaires. Data was then transferred and stored in the de-identified REDCap database, using a unique identifier for identification purposes. Paper questionnaires were stored at PCC in a locked cabinet for a minimum of 5 years.

Contact Tracing and Clinical Summary Reports

A contact tracing summary report template was developed to provide situational updates at fortnightly stakeholder meetings. The report template included summary data by contact risk-level (ultra-high, high, medium, low), each of which were separated into those who require a secondary screening or not. A secondary screening would be required when exposure to the index case occurred less than 56 days from screening date. The 56 day incubation period was discussed and agreed upon by response partners.

Data was summarised for the reporting period by total contacts tested, contacts still requiring testing, contacts no longer requiring testing, each type of screening test and possible outcomes, completion or need for MDT clinic review, totals found to be positive for active TB or LTBI, totals commencing treatment options, and whether genetic links were found between isolates of secondary cases and the index case. A baseline data extraction was completed on 13th September 2018, which was used to populate a contact tracing summary report for the ultra-high risk contacts.

Clinical summary reports were also developed to provide the response partners and MDT clinical consultants summaries of contacts by risk level. These reports include more specific information for contacts regarding screening, diagnoses, treatment, and a visual flowchart of the appropriate screening and management algorithms (Figures 1 & 2). Baseline data was extracted on 13th September 2018 which was used to prepare a clinical summary report for the ultra-high risk contacts.

Data for the reports was extracted from the REDCap database, outputted in .csv format, and summarised to populate both reports for distribution.

Risk Assessment

As part of the public health response, I undertook a risk assessment to evaluate the management of this incident during the baseline phase of follow-up from 2nd May 2018 to 13th September 2018.

Areas for consideration in the assessment included: retrospectively identifying the risks or points of weakness, what processes were undertaken during the initial phase of the contact investigation and screening follow-up, any resulting issues as a result of

the methods or procedures implemented, and the presentation of mitigation strategies to undertake in the event of a similar incident occurring in the future.

Response partners were consulted during the development of the assessment, providing input into the key areas needing improvement, as well as to provide detailed accounts of the discussion and actions taken during the public health response. A final report was provided to the response partners for future reference as required.

Data Analysis

Data collected in the REDCap database was analysed to provide an epidemiological summary of the Stage 1 baseline follow-up for contacts in the ultra-high risk category in a report for dissemination to key stakeholders. Data was presented in the context of person, place, and time. Data for secondary cases was presented in a de-identified line listing which included demographic information, final exposure date, date of first screening, results from screening tests completed, and follow-up status.

Ethical Considerations

Social considerations and sensitivities relevant to this study included the review of patient clinical information and histories, with selected details entered into the REDCap database for contact investigation and screening management purposes. Only staff whose normal duties include reviewing clinical data had access to clinical systems such as the Notifiable Conditions Information Management System (NCIMS) and PowerChart, the clinical database used in NSW hospitals.

The confidentiality of contacts' identities was ensured by the use of a unique identifier in the REDCap database, matched to each patient in a secure Excel document kept in the WSPHU secure drives, with access only given to key staff for use. Only approved staff had access to the REDCap database, with limited functionality as required.

The ethical aspects of this applied investigation were approved by the ANU Human Research Ethics Committee, Protocol #2017/909.

Results

Contact Tracing and Clinical Summary Reports

Summary reports for contacts categorised as ultra-high risk were extracted from the REDCap database on 13th September 2018 (Appendices 5.E - 5.F). During the baseline period, 152 contacts were categorised as ultra-high risk, with 102 having received initial IGRA screening tests. Thirteen percent (13/102) were identified as needing a secondary follow-up screening (i.e. screening occurred less than 56 days since exposure), 3% (3/102) were identified as needing no further screening, and 84% (86/102) were not specified. Of the 102 contacts receiving an IGRA, there were seven positive, 88 negative, four indeterminate, and three awaiting results. Of those with an indeterminate result, all received a repeat IGRA, with one negative, one indeterminate and two awaiting results. 41 contacts received a TST test, with three positive results, 27 negative results, and 11 awaiting results. Two contacts had received a MDT clinic review, with one awaiting review. 138 ultra-high risk contacts were identified as needing either initial or repeat screening during the next screening phase. At the time of analysis, no data was entered for treatment or prophylactic measures taken.

Baseline Summary of Positive Secondary Cases

Clinical testing and management of contacts occurred throughout the baseline screening period. Despite up to date testing, delays occurred for entering data into the REDCap database due to limited staff resources available. As such, details of current positive cases were discussed during fortnightly TB meetings, and the data reflected

within these meetings does not match that extracted from the database in the summary reports.

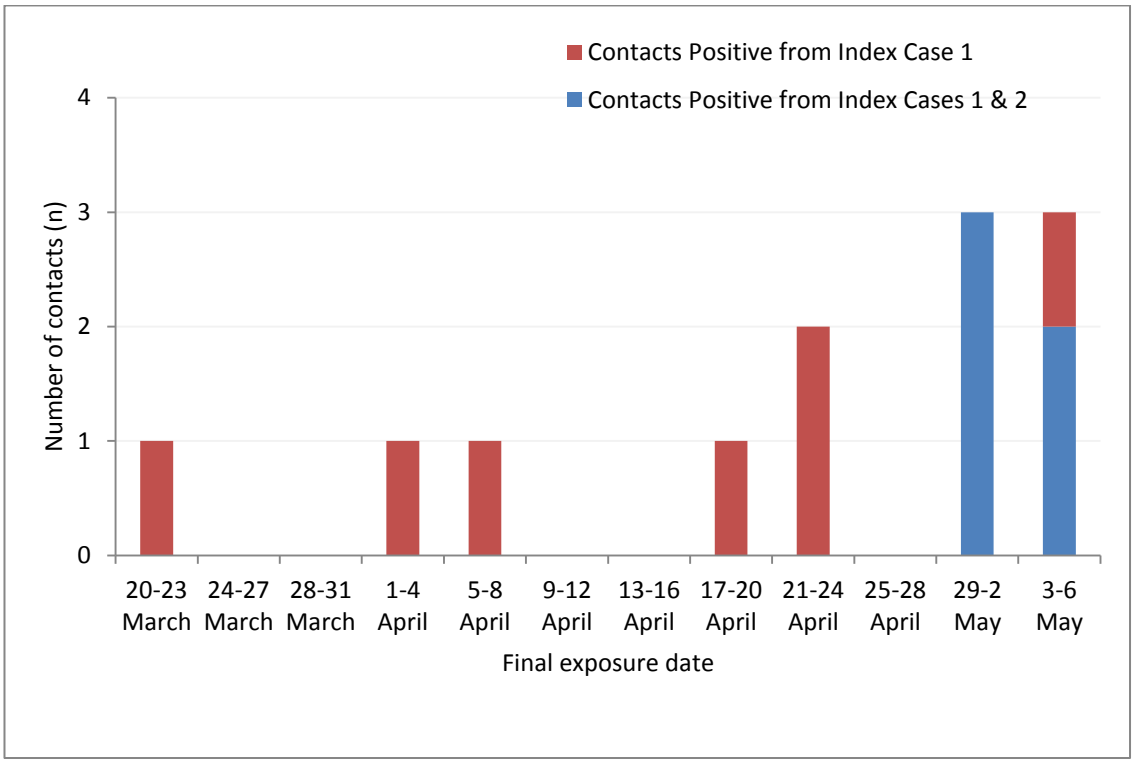
Fourteen contacts were identified as positive for one or more screening tests; an IGRA, TST, or CXR (Table 2). The management of these cases was taken up for discussion by the MDT to adequately assess their future screening and treatment options. Four cases were assigned CXR surveillance, two required repeat screening, two required an initial TST, one required an induced sputum exam, one needed review of a high-resolution computed tomography (HRCT), and one was placed on Rifabutin treatment. Three cases were awaiting discussion at a subsequent MDT meeting.

Of the cases, seven were exposed only to Index Case 1 and five were known to be exposed to both Index Case 1 and 2 (Figure 3). The earliest final known exposure date for these positive cases was on 20th March 2018, and the most recent exposure date was 3rd May 2018.

Table 2: Baseline line listing of positive secondary cases of tuberculosis in New South Wales, 2018

CaseID	Age	Sex	Index Case Contact	Final Exposure Date	First Screening Date	IGRA	TST	CXR	Current Status
1	51	F	1, 2	3/05/2018	17/05/2018	Negative	Negative	Abnormal	Repeat IGRA/TST
2	61	M	1	24/04/2018	24/05/2018	Positive		Abnormal	Induced Sputum
3	39	M	1, 2	3/05/2018	25/05/2018	Indeterminate	Negative	Normal	CXR Surveillance
4	54	M	1	18/04/2018	31/05/2018	Positive		Normal	CXR Surveillance
5	60	F	1	3/05/2018	31/05/2018	Positive		Abnormal	CXR Surveillance
6	66	F	1	20/03/2018	6/06/2018	Negative	Negative	Abnormal	Repeat IGRA/CXR
7	66	F	1	3/04/2018	7/06/2018	Positive		Abnormal	CXR Surveillance
8	47	M	1, 2	1/05/2018		Negative	Positive	Abnormal	HRCT for review
9	57	M	1, 2			Negative		Abnormal	Need TST
10	53	M	1	24/04/2018	25/05/2018	Negative	Positive	Normal	Rifabutin Treatment
11	60	F	1, 2	30/04/2018	31/05/2018	Indeterminate	Negative	Normal	Need TST
12	64	M	1, 2	2/05/2018	7/06/2018	Indeterminate	Negative	Abnormal	
13	66	M	1		22/06/2018	Positive		Normal	
14	47	M	1	7/04/2018	5/06/2018	Negative	Positive	Normal	□

Figure 3: Final known exposure dates of positive secondary cases of Index Case 1 and Index Case 2



Risk Assessment Summary

A risk assessment was produced to identify, describe, and propose solutions for the key risks and challenges in the management of TB contact tracing investigation and screening in a healthcare facility involving immunosuppressed patients. Through consultation with response partners, five areas were identified as needing improvement should a similar incident happen in the future: stakeholder engagement, human resourcing, data management, contact management, and communications. The risk assessment identified the key risks, processes which were initially undertaken during the response efforts, resulting issues that developed due to said initial processes undertaken, and possible mitigation strategies. Mitigation strategies were

presented to enable the development of strategies for more efficient case and contact management in the event of the reoccurrence of a similar acute public health incident in the future.

Discussion

Overall, the public health response to the exposure of a large number of contacts to an active case of TB was delayed due to several factors. An early assessment of the complexity of the incident, along with the production of clear roles and responsibilities for all parties, and the identification of one or more individuals to manage these, would have significantly reduced the delayed response. It is clear that the lack of surge resourcing was a barrier as well, and from this exercise, funding sources for additional support should be identified in the instance of a similar incident occurring. While the priority is the current follow-up of exposed contacts, thorough consideration should have been made to the tools required to track and manage the follow-up process. In this instance, there were no tools available to adequately capture the uniqueness of this incident and the adjusted follow-up requirements needed. As such, the collection of real-time data from contact screening was delayed, resulting in a delay in the data entry, and thus not utilising the full usefulness of the developed database to assist in contact management and tracing activities during the baseline phase of screening.[13]

As noted previously, the data collected from the REDCap database to produce the contact tracing and clinical summary reports varied to that from internal TB meetings. The delay in data entry and inability to utilise the database as it was intended exemplifies the struggle between the coordination and documentation of a public health incident. While the priority is the coordination of the follow-up screening, and as such this was never challenged, tools to assist in this process were either unavailable or incomplete. The lack of additional staff resources, clear plan for outputs or reports to assist in the follow-up process, and the identification for a specific data

collection and management role led to the delay, and complexity of, contact follow-up. Ultimately the database will contain all relevant case data and will be a useful tool in prospective follow-up phases and screening of further contacts or those needing repeat screening. It will also serve as a basis for future research on the incident when follow-up is complete. However, overall, the delay in the development of this data collection tool, in addition to the other identified areas for improvement in the risk assessment report, resulted in the provision of a foundation for future public health incidents which are unique in nature. The risk assessment report provides topics for consideration to be able to make appropriate decisions and management plans when faced with a complex, time-sensitive event which needs immediate attention in the future.

While areas for improvement have been identified, the response did indeed succeed in a number of areas. Contacts that were exposed to the original case were identified for follow-up. These contacts were contacted for testing, clinical review, and treatment, and will continue to be monitored as required. Additionally, several pieces of documentation were revised or developed in response to this incident. These guidelines and resources will prepare response teams to provide appropriate support for similar, future events.

Conclusion

The response to a complex TB contact tracing and screening incident in NSW led to the identification of several areas for improvement in follow-up practices. Delays were encountered in the contact screening process which had the possibility of life-threatening consequences for immunocompromised contacts. The identification of several areas for improvement from this incident provides suggestions for consideration in the instance of a similar event. Discussions should be prompted regarding current TB guidelines and available resourcing in the event of large public health incidents such as this. It is the hope that the documentation of identified issues and the provision of potential solutions may result in procedural or policy change in the management of similar large and uncommon public health incidents.

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Appendices

A risk assessment for the contact investigation and follow-up screening of an active case of tuberculosis amongst ultra-high risk contacts in Western Sydney, New South Wales

Introduction

The purpose of this document is to identify, describe, and propose solutions for the key risks, and challenges in the management of tuberculosis (TB) contact tracing investigation and screening in a healthcare facility involving immunosuppressed patients. This document refers to the process, which was undertaken leading up to, and during, the baseline phase of contact screening for an active case of pulmonary TB in Western Sydney (WS) Local Health District (LHD), New South Wales.

WSLHD is a region which is comprised of a highly multicultural population, with an increasing number of migrants from countries with a high TB burden.[1,2] The population growth in WS is projected to continue with increasing migrants from these countries.[1,2] It is therefore likely that similar incidents will occur within healthcare settings. Timely contact investigations and follow-ups are essential to minimise any negative effects of a delayed response and prevent further TB transmission. Limited literature on similar incidents makes the documentation of the processes undertaken essential to improve upon or establish specialised protocols for use during future incidents.

Five key challenges have been identified which include stakeholder engagement, human resourcing, data management, contact management, and communications. The following pages describe the key risks identified, processes which were initially undertaken, any resulting issues that developed due to said initial processes undertaken, and mitigation strategies. Mitigation strategies have been presented to enable development of strategies for more efficient case and contact management in the event of the reoccurrence of a similar acute public health exposure in the future.

i. Stakeholder Engagement

i.a. Risks identified

1. Identification of stakeholders

All relevant stakeholders needed to be engaged to participate in the active management of the contact investigation, clinical screening, and case management.

i.b. Processes undertaken

1. Decisions of who to approach were made by the Western Sydney Public Health Unit (WSPHU) director. The Westmead core TB management group was convened. The New South Wales Health System Support Group (HSSG) TB Program convened the TB expert panel for consultation on key risk assessment and management decisions. Finally, following discussions between the core group and the expert panel, a clinical Multi-Disciplinary team (MDT) was assembled to review and oversee the management of contacts with complex medical backgrounds at a weekly clinic.

i.c. Resulting issues

The WSPHU managed the identification and assemblage of the core group. Core group members participated in the expert panel, and key clinical representatives from the core group identified members for the MDT. No resulting issues were identified in this instance and the identification of stakeholders was conducted in a timely manner.

i.d. Mitigation strategies

Protocols should be established and documented on critically required roles and/or personnel for stakeholder engagement. Contact with potential stakeholders should be made within one working day of case notification, with first meeting occurring within the first week. Discussions on additional expert personnel or stakeholders to include should be discussed at this point in time given the complexities and needs of the individual risk exposure.

ii. Human Resourcing

ii.a. Risks identified

1. The additional burden on current internal staffing resources.

The size of the contact tracing activity identified the urgent need for additional human resources to perform administrative, logistical and clinical duties. Key tasks that were required (in some cases needing specialised staff) were database creation and data management, contacting identified contacts of the index case via letter mail-out and follow-up telephone calls, follow-up calls to arrange necessary screening tests, and logistics in organising and staffing additional clinic appointments, for clinical review and ad-hoc screening clinics.

2. The need for additional clinical and laboratory staff.

Additional clinical staff was needed to perform clinical examinations and additional staff hours were required to process an increased volume of laboratory samples.

ii.b. Processes undertaken

1. Current staff were requested to assist where available. The WSPHU was requested to provide surge capacity.

2. Specialised clinical staff were sourced based on expertise, often requested to assist in additional to regular duties.

3. NSW Health staff employed in other jurisdictions (NSW TB Program and Northern Sydney LHD) were recruited to assist with screening clinics and data entry.

ii.c. Resulting issues

The ad-hoc nature of surge staff provision and the delay in formal resourcing of additional staff was a major challenge in managing the contact tracing effort. Timelines for contact follow-up and screening were extended due to staffing capacity and staff also trying to maintain 'Business as Usual'. This led to the inability to provide the ideal screening protocols, including the administration of a baseline tuberculin skin test (TST) in conjunction with an Interferon-Gamma Release Assay (IGRA) blood test as per the advice of the TB Expert Panel and NSW TB Contact Investigations guidelines (currently awaiting final approval).[3]

ii.d. Mitigation strategies

Upon notification of an index case and an assessment of the expected scope of the contact tracing activities, an assessment of current staffing availability and likelihood of workforce stress should be undertaken by the stakeholders. This assessment would need to be escalated and actioned by facility management executives to identify how to provide additional resources and support. There should be a formal funding pool that is reserved for urgent public health risk events, which may need to be a joint consideration by LHDs and the MOH. This would remove the financial barriers that often delay the approval and recruitment of additional staff.

There should be a mechanism developed and agreed upon, including the identification of possible funding sources, to allow for the timely identification and recruitment of expert staff from other NSW Health jurisdictions to assist with public health risk events

iii. Data Management

iii.a. Risks identified

1. Multiple sources of data and lack of master copies

Due to the nature of project, line lists of patients from multiple clinical departments were circulated amongst numerous stakeholders, which could cause confusion. No protocol was developed or used regarding the labelling, saving, and distribution of data. There is no current NSW standard mechanism for recording contacts of TB screening.

2. Database creation

A database was needed to capture case and contacts' personal, clinical, and travel history, document the timing and results of TB screening and record clinical assessment, management and outcome of each contact. There were 2 main objectives for the database – for public health contact assessment and for systematic recording of complex contact clinical history and management plans. Due to the urgency to commence the contact tracing activity, a number of tools were used for data management. Excel spread sheets listing all contacts, their unique hospital identifier, duration, site and dates of exposure were created. A TB contact management spreadsheet was developed which included contact details, their risk categorisation and details of screening tests. Finally a REDCap database was created to capture essential information for clinical decision making.

3. Unknown reporting needs and required outputs

No current method of tracking the progress of all index case contacts was identified. The identification of which specific details to be included in clinical and contact tracing summaries needed to be identified and agreed upon for fortnightly stakeholder meetings, to assess progress of follow-up efforts.

iii.b. Processes undertaken

1. Documentation was circulated ad-hoc without consistent labelling.

2. Excel spread sheets and a REDCap database were produced based on initial purpose and to communicate key information.

3. Reporting needs were identified early on based on a previous large TB screening event, however no consensus was made on specific information to be included in such reports. As a result, no data-specific reports or processes for situational updates were produced.

iii.c. Resulting issues

1. There was some confusion over what the most up to date documents were, and in some cases this resulted in old data being referenced or referred to, resulting in inconsistent and/or incorrect data being collected.

2. The REDCap database needed to be re-developed to combine information from the excel spread sheets in the clinical management system, based on re-defined contact risk-level definitions, the specific needs of exported reports based on preparing clinical and contact investigation summaries, possible future research outputs, and user-friendliness of the database. Complex screening algorithms were reviewed to incorporate skip logic in the flow of questioning in the database for accurate representation of contacts' pathways and clinical screening statuses. A resulting loss of approximately 4 weeks' time resulted from the generation of the final REDCap database for the needs of the project and its outputs.

Additionally, as a result of not testing the database thoroughly, through the data entry process it was identified that several skip logic functions were limiting the entry of testing results. This resulted in a loss of approximately one week of time.

3. The development of clinical and contact investigation summary reports needed approximately two weeks' time to develop. This time period added to the delay in producing a comprehensive database, delaying the data entry process further.

4. The REDCap database is hosted on a University of Sydney server, not within the NSW Health firewall. This lead to a requirement to de-identify the patient records, making identification of contact records more difficult and potentially leading to data entry errors.

iii.d. Mitigation strategies

1. Stakeholders should discuss proper protocols for saving and circulating most recent data for use. A single source of truth should be identified for all documents and labelled accordingly. If time and resources are available, a single data manager should be allocated who other team members can forward data queries to.

2. A dedicated staff member should be allocated to the creation and management of the database. A needs assessment should be undertaken to identify the purposes for the database, and ways in which the data will ultimately be used to develop a cohesive database. It is appropriate to consider the purchasing of REDCap memberships by NSW Health to be able to provide a widely-accessible data management system for future instances of urgent contact investigation and follow-up. The current contact tracing database design can be shared across the TB and public health network to provide a modifiable template that can be adjusted to suit individual needs.

3. Stakeholders should meet in the early period of index case notification to discuss the overall tracking of contact data management. Methods of production or extraction of this information should be discussed and assigned to a staff member for completion.

iv. Contact management

iv.a. Risks identified

1. Risk classification definitions and prioritisation specific to this incident

A clearly defined set of risk categories and classifications for all contacts of the index case is needed, based on their exposure status and medical status.

2. Adverse event monitoring for drug interactions

Contacts placed on preventative tuberculosis treatment should be monitored. The clinical management of these contacts needs prioritisation and extra resources to manage them for large investigations, particularly with contacts who are more likely to have drug interactions.

iv.b. Processes undertaken

1. High, medium, and low risk categories were identified based off of NSW Health documentation and expert review.

2. A multidisciplinary team was organised to review complex case management decisions and review case care and progress.

iv.c. Resulting issues

1. For this event, the complex backgrounds and exposure periods for index case contacts required more clearly defined risk categories, with the addition of a fourth ultra-high risk category for clarification regarding follow-up. Redefinition of risk categories resulted in database modification and the re-assessment of each contact to re-categorise their assigned risk level. As a result, some clinical data in the new database needed to be re-entered.

iv.d. Mitigation strategies

1. At the initial stakeholder meetings, discussions should continue to occur around the proper prioritisation of contacts based on clinical consequences, exposure periods, and current, document risk-level criteria. Agreement should be made within the group as to definitions which will be used for the entirety of the follow-up procedures for consistency.

v. Communications

v.a. Risks identified

1. Internal communications between stakeholders

There is a need to oversee the delegation of roles and responsibilities to ensure staff understand the designated task and have all the necessary information to complete

the task and they are followed up to ensure task completion. During urgent and high stress incidents, staff may unknowingly miss a delegated task that is not routinely allocated to them. Due to the volume of communication (emails and phone calls) and the focus of the group being the high priority patients, there was a delay and misunderstanding of who would follow-up staff contacts.

2. Initial contact with identified index case contacts

Index case contacts received letters, requests for clinical testing, and telephone calls from varying sources and at different time points, causing confusion and concern. Poor staff resourcing and support may have contributed to these actions.

3. Media

A decision on the need to provide a statement to the media of the incident needed to be made. If provided, consequences including creating public alarm and/or the additional need for staffing resources to be provided to respond to individual queries.

v.b. Processes undertaken

1. The creation of a Westmead core TB management group identified the need to meet and discuss incident-related issues on a fortnightly basis. A core email group was also created to share information and obtain clarification if needed. While both the group meetings and email exchanges allowed for the dissemination of relevant information, the oversight in follow-up of staff contacts was still missed.

2. Index case contacts, especially those of ultra-high risk, had previously been instructed to manage aspects of their healthcare with their regular healthcare team.

Ideally all initial communication for the ultra-high risk contacts about the incident and each contact's possible exposure should have been discussed by their usual healthcare team. However, given limited staffing resources and the urgent timelines for initial communications, a number of index case contacts received letters, requests for clinical testing, and telephone calls from varying sources, causing confusion.

3. Discussions were undertaken on the need to provide the media with a statement regarding the incident. A number of factors contributed to the decision to take a non-proactive approach to alerting the media.

- All case contacts were able to be identified through hospital appointment records.
- Case contacts were in the process of being informed of their exposure and testing requirements. It was deemed inappropriate for case contacts to receive initial contact from the media instead of their healthcare providers or a member of the management team.
- There was no further or ongoing risk to the general public.
- No details of the incident had been unofficially circulating, taking the pressure off the need to provide a public statement identifying the facts of the situation.

As a result, a holding statement was prepared in case there was a need for distribution as per usual practice.

v.c. Resulting issues

1. Staff were unclear of exactly how contact tracing would be performed across the various departments involved (renal, TB service, Public Health and Infection Control), resulting in delays of contacting index case contacts.

2. Low staff resourcing resulted in the need for a number of stakeholders to initially contact the index case contacts.

3. At time of writing, no statement has been needed to be released to the media. No resulting issues have been identified thus far.

v.d. Mitigation strategies

1. Individual(s) need to be identified or sourced to manage roles and responsibilities. This individual(s) will need to assess task completeness and ensure the satisfactory progression of the incident follow-up. Additionally, a key contact within each key centre needs to be identified to which any internal or external queries are directed.

2. Previously defined procedures for initial communication with index case contacts should be adhered to, ensuring the most streamlined, efficient, and timely follow-up possible. Dedicated staff within identified primary providers' clinics need to be resources or supported to conduct the initial communications and follow-up with identified index case contacts.

3. Future incidents of similar nature may require a media statement to be released due to the individuality of each outbreak and its management. It is suggested that a non-

proactive approach be considered in the future, unless deemed inappropriate based on the parameters of the individual incident.

References

1. NSW Health. Tuberculosis 2012-2014 [Internet]. 2018. Available from: https://www.health.nsw.gov.au/Infectious/tuberculosis/Documents/tb-report-2012-14.pdf
2. Norton S, Bag SK, Cho JG, Heron N, Assareh H, Pavaresh L et al. Detailed characteristics of the tuberculosis epidemic in Western Sydney, draft publication.
3. NSW Health (2018 – draft publication) Tuberculosis Contact Investigation Guidelines.

Appendix 5.B: Patient Letter

Health
NSW Government
Western Sydney
Local Health District

14th May 2018

Patient ID: «MRN»

Western Sydney LHD Tuberculosis Services
Parramatta Chest Clinic
162 Marsden Street, PARRAMATTA 2150
p. 9843 3110 | f. 9843 3116
e. wslhd-parramatta-chestclinic@health.nsw.gov.au

«Given_Names» «SURNAME»
«ADDRESS»
«Suburb» «PC»

Dear «Given_Names»,

The Western Sydney Tuberculosis Service has been notified that you have been in contact with a person diagnosed with infectious tuberculosis (TB). Our role is to coordinate the screening of people exposed to the TB case so that anyone infected is identified as early as possible and offered preventive treatment.

This is a free and confidential service.

In this case, the risk of the disease having spread has been assessed as **medium**. We recommend that you have a blood test for TB – ***QuantiFERON TB Gold Plus® (QFT-Plus)***. This test requires a small volume of blood (4mL) to be drawn. This test should be done at your next scheduled blood test or in the next 2-3 weeks, whichever comes first. Ideally, this blood test should be done at Westmead Hospital.

What do I need to do?

1. ***Read this letter and the enclosed information carefully***
2. ***Book in for the QFT-Plus blood test – contact the Renal Clinic on 8890 6681 to make an appointment***
3. ***Complete the questionnaire and return it to Parramatta Chest Clinic***

The QFT-Plus test will be repeated in approximately three (3) months, at the end of the 'incubation period' to assess whether you've been infected.

All people with "positive" test results will be referred for a chest x-ray and then be reviewed by a specialist physician to determine your individual risks and prescribe preventive therapy if required.

All tests and any subsequent follow-up are free of charge.

Please read carefully all enclosed documents, then complete the health questionnaire also enclosed. Once complete, please scan or take a photo and return this questionnaire to the Chest Clinic email – see above. Alternatively, you can post the completed questionnaire to the clinic address.

Further information about TB is available on the NSW Health website (in English and other languages): http://www.health.nsw.gov.au/Infectious/tuberculosis/Pages/tuberculosis-factsheets.aspx

If you have any further questions about TB or the screening process, please don't hesitate to phone me on 9843 3110 or via email (above).

Yours sincerely,

Evan Ulbricht
TB Area Coordinator / Clinical Nurse Consultant
Western Sydney TB Services

Appendix 5.C: NSW Health TB Contact Investigation Questionnaire

Health Questionnaire – TB Contact Investigation

NSW Health Western Sydney Local Health District

Please answer the following questions prior to attending clinic for the screening blood test.

Current Symptoms

1. **Do you currently have a cough that has lasted longer than 2 weeks?** *Yes ☐ No ☐*
   a) **If yes, have you had any episode of haemoptysis (coughing up blood)?** *Yes ☐ No ☐*
2. **Have you had fever or night sweats in the past month?** *Yes ☐ No ☐*
3. **Have you had any unexplained weight loss in the past month?** *Yes ☐ No ☐*
4. **Any other concerning symptom(s) in the past month?** *Yes ☐ No ☐*

If Yes, please provide detail

Background History

What is your country of birth? _____

Have you ever lived or travelled overseas? *Yes ☐ No ☐ If Yes, please provide detail*

Year of Travel	*Country(ies) visited*	*Duration of Stay*

Do you have any medical conditions or are you on any treatment that affects your immune system? *Yes ☐ No ☐*
If Yes, please provide detail

eg. History of cancer, HIV, diabetes, kidney disease, organ transplantation

TB History

A. **Have you ever been diagnosed / treated for active TB disease?** *Yes ☐ No ☐*
B. **Have you ever been diagnosed / treated for latent TB infection?** *Yes ☐ No ☐*
C. **Have you ever had contact with a person with TB?** *Yes ☐ No ☐*
D. **Have you ever been tested for TB?** *Yes ☐ No ☐*
E. **Did you have BCG (TB) vaccination when a child?** *Scar on upper arm?* *Yes ☐ No ☐*

If you answered yes to any of the above questions, please provide further information, including the date and type of treatment, contact with a person known to have TB, results of any previous tests for TB or location of BCG scar

Thank you for completing this health history.

Please either scan or photograph the completed questionnaire and email to wslhd-parramatta-chestclinic@health.nsw.gov.au or mail to Parramatta Chest Clinic, 162 Marsden Street, Parramatta NSW 2150

Appendix 5.D: Samples of REDCap Database Demographic, Clinical Background, Screening, and Treatment Questions

Study ID	317
Demographic Characteristics	
Contact Name (deidentified)	
Gender * must provide value	○ Female ○ Male reset
Year of birth	
Age in years	
Exposure	
Which index case was this contact exposed to? (Can select both if required)	☐ Index Case La Es ☐ Index Case Ra Da
Risk group * must provide value	○ High ○ Low ○ Medium ◉ UltraHigh reset
Has 'Risk group' been updated?	○ Yes ○ No ○ Not needed reset
Ultra-high risk group category	○ Renal transplant patient ○ Renal non-transplant patient with immunosuppression ○ Urology patient with immunosuppression reset
Relationship to case	○ Household ○ Workplace ○ Educational ○ Healthcare ○ Institutional ○ Social ○ Other reset
Initial exposure date	○ 24/01/2018 ○ 19/02/2018 ○ 19/03/2018 ○ 20/03/2018 ○ 4/04/18 ○ 6/04/2018 ○ 7/04/2018 ○ 9/04/2018 ○ 18/04/2018 ○ 19/04/2018 ○ 23/04/18 ○ 30/04/2018 ○ 1/05/2018 ○ 2/05/2018 ○ 3/05/2018 ○ 8/05/18 reset

Are you Aboriginal or Torres Straight Islander?	(•) No ( ) Yes ( ) Declined to answer reset
Have you ever lived or travelled overseas?	( ) No (•) Yes reset
Year of travel	2015
Countries visited	Vietnam Expand
Duration of stay	21 days
Year of travel	
Countries visited	Expand
Duration of stay	
Year of travel	
Countries visited	Expand
Duration of stay	
Do you have any medical conditions or are on any treatments that affects your immune system?	(•) No ( ) Yes reset
Have you ever been diagnosed/treated for active TB disease?	(•) No ( ) Yes reset
Have you ever been diagnosed/treated for latent TB infection?	(•) No ( ) Yes reset
Have you ever had contact with a person with TB prior to this exposure at Westmead Hospital?	( ) No (•) Yes reset
Have you ever been tested for TB before May 2018?	( ) No (•) Yes reset
Did you have BCG vaccination as a child?	(•) No ( ) Yes reset

Study ID	317
Date of first screen?	04-09-2018 Today D-M-Y
Has first IGRA testing been completed?	◉ Yes ○ No reset
Date of first IGRA testing?	Today D-M-Y
Outcome of first IGRA testing?	◉ Positive ○ Negative ○ Indeterminate reset
First IGRA Tb Ag1 value	
First IGRA Tb Ag2 value	
First IGRA mitogen value	
Has first CXR and symptom check been completed?	○ Yes ◉ No reset
Has a TST been completed?	◉ Yes ○ No reset
Date of TST?	04-09-2018 Today D-M-Y
Result of TST?	○ <5 mm ◉ 5-9 mm ○ 10-15 mm ○ >15 mm reset
Exact TST result value	8 mm
Decision of outcome of TST?	◉ Positive ○ Negative reset
Has contact completed a MDT Clinic Review?	◉ Yes ○ No reset
Date of MDT clinic review ?	04-09-2018 Today D-M-Y
Location of MDT Clinic Review?	◉ Multidisciplinary team (MDT) clinic, Westmead ○ Chest clinic ○ ID clinic ○ Renal clinic ○ Other reset
Anything worth noting from MDT clinic review?	Expand
Has the contact completed a sputum and/or Bronchoscopy?	○ Completed ○ Not required

Study ID	317
Outcome of Screening?	◉ Active TB ○ Latent TB ○ Screening negative ○ To be determined ○ Other reset
Is the active TB pulmonary or extrapulmonary?	◉ Pulmonary only ○ Extrapulmonary only ○ Both pulmonary and extrapulmonary reset
Date of diagnosis of Active TB	04-09-2018 Today D-M-Y
Please list symptoms at diagnosis	☐ No symptoms ☑ Fever ☐ Weight loss ☐ Cough ☐ Haemoptysis ☐ Pain ☐ Mass ☐ Finding on imaging
What sample was this diagnosis made on?	☐ No positive sample ☑ Sputum ☐ Induced sputum ☐ BAL ☐ Lymph node ☐ Urine ☐ Biopsy of other tissue
What test was positive on this sample?	☐ ZN stain ☑ Mycobacterial culture ☑ Mycobacterial PCR ☐ Granulomas on histology
Was this isolate shown to be molecularly the same as the source TB strain, and if so, to which index case?	◉ Yes, Index Case 1 ○ Yes, Index Case 2 ○ Unrelated Strain ○ Results to be determined reset
What treatment was given for Active TB?	☐ Rifabutin ☑ Rifampicin ☐ Pyrazinamide ☐ Ethambutol ☐ Moxifloxacin ☐ Other
Please list any adverse effects that occurred during treatment.	☑ None ☐ Hepatotoxicity ☐ Rash ☐ Drug interaction ☐ Gout ☐ Ocular toxicity ☐ Neuropathy

Appendix 5.E: Ultra-high Risk Contact Tracing Summary Report

Ultra-High Risk Patient Summary

	Total	Group 1	Group 2
# in ultra-high risk category at start of reporting period	152	13	3
# needing no further follow-up (closed)	2	0	2
Revised # to be followed up in subsequent reporting period	150	13	1

Screening

Group 1 Contacts – Requiring 2nd Screening - <56 days since exposure
Total Number of ultra-high risk Group 1 contacts: XX

Screening test	Total Tested this Period	Positive	Negative	Indeterminate	Cumulative # Tested to Date
First IGRA testing	13	0	13	0	13
Repeat IGRA testing *(contacts with indeterminate results)*	0	0	0	0	0
Initial TST testing *(contacts with negative or indeterminate results)*	6 (1 no result)	0	5		6
	Total Reviewed this Period	**Total Needing Review**			**Cumulative # Reviewed to Date**
MDT Clinic Review	0	0			0

Group 2 Contacts – Requiring no further screening - >56 days since exposure
Total Number of ultra-high risk Group 2 contacts: XX

Screening test	Total Tested this Period	Positive	Negative	Indeterminate	Cumulative # Tested to Date
First IGRA testing	89 (86 unspecified group)	7	75	4	89
Repeat IGRA testing *(contacts with indeterminate results)*	4(2 no result)	0	1	1	4
Initial TST testing *(contacts with negative or indeterminate results)*	35	3	22		35
	Total Reviewed this Period	**Total Needing Review**			**Cumulative # Reviewed to Date**
MDT Clinic Review	2	2			2

Treatment and Prophylaxis

LBTI

No. of final screenings that were determined as having LTBI	N/A
No. of final screenings commenced on	N/A

No. of final screenings commenced on regular observation follow-up	N/A

ACTIVE TB

No. contacts with active TB development	N/A
No. who have commenced treatment	N/A
No. with results genetically linked to case 1	N/A
No. with results genetically linked to case 2	N/A
No. with specimens that are unrelated to case 1 or 2	N/A
No. with genetic links of specimen to be determined	N/A

Appendix 5.F: Ultra-high risk clinical summary report

Ultra-High Risk Clinical Summary (renal transplant, renal non-transplant w/immunosuppression, urology w/immunosuppression)

Summary	Total	Action Summary for Next Screening Period	Total
Total number of contacts at the start of this screening period needing testing	152	Total number needing CXR & symptom checks	80
Total number tested this period	102	Total number needing TST test	
Total number overdue for testing this period	50	Total number needing IGRA #2	2
Total number needing testing next screening period (inclusive of overdue)	138	Total number needing MDT clinic review with/without Sputum+/- Bronchoscopy	1
		Total number needing CXR every 2-3 weeks	27

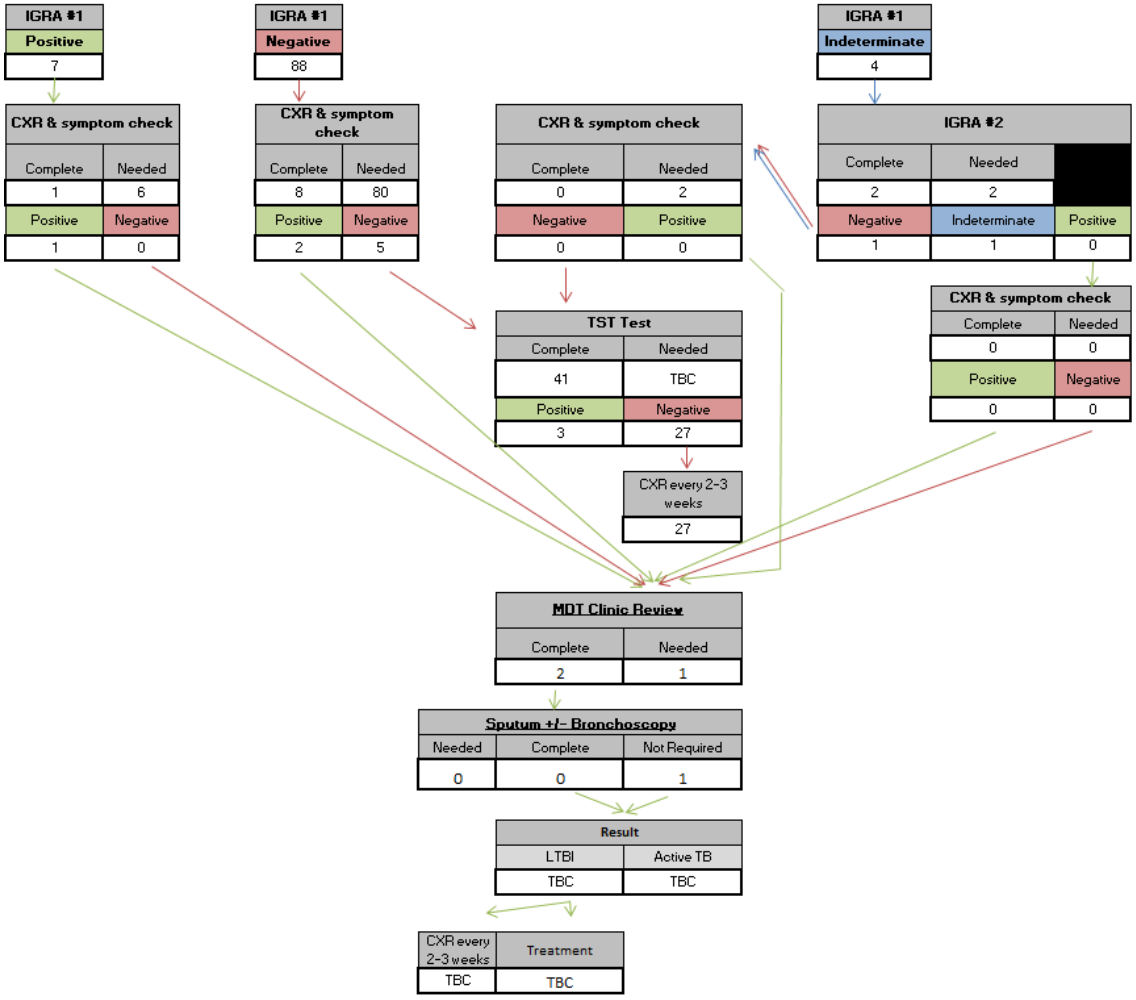
Testing Outcomes and Treatment Summary

Active TB			
Total	Treatment	Surveillance	Closed
TBC			

Latent TB			
Total	Treatment	CXR Surveillance	Closed
TBC			

Negative
Total

Needing Interpretation
Total


IGRA #1
Positive
7
IGRA #1
Negative
88
IGRA #1
Indeterminate
4
CXR & symptom check
Complete
Needed
1
6
Positive
Negative
1
0
CXR & symptom check
Complete
Needed
8
80
Positive
Negative
2
5
CXR & symptom check
Complete
Needed
0
2
Negative
Positive
0
0
IGRA #2
Complete
Needed
2
2
Negative
Indeterminate
Positive
1
1
0
CXR & symptom check
Complete
Needed
0
0
Positive
Negative
0
0
TST Test
Complete
Needed
41
TBC
Positive
Negative
3
27
CXR every 2-3 weeks
27
MDT Clinic Review
Complete
Needed
2
1
Sputum +/- Bronchoscopy
Needed
Complete
Not Required
0
0
1
Result
LTBI
Active TB
TBC
TBC
CXR every 2-3 weeks
Treatment
TBC
TBC

6. Teaching Sessions

Lesson from the Field &
A Case Study Teaching Session

6. Teaching Sessions

Prologue

Background

The Master of Applied Epidemiology (MAE) program requires all students to develop and conduct two teaching sessions; the first, a Lesson from the Field (LFF) session, was presented to several members of my cohort while the second, a Case Study Teaching Session, was presented to the first year MAE cohort.

My Role

For the LFF, my role included identifying an issue which I encountered in the field which I acknowledged as challenging, and which I believed others could benefit from. I developed a lesson plan, mock dataset, and a worksheet for members of my cohort to complete. Lastly, I coordinated and facilitated a teaching session to complete the activity.

For the first year MAE teaching session, I was involved with the development of the teaching topic, preparation of teaching materials and PowerPoint slides, presentation of lecture material, and facilitation of the teaching session.

Lessons Learned

I had casually taught in group sessions previously; sessions which did not require a structured lesson plan. I enjoyed being able to go through the processes of understanding why a topic is taught and the preparation it requires. I learned to appreciate the time and consideration it takes to develop a thoughtful teaching

session. In addition, I was able to practice my skills in group discussion facilitation and public presentations.

I also found it challenging, yet rewarding, to teach others a new skill, having to start from basic level knowledge and build up to more complex topic points. Through the development of the sessions, my knowledge on the topic areas was also solidified, and I was able to explain complex methodologies simply.

Public Health Implications

While there were no direct public health implications as a result of these two teaching sessions, I hope that the lessons taught to both members of my LFF session and the first year MAE cohort will improve the quality and soundness of their future public health work. Additionally, I was able to gain teaching experience, which I hope in the future will allow me to contribute to the education of students in the field.

Acknowledgements

I would like to acknowledge Julia Maguire, Kaitlyn Vette, and Brigitta Osterberger, whom I collaborated with in the development and preparation of the teaching session presentation to the first year MAE cohort. I would also like to acknowledge my ANU supervisor Martyn Kirk for his guidance on developing a lesson plan for my LFF activity and my field placement supervisors Aditi Dey, Frank Beard, and Helen Quinn for their support.

Lesson from the Field

The subject topic for my LFF came from a methodological challenge I faced during the design process of my epidemiology project: *Australian Immunisation Register Data Transfer Audit - Stage 2*. While developing the methodology for the study, I knew I was going to be faced with identifying stratified sample sizes based on multiple layers. Previously I had learned how to calculate sample sizes for single random samples, but was left feeling unprepared when having to calculate stratified sample sizes.

Through searching relevant literature and consultation with ANU biostatisticians and field placement supervisors, I was able to determine the appropriate methods to derive the required sample sizes to conduct the study. I was also able to calculate the corresponding weights which would need to be added during the data analysis phase of the study as well.

The skills I gained during this process are applicable to future studies which I may undertake, and thus I felt that these were valuable skills to share with my cohort. As such, I developed my LFF session around the principles of stratified sample sizes and weighted analysis. The aims of the session were for the participants to be able to:

- derive stratified sample sizes and weights for application to analyses
- understand why weighting is important during some analyses
- derive weights to be applied during analyses
- conduct statistical analyses using weighted data
- interpret results from weighted analyses

I developed a scenario-based activity which was to be used to calculate simple stratified sample sizes and corresponding weights (Appendix 6.A), a dataset which would be used in conjunction with STATA statistical software, and identified several reference resources. Several questions were asked to the participants which challenged their knowledge of the application of the techniques used, as well as how to interpret the findings from the analyses.

Overall the LFF session was received very well by the participants, with feedback given that it was a useful skill to have acquired for their careers. Many of them had not yet undergone sample size calculations and viewed this exercise as a valuable resource to revisit when needed.

Case Study Teaching Session

Being able to teach the first year MAE cohort was an opportunity to identify any gaps in the teaching of my cohort which we thought would be beneficial to their knowledge. My team and I discussed several issues which we encountered in our work during our first year at our field placements which we felt would have been valuable to know prior to starting any projects. We decided that it would be useful to understand the purpose of, and how to properly write, participant information sheets, and to understand the ethical considerations which need to be reviewed in their development and use.

Our group produced and presented a PowerPoint lecture (Appendix 6.B) which included the aims of the session, essential components of a participant information sheet, key ethical considerations when developing a participant information sheet, and additional resources, including Australian National University guidelines. Additionally, we created an activity sheet and model answers which was used to test the skills taught to the cohort (Appendix 6.C).

After the teaching session, a group evaluation was distributed via Survey Monkey to both the first year MAE cohort for their feedback (Table 1), as well as to the second-year cohort for peer-review feedback (Table 2). Some of the written feedback of what the students learnt from the sessions included:

"*Different ways of engaging the audience especially when everyone is exhausted at the end of a long few weeks. Video and interactive sessions are really useful. I also learnt a lot of new content such as logic models, writing tips and informed consent.*"

“I really liked all the hands-on activities, that the information wasn't provided during course block and came from experience.”

Table 1: First Year MAE Scholar Feedback

Question	Highly useful	Useful	Neutral	Not very useful	Not useful at all
How did you find the format of the session?	2	8	4	0	0
How did you find the presenter's style?	2	7	5	0	0
How did you find the session content?	1	9	4	0	0

Table 2: Second Year MAE Scholar Peer Feedback

Question	Highly useful	Useful	Neutral	Not very useful	Not useful at all
How did you find the format of the session?	8	5	0	0	0
How did you find the presenter's style?	8	5	0	0	0
How did you find the session content?	10	2	1	0	0

Appendices

Appendix 6.A: Scenario-based Lesson From the Field Activity Worksheet

Stratified Sample Sizes and Weighted Analysis

> The corresponding zoom teleconference has been arranged for 15th March at 11:00 am AEST. Please contact me if you have not received the details.

Instructions: This lesson contains two sections. Section 1 contains a scenario in which you must develop stratified sample sizes and calculate the appropriate weights to add during analysis. Section 2 contains a STATA module in which you will apply these weights and conduct your analyses.

Learning Objectives: By the end of this lesson from the field you should be able to:

- Derive stratified sample sizes and weights for application to analyses
- Understand why weighting is important during some analyses
- Derive weights to be applied during analyses
- Conduct statistical analyses using weighted data
- Interpret results from weighted analyses

Resources: Please read the following on stratified sample sizes and re-visit the following resource available on Wattle:

1. Housen T. Weighted Analysis. Lecture presented at; 2017; Australian National University.

2. Stratified random sampling [Internet]. Lærd Dissertation. [cited 1 February 2018]. Available from: http://dissertation.laerd.com/stratified-random-sampling.php#step6

Section 1: Stratified Sample Selection and Calculation of Weights for Analysis

Scenario Part 1: The Department of Health (DOH) has received a high number of phone calls from practitioners complaining of a higher than normal incidence of illness in those aged 50 years and over due to the influenza virus, for 2017. This concerns DOH because a new influenza vaccination program was recently implemented to increase influenza vaccine coverage. You, as an epidemiologist in training, have been given the task to review the data geographically by influenza vaccination coverage level in NSW to see if being in a low, medium, or high coverage area is associated with contracting influenza after receiving a vaccination. You calculate your total sample size to be 100 randomly selected individuals from the NSW population, of those aged 50 years and over. From prior experience, you also know that in NSW, high coverage post codes are the most common, followed by medium, and then low. You also know that coverage levels are defined as:

High: ≥95%

Medium: 90-<95%

Low: <90%

To compensate for this, you decide that 50% of all included records will originate from low coverage areas, medium coverage areas will contribute 30%, and high coverage areas will contribute 20%. You also decide that you will divide all records into 3 age groups of 50-64, 65-84, and 85+ year olds. You look up Australian Bureau of Statistics population data and calculate that of the population in NSW of this age range, 40% are 50-64, 36% are 65-84, and 24% and 85+.

Task 1: Given the sample size required, proportions needing to sample by, coverage level categories, true population proportions, and age groups, calculate and fill in the table below with the required numbers needed per age group in each coverage level to complete your analysis[1].

Low Coverage			Medium Coverage			High Coverage		
50-64	65-84	85+	50-64	65-84	85+	50-64	65-84	85+
20	**18**	**12**	12	11	7	8	7	5

Example: Low Coverage:

1. 50% of 100 total records = 50
2. For 50-64 yrs, 40% of true population applied to 50 records = .4*50 = **20**
3. For 65-84 yrs, 36% of true population applied to 50 records = .36*50 = **18**
4. For 85+ yrs, 24% of true population applied to 50 records = .24*50 = **12**

Question 1: Now that you know what sample requirements you have, you need to calculate a weight to apply to each record during analysis. Without this weight, what will happen to the results of your analysis?

Results would not be generalisable to the true population of NSW, only to that within the weighted sample population.

Task 2: Open up your excel dataset titled 'NSW_Flu_Data'. You notice you have the variables ID, Postcode, Age in Years, Indigenous, Vaccinated, DevelopedFlu, and Coverage.

You must now calculate the required weights to be applied during analysis to each record based on its low, medium, and high coverage level status *(Hint: All unique postcodes in NSW are included in your dataset).*

Low Coverage Weight:

1. Calculate the proportion of low coverage postcodes in NSW/total unique postcodes in NSW. 11/38 = 28.95
2. Divide this proportion by the weight applied to the low coverage group. 28.95/50 = **0.58**

Medium Coverage Weight:

12/38=31.58

31.58/30=1.05

High Coverage Weight:

15/38=39.47

39.47/20=1.32

Now that you have your weights, you are now ready to analyse your dataset. Please move on to **Section 2**.

Section 2: Analysis of Weighted Data

Scenario Part 2: DOH is interested in descriptive data, as well as looking at whether Indigenous status, coverage level, and age were associated with individuals who contracted influenza based on their immunisation status.

Instructions: Import the excel dataset titled 'NSW_Flu_Data' in STATA. Also open up the word document titled 'Data_Dictionary'. You need to go ahead and get your dataset ready for analysis. Luckily, the dataset is already cleaned and ready to work with.

Task 1: With your data dictionary, re-label the variables Indigenous, Vaccinated, and DevelopedFlu with the STATA code below:

```
label define indig 1 "Indigenous" 2 "Non-Indigenous"
label values Indigenous indig

label define vacc 1 "Vaccinated" 2 "Unvaccinated"
label values Vaccinated vacc

label define flu 1 "Yes" 2 "No"
label values DevelopedFlu flu
```

Task 2: Using the STATA code below, you will now need to create the categorical variables 'Age_Group', 'Coverage_Level' (don't forget to round up! Ex: 91.5 rounds to 92!), and 'Outcome', and the numeric variable 'Weight'. Label your 'Age_Group' variable 50-64, 65-84, 85+. Label your 'Coverage_Level' variable Low, Medium, and High. 'Outcome' is a binary variable based on those who received a vaccination, whether they contracted influenza or not.

```
/*Generate 3 age groups and label them*/
```

```
generate age_grp=1 if AgeinYears <65
replace age_grp=2 if AgeinYears >64 & AgeinYears <85
replace age_grp=3 if AgeinYears >84 & AgeinYears <100
label define age1 1 "50-64" 2 "65-84" 3 "85+"
label values age_grp age1

/*Generate coverage level categories and label them*/
generate cov_level=1 if Coverage >94.4 & Coverage <100.0
replace cov_level=2 if Coverage >89.4 & Coverage <94.5
replace cov_level=3 if Coverage <89.5
label define cov1 1 "High" 2 "Medium" 3 "Low"
label values cov_level cov1

/*Generate weight variable*/
generate weight=1.32 if cov_level==1
replace weight=1.05 if cov_level==2
replace weight=0.58 if cov_level==3

/*Generate outcome variable*/
generate outcome=1 if Vaccinated==1 & DevelopedFlu==1
replace outcome=0 if Vaccinated==1 & DevelopedFlu==2
```

Task 3: 100 records need to be randomly selected for your determined sample sizes, which were based on the coverage and age requirements. For the purpose of this exercise only, run the following code in STATA.

```
sort cov_level age_grp ID
drop in 9/67
drop in 16/53
drop in 21/50
drop in 33/50
drop in 44/72
```

drop in 51/57

drop in 71/78

drop in 89/96

drop in 101/103

Task 4: Provide frequency counts of those in low, medium, and high coverage areas by vaccination status and whether they developed flu. Use the following STATA code:

sort cov_level

by cov_level: tab Vaccinated DevelopedFlu

Low Coverage

	Developed Flu		
Vaccination Status	Yes	No	Total
Vaccinated	3	13	16
Unvaccinated	7	27	34
Total	10	40	50

Medium Coverage

	Developed Flu		
Vaccination Status	Yes	No	Total
Vaccinated	3	11	14
Unvaccinated	4	12	16
Total	7	23	30

High Coverage

	Developed Flu		
Vaccination Status	Yes	No	Total
Vaccinated	1	9	10
Unvaccinated	2	8	10
Total	3	17	20

Question 2: How would you summarise the descriptive data above?

In low coverage areas, RR=0.91. In low coverage areas, individuals who received the vaccine had 0.91 times lower risk of contracting influenza than those who did not receive the vaccine.
In medium coverage areas, RR=0.86. In medium coverage areas, individuals who received the vaccine had 0.86 times lower risk of contracting influenza than those who did not receive the vaccine.
In high coverage areas, RR=0.5. In high coverage areas, individuals who received the vaccine had 0.5 times lower risk of contracting influenza than those who did not receive the vaccine.

Task 5: DOH is interested in whether Indigenous status, coverage level, and age were associated with individuals who contracted influenza based on their immunisation status. For this exercise you will need to conduct univariate logistic regression for each explanatory variable of interest against the outcome variable 'Outcome' to determine if each should be included in a base model. Fill in the table below. Use the following STATA code:

```
logistic outcome Indigenous [pw=weight]
logistic outcome i.age_grp [pw=weight]
logistic outcome i.cov_level [pw=weight]
```

Explanatory Variable	TOTAL OR (95% CI)	p-value
Indigenous Status		
Indigenous	0.5 (0.08-3.01)	0.45
Age Group		
50-64	ref	ref
65-84	1.79 (0.25-13.04)	0.563
85+	0.75 (0.05-11.31)	0.023
Coverage Level		
High	ref	ref
Medium	2.45 (0.21-28.72)	0.474
Low	2.08 (0.18-24.03)	0.558

Question 3: Do you need to include weights at this stage and why or why not?

Yes, you need to include weights if you want your results to be generalisable to the true population.

Question 4: Were any of the explanatory variables significantly associated with individuals who contracted influenza who had received the vaccination ($p \leq 0.25$)? If so, which ones?

No, Indigenous status, age group, or coverage level were significantly associated with individuals who contracted influenza who had received the vaccination.

Question 5: Is there anything you can think of which may have influenced the results?

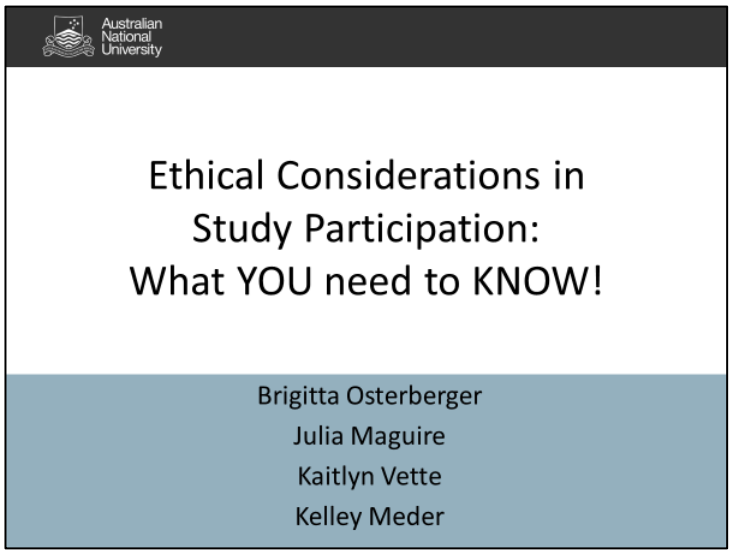
Out of the 100 individuals in the study, only 40 had an outcome status, thus reducing the sample size for the univariate logistic regression analyses. This reduction makes the results difficult to interpret.

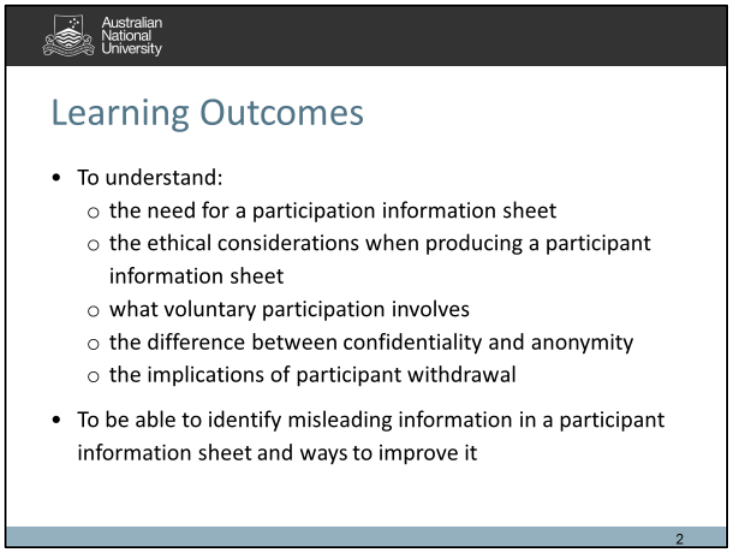
Conclusion: In a real life scenario you would continue the multivariate logistic regression model building process.

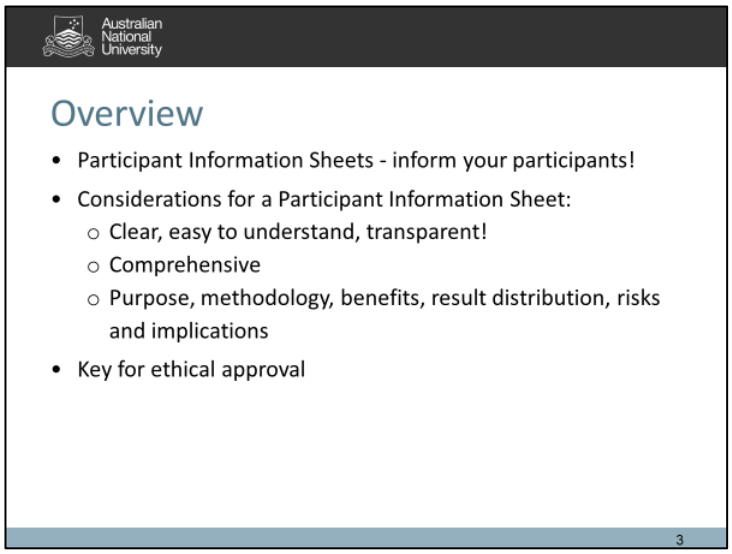
Additional Resource: The following resource may provide additional information if you wish to read more on weighted analysis and stratification.

Lee E, Forthofer R. Analyzing complex survey data. 2nd ed. Thousand Oaks (Calif.): Sage Publications; 2005.

Appendix 6.B: Presentation Slides for A Case Study Teaching Session







Australian National University

Confidentiality & Anonymity

4

Australian National University

Confidentiality & Anonymity

- Not the same thing
- Anonymous – cannot be identified
- Confidential – identifiable, but kept private
- Confidentiality can only be protected as far as the law allows
- It's ok not to protect confidentiality, as long as you are clear about it

5

Australian National University

Voluntary Participation & Withdrawal

- Remuneration
- Withdrawal without consequence
- Collecting anonymous information has implications for withdrawal
- Informed consent

6

Australian National University

Data Storage & Security

- Where and how
- How long
- Handling of data following the required storage period

7

Australian National University

Exercise

Augustus Gloop, MAE Scholar at the Willy Wonka Institute of Chocolate Science

The influence of child freckles on the consumption of Theobroma cacao: A randomised controlled trial.

8

Australian National University

Wrap Up

There is more involved with information sheets..

ANU PIS and consent form template online
https://services.anu.edu.au/research-support/ethics-integrity/information-sheets-consent-forms

ANU Code of Research Conduct
https://policies.anu.edu.au/ppl/document/ANUP_007403

Australian National Data Service Guide - 'Indentifiable, re-indentifiable, non-identifiable' data
https://www.ands.org.au/__data/assets/pdf_file/0003/737211/De-identification-edit-2018.pdf

9

Appendix 6.C: Case Study Teaching Session Worksheet with Answers

Participant Information Sheet

Researcher:

My name is Augustus Gloop and I am a Master of Philosophy (Applied Epidemiology) Scholar at the Willy Wonka Institute of Chocolate Science.

Project Title:

The influence of child freckles on the consumption of Theobroma cacao: A randomised controlled trial.

General Outline of the Project:

- Project title does not reflect the study… RCT?
- Description and methodology: lack of information about study design and analysis
- Participants: no exclusion criteria, no justification of small sample size
- Use of data and feedback: should always try to give participants feedback

Description and Methodology: I am conducting research on how freckles in children impacts chocolate consumption. This research seeks to understand how physical features influence chocolate consumption in children. I intend to interview 10 children with visible facial freckles under the age of 10 years.

Participants: 10 children with visible facial freckles under the age of 10 years. Children will be recruited from the confectionary aisle of a grocery store in the Sydney CBD.

Use of Data and Feedback: I will use the data collected for advertising purposes and to produce peer-reviewed published articles. Individual participants will not receive any feedback regarding their involvement or of the study findings.

Project Funding: I have raised money via a golden ticket competition sponsored by Willy Wonka's Chocolate Division.

Participant Involvement:

Voluntary Participation & Withdrawal: *(what is important to explain?)*

You may, without negative consequences, decline to take part or withdraw from the research without providing an explanation at any time until the work is prepared for publication (if the participant's data is re-identifiable), or until data are submitted to the researcher (if no personal identifying details are collected, and participation is completely anonymous).

What does participation in the research entail?

You are invited to take part in an interview with the chief investigator, Augustus Gloop, about your chocolate eating habits in day-to-day life. With your consent, I will record the interview so that I can accurately transcribe it, and the recordings will be destroyed after transcription. During the interview, I may ask some personal questions about how freckles on your face has impacted your chocolate consumption, including your relationship with other food.

Confidentiality: *(how would you phrase this?)*

Your confidentiality will be protected as far as the law allows

Location and Duration:

Interviews are expected to last approximately 10 minutes, and will be conducted at a place of your choosing – for example, your primary school, at the local supermarket or

in a place we can talk in private. I may contact you for another 10 minute interview if I would like to follow up on anything from the first interview.

Remuneration:

In recognition of your time, participants will be offered a Willy Wonka chocolate bar.

Risks: *(which 3 points would you mention?)*

Describe any **risks, discomforts**, **hazards or side effects** that might arise because of the subject of the research or the research method. Don't know what we are participating in, how your information will be used.

- no feedback to participants
- children may feel intimidated and obliged to participate
- no explicit adult consent
- supporting the chocolate industry
- used for advertisement
- recording the interview
- *OTHER – unlikely to be in the PIS*
- study design is not robust – not an RCT, small sample size
- no established link between freckles and chocolate consumption – no scientific basis for the study

Benefits:

It is unlikely that you will personally benefit from participation in this research other than happiness after eating the complementary chocolate bar. However, the work will support the chocolate industry.

Data Storage: *(what are the 3 headings that you would include?)*

Where, how long (5 years), what will happen at the end of the storage period (destroyed, archived, used further)

Privacy Notice:

In collecting your personal information within this research, the ANU must comply with the Privacy Act 1988. The ANU Privacy Policy is available at https://policies.anu.edu.au/ppl/document/ANUP_010007 and it contains information about how a person can:

- Access or seek correction to their personal information;
- Complain about a breach of an Australian Privacy Principle by ANU, and how ANU will handle the complaint.

Queries and Concerns:

Contact Details for More Information:

Call 1800 CHOCOLATE for more information

Ethics Committee Clearance:

The ethical aspects of this research have been approved by the ANU Human Research Ethics Committee (Protocol 20xx/xxx). If you have any concerns or complaints about how this research has been conducted, please contact:

Ethics Manager

The ANU Human Research Ethics Committee

The Australian National University

Telephone: +61 2 6125 3427

Email: Human.Ethics.Officer@anu.edu.au

Modified from Australian National University - Information Sheets and Consent Forms

https://services.anu.edu.au/research-support/ethics-integrity/information-sheets-consent-forms

7. MAE Experiences & Fieldwork

7. MAE Experiences & Fieldwork

Placement at the Gold Coast Public Health Unit: Enhanced Disease Surveillance for the 2018 Commonwealth Games

Introduction

In April 2018 I was fortunate enough to undertake a placement at the Gold Coast Public Health Unit (GCPHU) to participate in the efforts of enhanced disease surveillance during the 2018 Commonwealth Games. Working with the GCPHU was a wonderful learning experience, with the staff more than willing and encouraging for me be involved as much as possible.

My Role

For my role, I was involved in a large number of activities including: a number of high-level stakeholder meetings, monitoring data from the enhanced syndromic and sentinel surveillance systems (including gastrointestinal illnesses and cryptosporidiosis), analysing daily data to identify any epidemiological trends which may indicate increased levels of illness in the community, following-up with case report interviews and potential venues of reported disease clusters, working in the field collecting water samples and conducting infection control investigations, and contributing to a summary report of GCPHU actions.

Through my team's efforts of epidemiological analysis we were able to identify several venues contributing to a number of cryptosporidiosis cases which were treated promptly by the environmental health team to prevent further illness within the community.

Lessons Learnt

My time spent at the GCPHU was especially valuable in learning about stakeholder engagement and management, and the teamwork involved in good public health action. I was also exposed to working with EpiInfo and several syndromic surveillance systems. This was an extremely beneficial supplementary experience to the Masters of Applied Epidemiology program.

Acknowledgements

I would sincerely like to thank everyone at the GCPHU for making me feel welcome and contributing to my education, providing an overall valuable learning experience.

Lecture for University of Sydney: Clinical Science AMED3004

Introduction

NCIRS was approached to deliver several lectures to third year undergraduate students in the Clinical Science unit of study at the University of Sydney. I was able to volunteer to help develop and deliver content to the students, which was a new experience for me as I have not formally taught previously. I was looking forward to the challenge of synthesising my knowledge to create clear and concise content for these students.

My Role

Myself and Ms. Catherine Glover, NCIRS Research Officer, were tasked with developing and delivering a 20 minute lecture recording on the topic of public health surveillance in the context of vaccine preventable diseases. I developed and delivered lecture content (Appendix 7.A) which provided information and examples of the what, when, where, and why of disease surveillance within Australia. Catherine focused on vaccine effectiveness and vaccine safety. We also developed a number of multiple choice questions for use in examinations.

Lessons Learnt

I have not had formal lecturing experience in the past, so this was an opportunity for me to synthesise my knowledge of vaccine preventable disease surveillance within Australia, and deliver it in a cohesive manner to a more general audience.

Acknowledgements

I would like to thank Ms Helen Quinn for providing me with the opportunity to gain some teaching experience, as well as Ms Catherin Glover for co-producing and delivering the lecture content.

Fieldwork in Samoa: The SaMELFS Study

Introduction

During my MAE I was able to assist with fieldwork for the Surveillance and Monitoring to Eliminate Lymphatic Filariasis and Scabies from Samoa: SaMELFS Samoa study (Appendix 7.B). This study aimed to collect baseline disease prevalence data for lymphatic filariasis and scabies to assess the impact of a 3-dose mass drug administration (MDA) program for Samoa, the first time a 3-drug MDA had been implemented on a national scale. I worked on this project for three weeks in September 2018.

My Role

My role in this study started by helping to conduct a training week for local Samoan volunteers to explain the study and varying duties, and to assess the volunteers to gauge if they were qualified to participate in study activities. For my main role in this study I acted as an Australian Team Leader, managing a team of three local Samoan volunteers to administer an electronic questionnaire, conduct a basic clinical examination for lymphoedema and/or scabies, and to collect a small sample of blood for laboratory testing for individuals who qualified for participation. I also helped to manage the laboratory and sample testing. Lastly, I assisted in the checking of data quality and produced weekly data summary reports for stakeholders.

Lessons Learnt

My experience in Samoa was my first fieldwork experience in which I could use my epidemiological training. In addition to learning about lymphatic filariasis and scabies in Samoa and the Western Pacific region, I learned how to: manage a team, work in an international setting while respecting local cultures and customs, liaise with international stakeholders, take finger prick blood samples, run filarial test strip blood tests, produce dried blood spot tests, and most challenging of all for me, how to put on medical gloves effectively.

Acknowledgements

I would like to acknowledge Professor Ross Andrews, who thought to notify me of this opportunity, my supervisors at NCIRS for supporting me to undertake this piece of work, my Australian and Samoan field team members, and Dr Colleen Lau for being an exceptional researcher, leader, and mentor on this study.

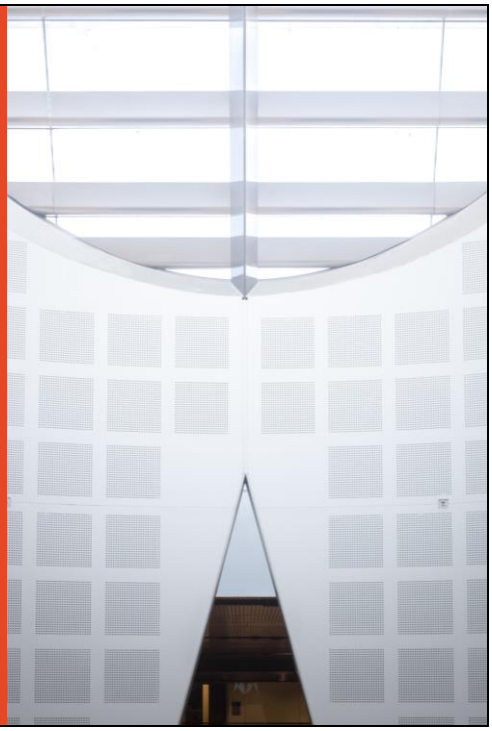
Appendices

Appendix 7.A: University of Sydney Lecture Slides

Surveillance of vaccines and vaccine-preventable diseases

Ms Kelley Meder, MPH, MIPH, MAppEpid(c)
Ms Catherine Glover, MS

THE UNIVERSITY OF SYDNEY



Objectives

1. Introduce you to the key principles of surveillance
2. Identify surveillance systems providing vaccine-preventable disease (VPD) data in Australia
3. Explain how vaccine surveillance data can be used to estimate vaccination coverage and vaccine effectiveness (VE)

Principles of Surveillance

THE UNIVERSITY OF SYDNEY

What is surveillance?

Definition: the collection of information for public health practice and/or action

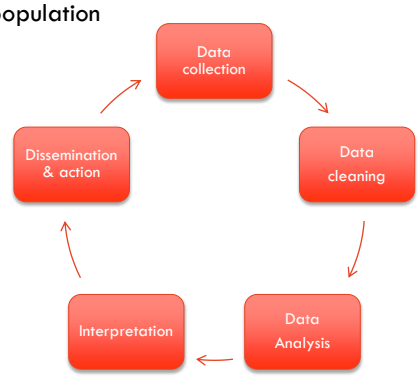
- Purpose:

Disease

- Establish baseline disease levels in a population
- Monitor levels of disease
- Detect outbreaks
- Evaluate control measures

Vaccines

- Determine vaccination coverage levels
- Determine vaccine effectiveness (VE)
- Monitor safety of vaccines
- Conduct research



1. Lee L. Principles and practice of public health surveillance. New York: Oxford University Press; 2010.

Types of surveillance systems used in Australia

Passive

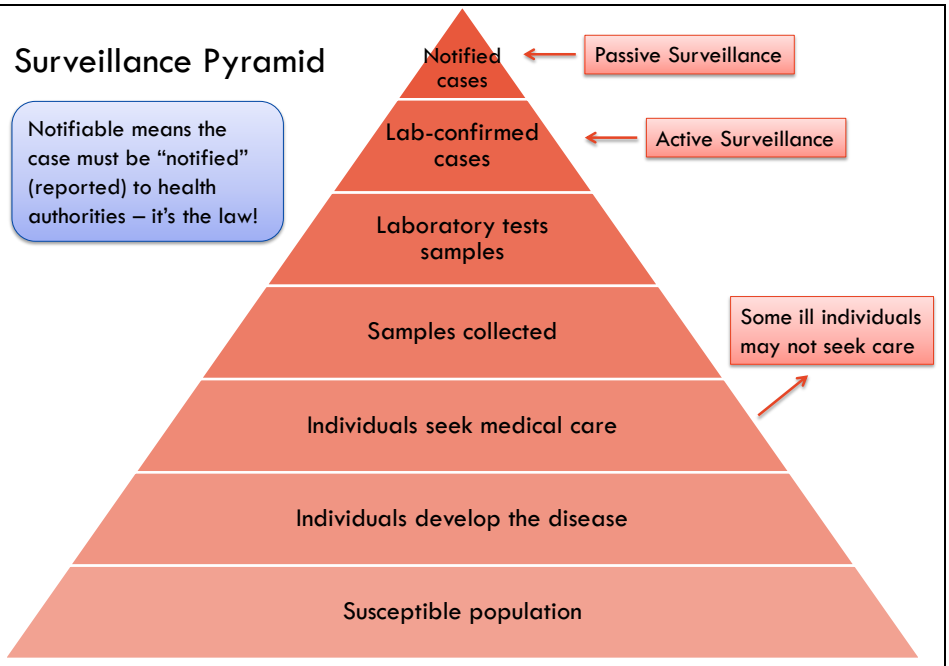
Active

Sentinel

Syndromic

Surveillance Pyramid

Notifiable means the case must be "notified" (reported) to health authorities – it's the law!



Where do the data come from and go to?
Commonly used surveillance systems and data

Systems

National Notifiable Disease Surveillance System (NNDSS)

Australian Immunisation Register (AIR)

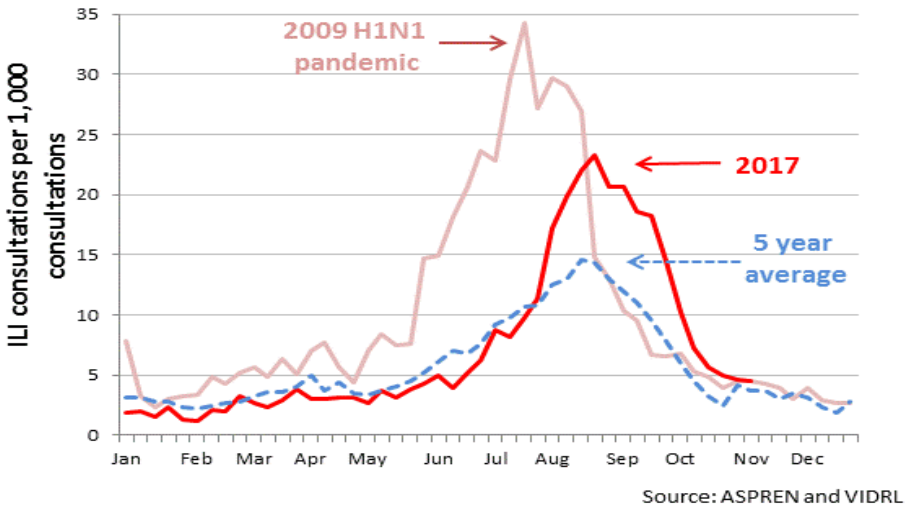
Paediatric Active Enhanced Disease Surveillance

Data

Mortality, hospitalisation data

Population, demographic data

Outbreak detection



Source: ASPREN and VIDRL

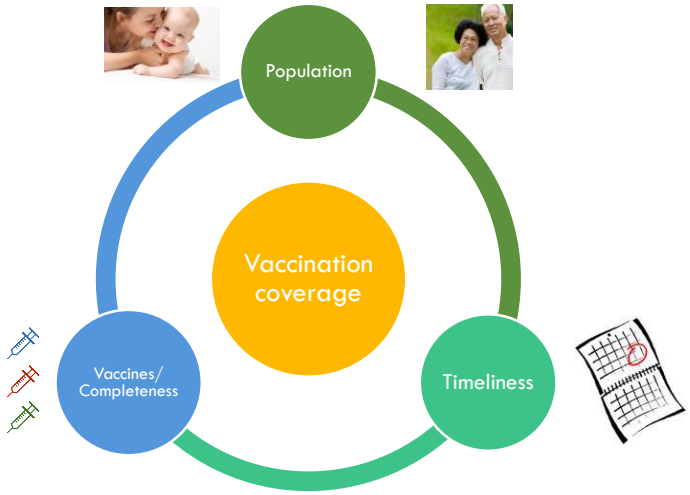
2. Australian Government Department of Health. 2017 Influenza Season in Australia. 2017.

Vaccination Coverage & Vaccine Effectiveness

THE UNIVERSITY OF SYDNEY

What is vaccination coverage?

Definition: the percent of eligible individuals who have been vaccinated



3. BC Centre for Disease Control. Immunization Coverage [Internet]. 2018. Available from: http://www.bccdc.ca/health-info/immunization-vaccines/immunization-coverage

Calculating vaccination coverage

Australian Immunisation Register

$$\frac{\text{Number of vaccinated individuals}}{\text{Size of eligible population}} \times 100\% = \frac{\textbf{297,300}\ \text{1-year-olds received MMR vaccine as recorded on AIR}}{\textbf{319,682}\ \text{1-year-olds registered on AIR}} \times 100\% = \textbf{93\%}$$

93% MMR vaccine coverage in 1-year-olds

What is vaccine effectiveness?

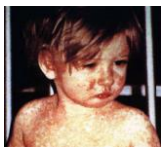
Definition: Reduction in outcome of interest in the **vaccinated** compared to the **unvaccinated**

- The effectiveness of a vaccine in a real world setting
- Effective…against what? Outcomes of interest:
  - Infection (lab confirmed)
  - Disease (clinically confirmed, suspected)
  - Serious disease (eg pneumonia)
  - Hospitalisation
  - Death

Some data sources

NNDSS | PAEDS | AIR

5. US Centers for Disease Control and Prevention. Principles of Epidemiology in Public Health Practice. 3rd edition; 2012. Available from: https://www.cdc.gov/ophss/csels/dsepd/ss1978/SS1978.pdf



Vaccine effectiveness examples

Measles	Influenza
– Stable virus	– Constantly evolving virus
– Stable vaccine that elicits good immune response	– Vaccine changes every year
– Single vaccine type (live)	– Different vaccine types (live vs inactivated)
– Primarily used in single age group (young children)	– Used in a variety of age groups
↓	↓
97% Measles vaccine effectiveness	**40-60%** Influenza vaccine effectiveness

6. US Centers for Disease Control and Prevention. Measles Vaccination [Internet]. 2018. Available from: https://www.cdc.gov/measles/vaccination.html
7. US Centers for Disease Control and Prevention. Vaccine Effectiveness – How well does the flu vaccine work? [Internet]. 2017. Available from: https://www.cdc.gov/flu/about/qa/vaccineeffect.htm

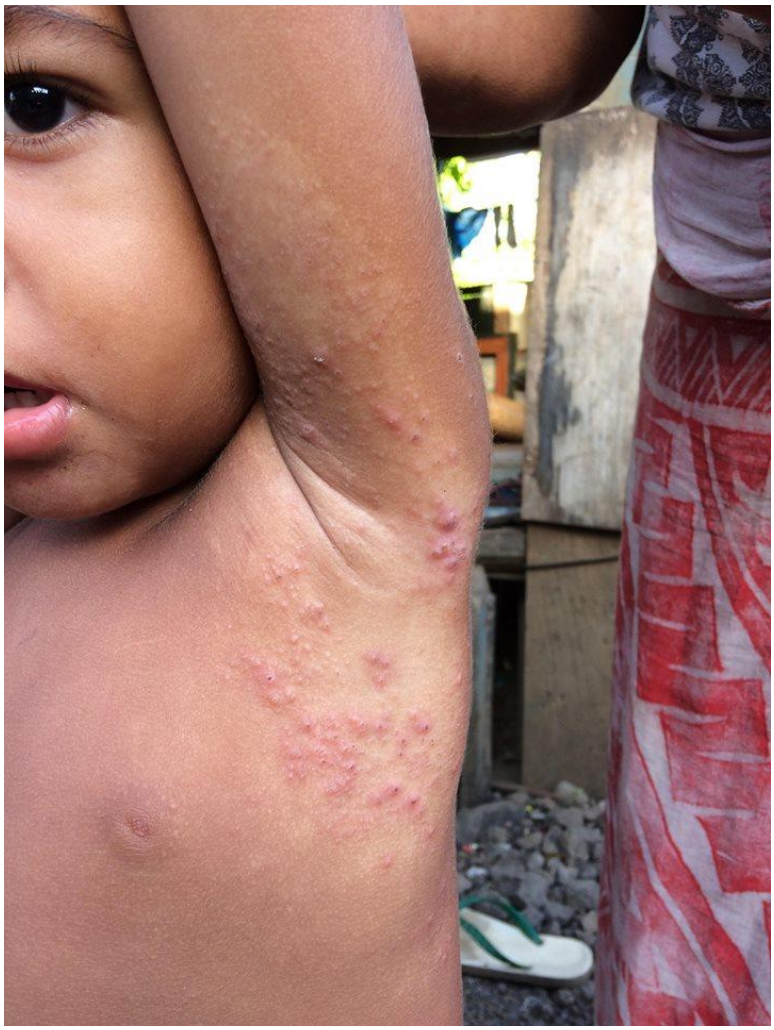
References

1. Lee L. Principles and practice of public health surveillance. New York: Oxford University Press; 2010.
2. Australian Government Department of Health. 2017 Influenza Season in Australia. 2017.
3. BC Centre for Disease Control. Immunization Coverage [Internet]. 2018. Available from: http://www.bccdc.ca/health-info/immunization-vaccines/immunization-coverage
4. National Centre for Immunisation Research and Surveillance. Fully immunised coverage at 12 months of age, by Statistical Area 3, Australia, 2016 [Internet]. 2017. Available from: http://www.ncirs.edu.au/provider-resources/coverage-information/coverage-maps/
5. US Centers for Disease Control and Prevention. Principles of Epidemiology in Public Health Practice. 3rd edition; 2012. Available from: https://www.cdc.gov/ophss/csels/dsepd/ss1978/SS1978.pdf
6. US Centers for Disease Control and Prevention. Measles Vaccination [Internet]. 2018. Available from: https://www.cdc.gov/measles/vaccination.html
7. US Centers for Disease Control and Prevention. Vaccine Effectiveness – How well does the flu vaccine work? [Internet]. 2017. Available from: https://www.cdc.gov/flu/about/qa/vaccineeffect.htm

http://www.ncirs.edu.au

http://www.immunise.health.gov.au

Appendix 7.B: Photos from the SaMELFS Fieldwork Experience




SILICA
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DANGER