Learning to Count

A thesis submitted for the degree of
Master of Philosophy (Applied Epidemiology)
at The Australian National University

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Declaration

I hereby declare that this submission is my own work and to the best of my knowledge it contains no materials previously published or written by another person, or substantial proportions of material which have been accepted for the award of any other degree or diploma at ANU or any other educational institution, except where due acknowledgement is made in the thesis. The work was undertaken from February 2020 to February 2022 as part of the degree of Master of Philosophy (Applied Epidemiology), Australian National University.

Signed: 

Date: 25th February 2022

I would like to acknowledge that most of my MAE placement took place on Cammeraygal Land. I would like to acknowledge all the Indigenous colleagues, teachers, stakeholders and friends who contributed so much to my placement.

I would like to acknowledge my supervisors, Dr Stephanie Williams and Dr Jeremy McAnulty.

There are many others I would like to thank individually. For a more detailed list of acknowledgements, please see the "Epi-logue" at the end of this volume.

Learning to Count

What you will not find in any of these chapters is the most important thing of all: how the MAE taught me to count.

Counting cases, counting tests, counting time, counting transmission. They are all basic skills for an epidemiologist, but not skills that I thought I had to learn. Arriving at Health Protection NSW early in the COVID-19 pandemic, I quickly realised how difficult this was in real life. I learned the importance of case definitions to count precisely. I learned the importance of counting denominators. I learned that you count differently at different times. I learned that there were power and politics in deciding who or what to count, and in doing the counting. Counting mosquitoes brought its own challenges.

I also learned to count as a trainee, and as a member of the team. I began at Health Protection believing that I was not important enough to reserve meeting rooms for phone calls with my supervisor. I told people that I could not do things because I was "small fish" at the Ministry. I learned, little by little, to become more confident and to make myself count.

I started to learn to make my "ethnic voice" count, too. To advocate for the multicultural community in public health. I have stopped apologising to public health colleagues for the low uptake of public health messages by my own people. I started to ask my colleagues to do better, even when it came to little things like collecting food consumption information from ethnic communities in outbreak questionnaires.

Finally, the most difficult lesson in counting was during a 3.5-month long hospital stay in the first year of the MAE. Counting days on the ward, counting the numbers that show clinical progress. I learned that sometimes counting did not change anything, and I just had to accept the number that came.

Thesis abstract

Through this thesis, I describe my field placement at Health Protection NSW (HPNSW) in fulfilment of the requirements of the Master of Philosophy in Applied Epidemiology (MAE).

After spending much of my first year in COVID-19 pandemic response activities, the second year of my MAE was mainly based in the Communicable Diseases Branch (CDB) of HPNSW, as a member of the team responding to other notifiable conditions in NSW. My epidemiological study project focuses on these other notifiable conditions. In this project, I reviewed the surveillance data for a range of notifiable conditions, for changes in the epidemiology that may be attributable to the events of 2020, particularly the restriction of international travel. The findings showed a decrease in the NSW incidence of most notifiable conditions associated with international exposure, with the notable exception of tuberculosis. In light of the lifting of travel restrictions in late 2021, these findings were presented to a range of HPNSW staff on 19 November 2021, to inform planning for surveillance strategies in NSW in 2022 and beyond.

My data analysis project was principally with the Environmental Health Branch (EHB) of HPNSW, but with extensive input from both CDB and the medical entomologists at the Institute of Clinical Pathology and Medical Research (ICPMR), the state arboviral reference laboratory. I reviewed the last decade of data from the NSW Arbovirus Surveillance and Mosquito Monitoring Program (ASMMP), and the corresponding human notification data for Ross River virus (RRV) and Barmah Forest virus (BFV) infections. I attended a laboratory visit to the ICPMR Medical Entomology Laboratory, and a field visit to a mosquito trapping site at Sydney Olympic Park. I also assisted with the weekly reporting of ASMMP data. In CDB, I was the main surveillance officer for vector-borne diseases for the latter half of 2021. All these activities enabled me to ground the design and analysis of these data in real world context. The findings of the project, and recommendations for the ASMMP derived from these findings, were presented to stakeholders on 19 January 2022. These finding supported the continued use of trapped mosquito counts to inform human RRV and BFV risk, and indicated that in future analyses, it could be useful to include a time lag between mosquito numbers and human notifications, to improve our understanding of the relationship between these variables in NSW.

The largest *Salmonella* Saintpaul outbreak in Australia to date, with a total of 585 confirmed cases across all States and Territories, took place between December 2020 and May 2021. This became a multi-jurisdictional outbreak investigation (MJOI) with NSW as the lead for epidemiology. At the time of the initiation of the MJOI, laboratory investigations had already linked human cases to spring onion that was an ingredient in a pre-packaged coleslaw product. I participated in the NSW team through conducting case interviews, managing and reviewing data, monitoring exposure clusters and assisting with additional activities such as retail loyalty card investigations. Subsequent environmental and epidemiological investigations in the MJOI could not add to the strength of the evidence. Ultimately, this investigation showed that despite laboratory and investigative innovations, there were challenges in demonstrating a sufficient strength of association when responding to outbreaks involving fresh produce items.

The COVID-19 pandemic overshadowed all that I undertook during the MAE. However, it came into the forefront for my surveillance evaluation project. As one of the first Surveillance Officers of the NSW Public Health Emergency Operations Centre in early 2020, I agreed to the daunting task of evaluating the NSW COVID-19 surveillance system. This project involved reviewing documents and

performance data, interviewing stakeholders, and continuing to participate in surveillance activities for both COVID-19 and other notifiable conditions in NSW. The findings and recommendations were presented to principal stakeholders on 29 October 2021, to inform the future development of the system. The main conclusions were that the system was positively regarded by stakeholders, but potential improvements included new user training, better data integration with laboratories, and more efficient methods to record and manage venues and epidemiological clusters.

As well as these projects, I was involved in a wide range of activities at HPNSW and ANU. This included responding to a variety of other outbreaks, teaching, preparation of reports, assisting with the preparation of policy documents, advising on queries relating to primary health, coordinating and presenting at Journal Club and R Coding Club. Through these efforts, I hope to have had a perceptible impact, however slight, on the frenetic journey of public health in NSW over the last two years.

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Counting Acronyms

Placement Overview

Overview of Placement

Person

Possible future MAE graduate, awaiting satisfactory completion of course requirements to meet confirmed case definition.

Place

I was placed at Health Protection NSW (HPNSW), the part of the NSW Ministry of Health tasked with coordinating strategies to prevent and respond to both communicable diseases and environmental health threats. I was particularly appreciative of the fact that the Communicable Diseases Branch (CDB) and the Environmental Health Branch (EHB) were together in the same organisation, a structure that was not found in many other jurisdictions.

Time

NSW COVID-19 pandemic response day 48 to day 690

Situation summary

Let me begin this placement description with COVID-19. There is no possible way to avoid the topic. It permeated each aspect of my field placement, even in situations that first appeared to be completely unrelated. I started at HPNSW in the pandemic response itself. While this was disruptive to the "usual MAE experience", the pandemic brought unique opportunities for learning and professional development (Chapter Six). Luckily, it also led to my surveillance project, evaluating the COVID-19 surveillance system in NSW (Chapter Five).

I am grateful for the prevalence of people with MAE experience in HPNSW. They were instrumental in my eventual evacuation from full-time pandemic work. I was given the permission to experience outbreak responses that ran to different rhythms, including a *Salmonella* Saintpaul Multi-Jurisdictional Outbreak Investigation (MJOI), which became my outbreak project (Chapter Four). I spent the second year of my MAE mostly working in the CDB, assisting in a range of activities related to the surveillance and control of a range of communicable diseases in NSW (Chapter Six). During the upsurge in COVID-19 activities with the Delta variant, my CDB role expanded to include following up individual cases of notifiable conditions outside of outbreaks, a role that would normally fall under PHUs. However, even during this time, I continued to be engaged with some of the activities of the EHB. My data analysis project on the NSW Arbovirus Surveillance and Mosquito Monitoring Program involved inputs from both CDB and EHB, fulfilling my initial goal of working across both branches (Chapter Three).

I could just focus on the academic content and say that all this work in communicable disease management provided a solid background for my epidemiological study project on the epidemiology of non-COVID-19 notifiable conditions in NSW in 2020 (Chapter Two). Or I could consider the broader picture of professional learning. A recurrent theme throughout this bound volume is that my MAE projects and general HPNSW work taught me many valuable lessons in working with stakeholders. It was difficult to admit how much I had learned in this space. I had thought that I had reasonable interpersonal skills through international experience, and I had worked in primary healthcare, where relationships were greatly valued. I came to realise that without having worked in government previously, the knowledge I lacked was what organisations wanted, and how this might be conveyed by individuals representing these organisations.

It is true that I leave HPNSW feeling like there are many more experiences that I would have liked to have. I had initial dreams of more field trips, and maybe even being deployed to somewhere quite different. As it turned out, even the mandatory conference presentation became an online activity (Chapter Three). In many ways, though, what I had originally imagined would have been a passive surveillance approach to finding learning opportunities. It would have been a simple matter of waiting for interesting emails or suggestions from colleagues. I hope I have been somewhat successful with active surveillance instead. With my field supervisor occupied by the demands of the pandemic response, I had to learn to be effective in networking, and to hunt for learning opportunities proactively. I learned the importance of having situational awareness over the activities in HPNSW, but would also acknowledge all my colleagues for remembering me when interesting events came up, inviting me to be an observer in teleconferences ranging from Hendra in a horse to avian tuberculosis in a chicken.

Summary of MAE requirements

I completed the following activities required by the MAE curriculum:

Table 1 – Completion of MAE requirements

	Chapter				
MAE requirement	**2 International travel restrictions and notifiable conditions in NSW in 2020**	**3 10-year Review of the NSW Arbovirus Surveillance and Mosquito Monitoring Data**	**4 *Salmonella* Saintpaul Multi-Jurisdictional Outbreak Investigation**	**5 Evaluation of the NSW COVID-19 Surveillance System**	**6 Teaching and Other**
Outbreak investigation			✓		
Epidemiological study	✓				
Data analysis		✓			
Evaluate a surveillance system				✓	
Literature review			✓		
Teaching activities					✓
Conference presentation			✓		
Report to non-scientific audience					✓
Peer-reviewed publication	✓				

Presentations and teaching

A list of presentations, and a list of teaching activities undertaken, can be found in Chapter Six.

Conferences attended

Table 2 – Conferences attended during MAE

Conference	Role
14th Mosquito Control Association of Australia (MCAA) Conference, incorporating the 13th Arbovirus Research in Australia Symposium, online, 30/08/2021 – 01/09/2021	Presentation: *"Summary of the 2019-2020 and 2020-2021 Arbovirus Surveillance Season in NSW"*, on 30/08/2021, with Suhasini Sumithra (HPNSW) as co-presenter
World Congress of Epidemiology 2021, online, 04/09/2021 – 06/09/2021	Attended as part of a social media volunteer team of early career epidemiologists / epidemiology trainees, providing publicity through Twitter for specific segments of the event assigned to me
International Meeting on Emerging Diseases and Surveillance 2021 (IMED 2021), online, 04/11/2021 – 06/11/2021	Attended as a general attendee
Australian Influenza Symposium 2021, online, 11/11/2021 – 12/11/2021	Attended as general attendee, as part of the CDB Respiratory / Biopreparedness Team

Learning to Count

2

Counting Travellers

International Travel Restrictions and Notifiable Conditions in NSW in 2020

Epidemiological Study: List of Abbreviations

ARF	Acute rheumatic fever
BBV	Bloodborne virus
BFV	Barmah Forest virus
CDC	(US) Centers for Disease Control and Prevention
CDNA	Communicable Diseases Network Australia
CQPHU	Central Queensland Public Health Unit
ED	Emergency Department
GP	General practitioner
Hib	*Haemophilus influenzae* type b
HIV	Human immunodeficiency virus
HPNSW	Health Protection NSW
IMD	Invasive meningococcal disease
IPD	Invasive pneumococcal disease
LGV	Lymphogranuloma venereum
NCIMS	Notifiable Conditions Information Management System
NCRES	Notifiable Conditions Records for Epidemiology and Surveillance
NNDSS	National Notifiable Disease Surveillance System
NSW	New South Wales
PCR	Polymerase chain reaction
RHD	Rheumatic heart disease
RRV	Ross River virus
STEC	Shigatoxigenic *E. coli*
STI	Sexually transmitted infection
TB	Tuberculosis
VPD	Vaccine Preventable Disease
VTEC	Verotoxigenic *E. coli*
WA	Western Australia
WHO	World Health Organization

Epidemiological Study Project: Prologue

My role

An idiosyncrasy that some of my colleagues at Health Protection NSW (HPNSW) knew me for was that I loved parasites and viruses, but was not nearly as keen on bacteria. I also had an irrational preference for vector-borne diseases. When it came to picking a topic for my epidemiological study project, these quirks made themselves known. My field supervisor, Jeremy, had suggested reviewing the epidemiology of other respiratory conditions in NSW, in light of public health measures introduced for COVID-19. I considered this suggestion but decided to negotiate: “Okay, but only if I get to look at malaria too. Oh, and maybe dengue? Why don’t we make this project about international travel-related conditions instead?”

- Designed the project, with guidance from supervisors, and obtained research ethics approval
- Reviewed publicly available incidence data for all notifiable conditions in NSW, assigning conditions to part 1 or part 2 of the project, or excluding conditions from analysis based on sample size and known epidemiology; The known epidemiology in NSW was determined through a combination of discussion with managers and other senior staff, and reviewing existing guidelines and reports
- Formulated hypotheses for the expected trends for each condition in 2020, informed by known epidemiology and additional insights from discussions with managers
- Extracted line-listed notification data for each selected condition using RStudio software
- Performed basic descriptive epidemiological analyses on the notification data that I had extracted, and created incidence curves for each condition for the years 2015 to 2020
- Retrieved and reviewed comparable information from other jurisdictions in Australia and overseas for similarities and differences in trends observed elsewhere
- Discussed preliminary project findings with CDB team managers, to explore possible reasons for the trends observed, and the relationship between these trends and behavioural changes due to the COVID-19 pandemic
- Discussed preliminary findings for overall trends observed in part 1 of the project with Acting Directors of the CDB, as part of their process for planning a CDB workshop to prepare for the reopening of international borders
- Used the resources and background insights gained through project work to prepare a segment on international trends in communicable diseases at each CDB weekly surveillance meeting; parts of these presentations were shared with Directors of Public Health Units
- Assisted with ongoing discussions between CDB and the NSW Public Health Response Branch (PHRB) on formulating a joint border reopening strategy
- Organised a meeting between CDB and the Smartraveller website team at the Commonwealth Department of Foreign Affairs and Trade to discuss public health communications to people planning to travel overseas, and to Australians already overseas needing advice about communicable conditions
- Presented my findings for part 1 of the project, and for selected conditions in part 2, to executives, managers and other staff members in CDB and PHRB (Copy of presentation included in chapter)
- Drafted recommendations for surveillance and public health actions targeting overseas-acquired infections, and discussed these recommendations with HPNSW staff as part of my project presentation

- Presented my findings for selected conditions in part 1 and part 2 of the project to an information-sharing teleconference between HPNSW and the Public Health Division of the Oregon Health Authority (US)
- Adapted the report for part 1 of the project for submission to a peer-reviewed journal, targeting *Communicable Diseases Intelligence* (Copy of draft manuscript included in chapter)

Lessons learned

A confession that I have wanted to make about this project is that all along, it has made me feel guilty in several different ways. Towards the beginning, when the future possibility of international travel was still distant and hypothetical, I felt uneasy that I had maybe tricked my supervisor into indulging me to pursue a topic that had minimal benefit to public health in NSW. Later, when we did start planning for international border restrictions lifting, I felt that I was stealing my colleagues' time for other CDB work with concerns relating to my own project. Even later, when the borders did open, and we waited vigilantly for the onslaught of measles that never came, I felt like the boy who cried wolf. Had I given my colleagues sleepless nights for nothing? There was a part of me that hoped for just one measles case to vindicate my work, but then of course, I started feeling guilty about wishing for measles too. After each of my weekly presentations on the international trends of infectious diseases, I would ask a few of my colleagues, with trepidation, whether they were really interested in those overseas figures, or whether they were just appeasing my interest in travel medicine. I continued to do this even after my international infectious disease surveillance presentations were shared with Directors of Public Health Units, or when my supervisor asked me to present my work to international colleagues, which were surely signs of some level of support from very senior people.

You might expect this narrative to take a sudden turn at some point, where I reach a sudden epiphany and shed all these doubts. Like you, I was waiting for that moment that vindicated everything It never happened. The lesson I learned, here, was to accept that not everything can be well-defined and goal-oriented when preparing for the unknown. I also learned to accept that not everything that we do in public health comes with instant gratification, and some activities are possibly not useful at all in hindsight. At the time, though, not even senior staff can predict whether certain projects might be useful in the future.

On a more positive note, this project made me quite adept at working with surveillance data for notifiable conditions in NSW. Having to manipulate these data for each condition one by one, I became familiar with the structure of the dataset, and the subtle adjustments that had to be made to accommodate the peculiarities of each condition. Ironically, despite the hundreds of thousands of records of notifiable conditions in NSW, this project taught me many lessons in working with small data. I learned the limitations of small sample sizes, and the conclusions that cannot be drawn without adequate case numbers to analyse.

Public health impact

This project was the last of my MAE projects that I started, but one that I hurried to complete. I was trying to race against the reopening of international borders. The new Premier of NSW only gave us slightly more than two weeks of advance warning. It was probably unnecessary pressure that I imposed on myself, but I saw the opportunity to increase the impact of my work. I asked Jeremy to lock in a date for my presentation of my findings to a large group of potentially interested people before I had any certainty that I could complete my analyses in time.

I feel that in the end, the impact of this project was not in the report that I wrote, but in many of the related activities. In planning for the project, and discussing the trends observed in 2020 with the CDB Acting Directors and team managers, I stimulated dialogue that complemented the preparatory activities for our joint border reopening strategy with the PHRB. I assisted with facilitating additional discussions with the PHRB and with the Commonwealth Smartraveller staff. My international communicable diseases reporting was shown to senior staff across NSW, and also made known to the members of the Communicable Diseases Network Australia, who then decided to hold their own workshop to prepare for the return to overseas travel on a national scale.

In the end, though, I felt that the potential for public health impact of this project was much greater than how events unfolded in reality. Despite the flurry of preparatory activities, that wave of overseas-acquired conditions never came.

MAE core activity requirements

- Design and conduct an epidemiological study
- Prepare an advanced draft of a paper for publication in a peer-reviewed journal

Acknowledgements

First of all, I must thank my supervisors, Stephanie Williams and Jeremy McAnulty, for being patient with my evasive looks and attempts to change the topic for so many months when they asked about my progress with this project. I hope that they were both relieved and encouraged by my sudden motivation after the imminent lifting of border restrictions was announced. As always, Steph provided her policy expertise to my novice attempts at writing recommendations. Jeremy facilitated the sharing my work with a broader audience, including his colleagues in Oregon.

There are so many people in CDB whom I would like to thank. I will start with our Acting Directors, Shireen Durrani and Elaine Tennant, for supporting and sharing in my enthusiasm for surveillance of travel-related conditions, and for promoting my international communicable disease surveillance reporting work to a broader audience. Thank you to each of the CDB team managers, Roy Byun, Keira Glasgow, Steven Nigro and Ellen Donnan, for taking the time to have multiple detailed discussions about the epidemiology of specific conditions, and pointing me to additional reading material. Thank you to Annabeth Simpson for laying some of the groundwork for my project by reviewing some of the previous CDB international travel-related communications strategies pre-pandemic.

I must also thank the Public Health Rapid Emergency Disease and Syndromic Surveillance (PHREDSS) Team for giving me invaluable advice on the manipulation of surveillance data to create incidence curves almost as polished as theirs.

Finally, I would like to thank Emma Field for responding patiently to all my questions, especially when I worried repeatedly that this project would not be good enough for an MAE.

Abstract

Background

International travel restrictions came into effect in NSW in 2020, in response to the COVID-19 pandemic. Most of these restrictions were from 21 March onwards, and limited inbound and outbound travel. In addition to these measures, the pandemic resulted in additional changes to human movement and behaviour in NSW. All these changes were thought to have an impact on the epidemiology of other notifiable conditions. The purpose of this study is to explore the trends in notifiable conditions observed in NSW in 2020, focusing on conditions related to international travel in Part 1, and describing briefly the epidemiology of other notifiable conditions in Part 2.

Methods

Eight conditions, where the transmission patterns in NSW were known to be associated with international travel, were selected for Part 1 of this project. These were: influenza, tuberculosis, measles, hepatitis A, typhoid, dengue, chikungunya and malaria. Other conditions, where the number of notifications in 2015-2020 were sufficient for analysis, were assigned to Part 2. Notification data collected for the routine surveillance of each of these conditions, for the period 1 Jan 2015 to 31 December 2020, were extracted from the NSW Notifiable Conditions Records for Epidemiology and Surveillance database. Each of these conditions were described in terms of their incidence in 2020, compared to trends observed in 2015-2019, through examining epidemiological curves comparing both periods. Additionally, for each condition selected in Part 1, hypotheses were formed relating to expected epidemiology from 21 March to 31 December 2020. Each hypothesis was examined through comparing the number of notifications observed in this period, and the demographic characteristics of notified cases, with trends observed from 21 March to 31 December 2015-2019.

Results

Of the conditions in Part 1, only tuberculosis showed an increase in incidence from 21 March to 31 December 2020, compared to the same dates in the five-year period from 2015-2019. All seven of the other conditions in Part 1 showed a reduction in incidence in 2020 compared to 2015-2019, particularly in the period between 21 March and 31 December of each year, where there was a 100% reduction in both measles and chikungunya in 2020. Twenty-nine conditions were reviewed in Part 2, with a reduction in incidence in 2020 compared to 2015-2019 observed for 21 of these conditions. Notably, of the eight conditions in Part 2 where the incidence in 2020 was unchanged or increased compared to 2015-2019, four (Ross River virus infection, Barmah Forest virus infection, leptospirosis and psittacosis) have complex mechanisms of transmission involving other arthropod or animal species.

Conclusion

International travel restrictions and social public health measures from March 2020 onwards have affected the notification patterns of a range of notifiable conditions in NSW, due to a combination of decreased importation of infection, decreased secondary transmission of any overseas-acquired infections and general behavioural changes in both social interaction and healthcare access. This analysis contributed to preparations for the potential of resurgence of these conditions as international borders reopen and social restrictions lift in NSW. The restrictions on international travel also offered a unique opportunity to observe local communicable disease transmission patterns in NSW, without additional complexities introduced by imported infections. These observations have the potential to inform general knowledge about the endemic nature of individual conditions in NSW.

Part 1: The impact of international travel restrictions on selected notifiable conditions in NSW in 2020

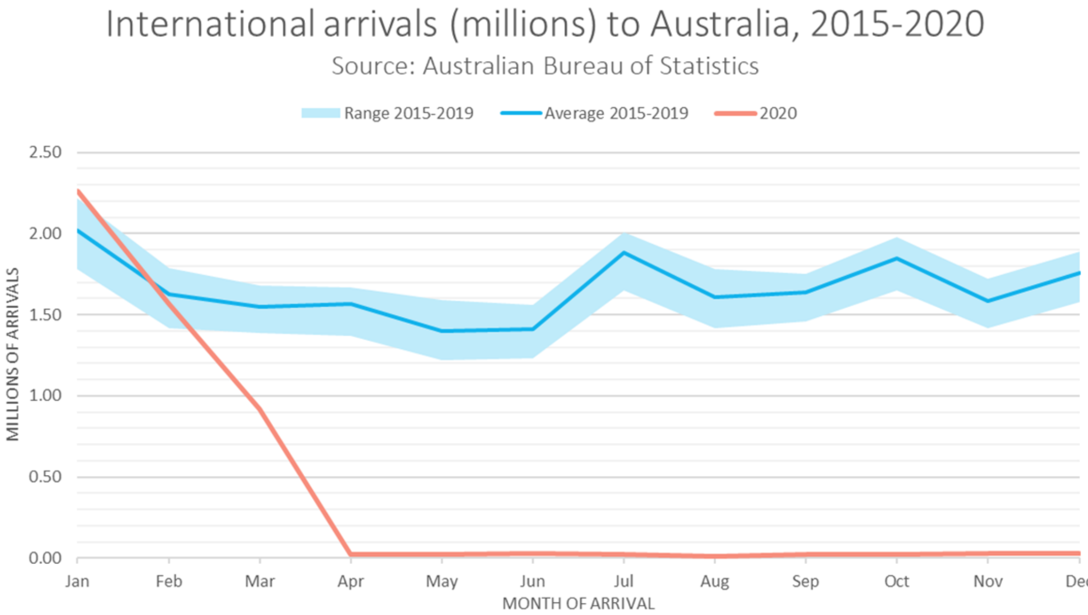
Background

International travel was profoundly impacted by the events of 2020(1, 2). Globally, the COVID-19 pandemic disrupted pre-existing travel and migration patterns and planned large-scale events, such as the Tokyo Olympics and the Hajj and Umrah pilgrimages(3, 4). Many governments implemented international border closures as a public health measure to delay or reduce the introduction of COVID-19 in their jurisdictions(2).

In Australia, limitations on international travel began in February 2020, with restrictions on foreign nationals arriving from mainland China(1). Subsequent updates to Commonwealth directions added to the list of countries from which travel was limited, and culminated in more widespread international travel restrictions, including a ban on all foreign national arrivals in Australia on 20 March 2020. On 25 March 2020, the federal government limited outbound international travel by Australian citizens and permanent residents. For returning residents, quotas were introduced on the number of daily arrivals to Sydney Airport from July 2020. The requirement for all international arrivals to self-isolate for 14 days came into force from 15 March 2020, and was restricted further to government-managed quarantine on 28 March 2020. There was an additional ban on the arrival of international cruise ships, effective 15 March 2020. These restrictions remained in place for the remainder of 2020.

As a result of international travel restrictions and limits on incoming passengers, the number of overseas arrivals to Australia decreased steeply from January 2020 onwards (Fig x1; Data: Australian Bureau of Statistics(1)). From a ten-year record of 2.26 million arrivals per month in January 2020, this figure remained below 50,000 from April to December. Although international arrival numbers specific to NSW were not released, it is likely that they reflected the national trends. Of all 4.6 million arrivals to Australia in 2020, 36.6% short-term visitors nominated NSW as their intended destination, and 34.4% of returning residents stated that NSW was their intended address(1).

Fig x1 - International arrivals to Australia, 2015-2020(1)



The disruptions to travel patterns in 2020, among other public health measures, have been associated with changes in the epidemiology of infectious diseases globally. Analyses from Germany and from other regions of Australia showed reductions in international mobility led to a reduction in the incidence of diseases with a high proportion of overseas acquired cases (5-7).

The first and main part of this project aims to examine the epidemiology of a selected range of notifiable conditions in NSW, to assess the potential effects of international travel restrictions on notifications of infections observed in 2020. The findings of this analysis may be used to inform NSW public health strategies for these travel-related conditions, with the gradual lifting of international movement restrictions commencing from late 2021. Furthermore, the relative absence of overseas-acquired infections represents an opportunity for a more focused exploration of the local epidemiology and transmission patterns of these selected conditions. The second part of this project provides a brief overview of the 2020 trends for all other notifiable conditions in NSW, for which sufficient data are available. The purpose of Part 2 is to consider how a wide range of communicable conditions, with different local epidemiology and mechanisms of transmission, were affected by the broader set of public health measures introduced for the control of COVID-19. The methodology of this second part is detailed separately.

This project is the first broad review of the epidemiology of all notifiable conditions in NSW in 2020 other than COVID-19. To date, other studies of the same period in NSW have been restricted to internal use, and have involved individual conditions such as HIV or TB, or a group of conditions such as sexually transmitted infections (Ref: Internal documents). These studies have not examined changes to international travel patterns specifically in their aims. Similarly, studies covering the trends of a broader range of infectious conditions in other jurisdictions have occurred in contexts where international travel restrictions have not been as stringent or sustained(5, 8, 9). This analysis adds to these existing reviews by having a focus on the effects of international travel, and by including a wider range of infections.

The time periods examined in this project revolve around the ban on non-citizen and non-resident international arrivals that took effect on 20 March 2020. Additionally, the project considers other restrictions related to international travel that occurred in the two weeks before and after this date, namely the ban on international departures and the orders for mandatory quarantine. However, these restrictions were associated with various other consequences, including interruption of international cruising, changes in air traffic, flight routes and schedules, demographics of travellers, behaviour of travellers, and airline boarding procedures at the airport of departure. The terms “international travel restrictions” and “international border closures” are used interchangeably in this project to refer both to the inbound and outbound travel bans themselves, to the introduction of 14-day mandatory quarantine on arrival, and to the broader range of changes to international travel patterns to Australia that resulted from these restrictions.

Methodology

Part 1 of this project involved the descriptive data analysis of eight selected notifiable conditions. These conditions were selected based on consultation with senior public health staff in Health Protection NSW (HPNSW) within the Ministry of Health, which is responsible for overseeing the surveillance of notifiable conditions in the state(10). The following criteria were used:

1. Typical or known associations with international travel or recent arrival to Australia
2. Sufficient number of baseline notifications to observe meaningful changes in 2020

Conditions were included for analysis according to expert hypotheses of associations between local notifications with international travel. For example, as a condition that is not endemic to NSW, local outbreaks of measles would not be expected to occur without an index case with overseas exposures.

The baseline rate of notifications was another deciding factor in the selection of conditions for analysis. Certain conditions that are non-endemic to NSW, such as Japanese encephalitis or rabies, have had zero or low numbers of notifications for the five years prior to 2020. Therefore, it would not be possible to observe if there were any epidemiological changes to these conditions in NSW.

After the notifiable conditions for analysis were selected, condition-specific hypotheses were formed about the most likely trend, based on the salient features of each condition, in terms of its mode of transmission, incubation period and infectious period (Table x1). These specific hypotheses about each condition drew on prior knowledge about what was observed for each condition in NSW prior to 2020. Other public health measures introduced for controlling COVID-19, such as venue closures, stay at home orders, physical distancing and mask mandates, were also considered in relation to their impact on disease transmission.

The incubation and infectious periods for malaria caused by different *Plasmodium* species is outlined separately in Table x2, given the heterogeneity of these timeframes between the species. Fig x2 shows the natural history of the conditions selected with relation to 14-day mandatory quarantine, based on a scenario where the individual acquires the infection overseas, immediately prior to travel to Australia. This scenario maximises the possibility of local transmission in NSW. Tuberculosis is not shown in this diagram as most infections are not associated with symptomatic disease, and reactivation of infection can occur over the course of a lifetime(11).

Table x1 – Salient features of conditions reviewed(12)

Condition	Causative organism	Local transmission (NSW)	Local transmission (Australia)	Incubation period in days (typical)	Incubation period in days (range)	Infectious period in days relative to symptom onset at day 0 (typical)	Infectious period in days relative to symptom onset at day 0 (range)
Influenza	Influenza virus	Y	Y	2 to 3	1 to 7	-1 to +7	-1 to +10
Tuberculosis	*Mycobacterium tuberculosis*	Y	Y	N/A	14 to 70[a]	Indefinite when symptomatic	Indefinite when symptomatic
Measles	Measles virus	Y	Y	9 to 11[b]	7 to 18	-1 to +7	-1 to +11
Hepatitis A	Hepatitis A virus	Y	Y	28 to 30	15 to 50	-14 to +14	
Typhoid fever	*Salmonella enterica* serovar Typhi	Y	Y	8 to 14	3 to 60	0 to +42	0 to +120[c]
Malaria	*Plasmodium spp.*	N	Y	9 to 40	7 to 300	N/A	0 to many years[d]
Dengue	Dengue virus	N	Y	4 to 7	3 to 14	-1 to +5[d]	-1 to +12[e]
Chikungunya	Chikungunya virus	N	N	3 to 7	2 to 12	0 to +6[d]	0 to +12[e]

[a] Timing in relation to having an immunological response to testing.
[b] Timing in relation to onset of prodrome.
[c] Not including chronic carriers.
[d] Untreated or inadequately treated, with most transmission requiring the presence of a competent mosquito vector.
[e] Viraemic period, with transmission possible in the presence of a competent mosquito vector.

Table x2 – Incubation and infectious periods of malaria caused by different Plasmodium species(13, 14)

Species	Incubation period in days (typical)	Incubation period in days (range)	Infectious period in days relative to symptom onset at day 0 (range)	Additional notes
All *Plasmodium* species	9 to 40	7 to 300	0 to many years*	
Plasmodium falciparum	9 to 14	7 to 14	0 to 1 year	
Plasmodium vivax	12 to 18	12 to 300	-9 to 5 years	Relapses can occur in untreated patients
Plasmodium ovale	12 to 18	12 to 18	-9 to several years	
Plasmodium malariae	18 to 40	18 to 40	0 to over 40 years	

*Untreated or inadequately treated, with most transmission requiring the presence of a competent mosquito vector.

Individual line-listed data for each notifiable condition were extracted from the NSW Notifiable Conditions Records for Epidemiology and Surveillance (NCRES) database using RStudio software(15). This database stores de-identified information on all cases of most of the communicable conditions notified to NSW Health up to 22:00 the previous evening. Notifications in NCRES are classified as confirmed, probable or other according to case definitions published by the Communicable Diseases

Network Australia (CDNA) and adopted in NSW as part of routine surveillance activities for notifiable conditions(16).

The date of onset represents the date that the case reported onset of symptoms when interviewed by public health staff. If this date is unavailable, the date of specimen collection is selected automatically as the date of onset by algorithms in the NSW information management systems. The date of onset was chosen because it was one of two dates uniformly available for all notifiable conditions in the NCRES database. This facilitates consistency across all notifiable conditions analysed. The other date available, the date of notification, was not used because there is considerable variability in the case definitions and notification procedures for each condition. Therefore, this date represents different points in the natural history of each condition, and may not be useful for assessing the timing of infection against the date of international travel restriction. Using the date of onset also reduces the possibility of bias due to delays in testing and notification procedures at diagnostic laboratories during the pandemic. Additionally, similar analyses have been undertaken in other Australian jurisdictions using date of onset(7, 17). Therefore, using date of onset would allow greater comparability against national trends.

Descriptive summaries were performed for each condition, with comparisons of monthly notifications between 2020 and the five-year period from 2015 to 2019 inclusive. After examining overall annual trend for the full calendar year, more detailed analyses were performed for cases with onsets in the period after 20 March in each year, as the main international border closure event occurred on 20 March 2020. Using a similar period of the year for each year would reduce any bias from seasonal effects. Comparisons were made in terms of the demographic characteristics of cases, including the distribution of age, gender and geographical location of residence. For conditions where place of acquisition was available, this additional information was also compared between 2020 and the five-year period between 2015-2019. Where there were cases for whom additional travel or transmission details would be useful, this information was obtained from the NSW Notifiable Conditions Information Management System (NCIMS), where case interviews are stored. Additional information was also obtained from discussions with relevant HPNSW teams, and from a range of internal reports within HPNSW. Preliminary findings from the project were presented to stakeholders in HPNSW, with feedback from this discussion also informing this final report.

This project obtained approval from the Australian National University Human Research Ethics Committee (Protocol number 2021/463).

Fig x2 – Incubation and infection periods for selected conditions when acquired overseas on day before arrival in Australia, in relation to 14-day quarantine(12)

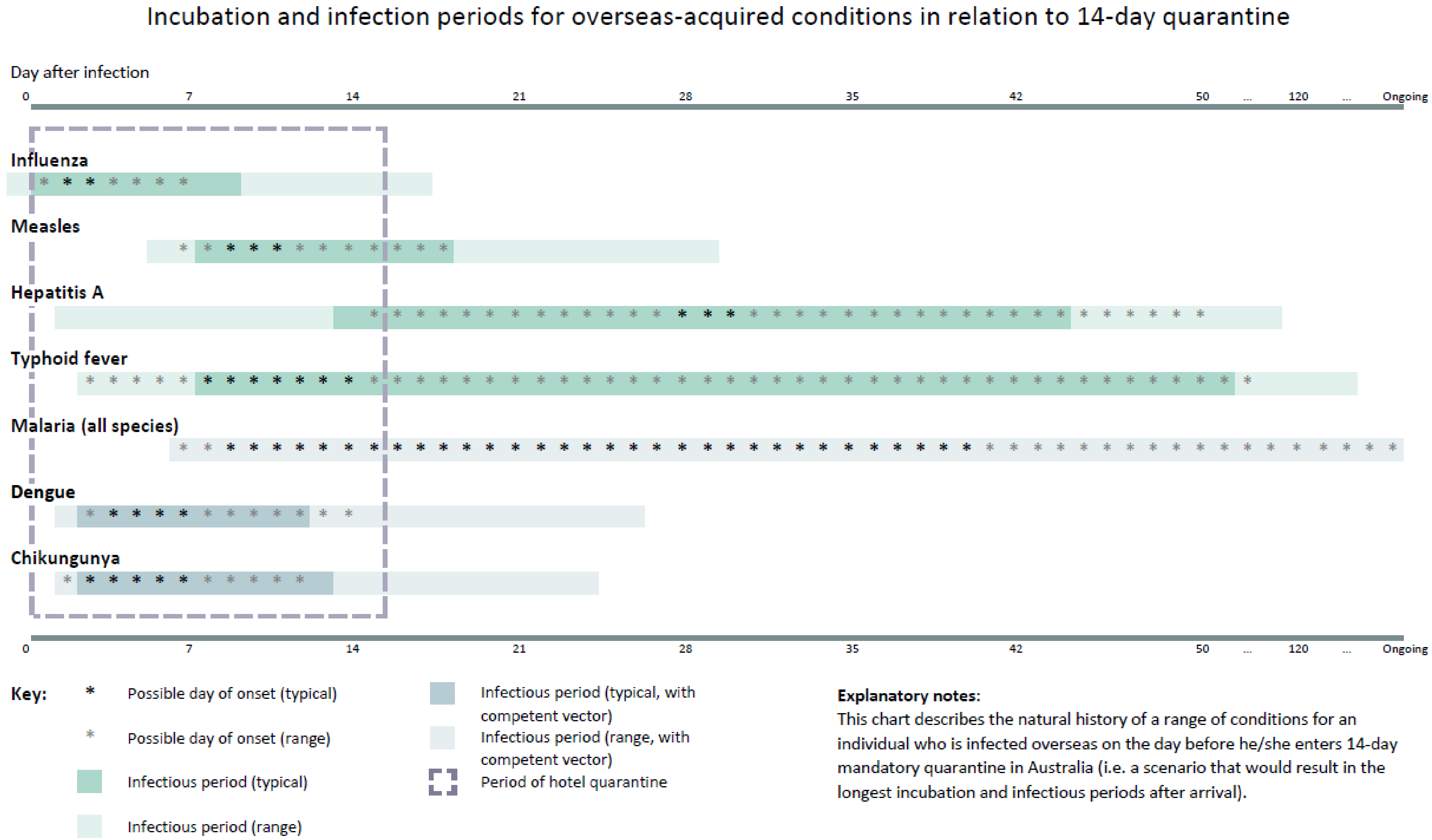
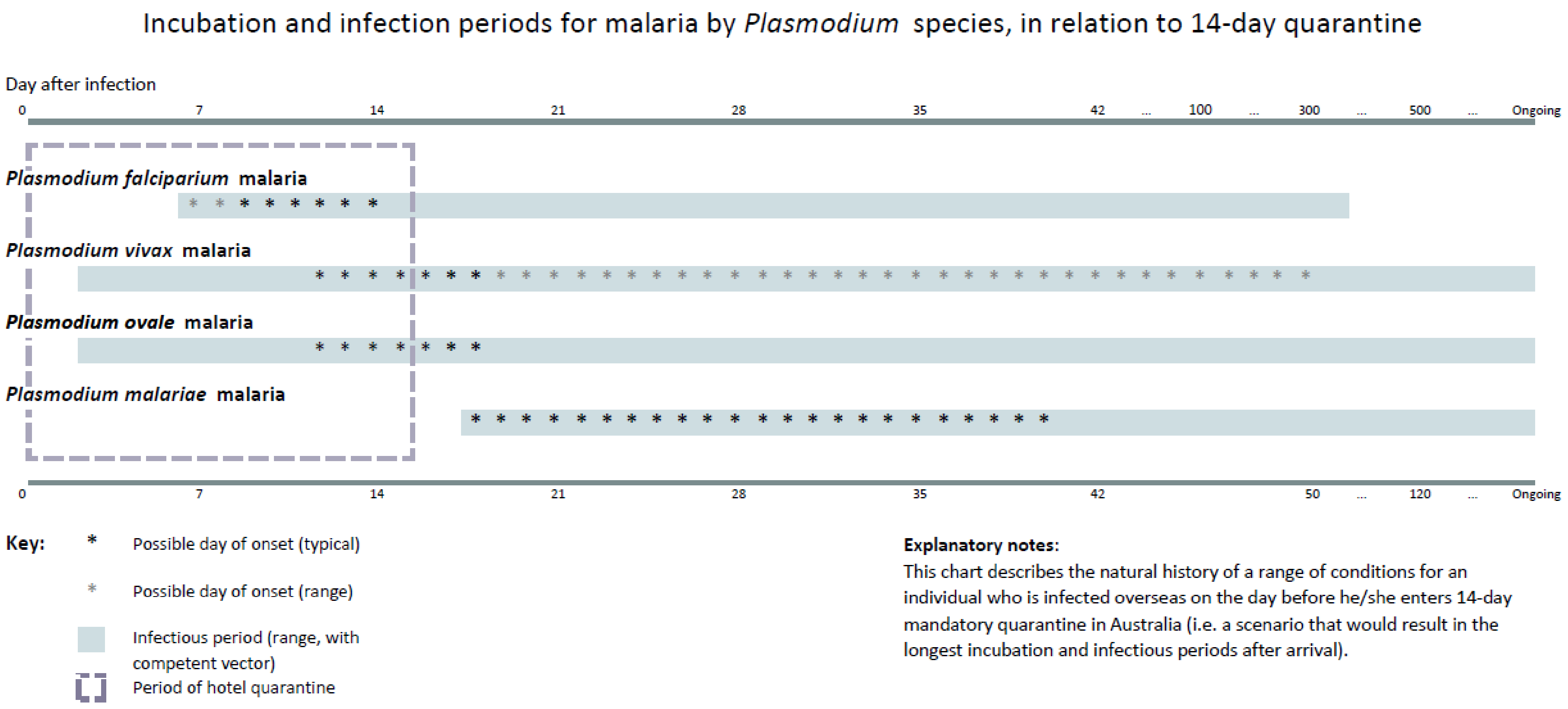


Fig x3 – Incubation and infection periods for species of Plasmodium *when malaria acquired overseas on day before arrival in Australia, in relation to 14-day quarantine(13, 14)*



Findings

All confirmed and probable notifications of each of the eight chosen conditions, with onset dates between 1 January 2015 and 31 December 2020, were extracted for this analysis. This resulted in a total 317,693 notifications, ranging from 149 notifications for measles to 310,924 notifications for influenza.

Influenza

Prior to 2020, notifications of confirmed influenza occurred year-round in NSW, with an annual winter peak of local transmission from June to October(18, 19). There were established seasonal patterns of circulation of influenza viruses, in terms of subtypes and strains, between Australia and the northern hemisphere through multiple international introductions annually(20, 21). Notably, from December 2018 to March 2019, there was an epidemic of "summer influenza" in NSW that was investigated more extensively(19). The investigation found a high proportion of cases related to international travel early in the epidemic, followed by a phase where the epidemic was sustained through local transmission.

The hypothesis for this study is that there would be a decrease in influenza notifications after the international travel restrictions were implemented. These restrictions would have reduced the opportunities for northern hemisphere strains of the influenza virus to be introduced to NSW. In addition, influenza and COVID-19 are both respiratory infections, which means that the public health measures that had been successful in controlling COVID-19 would also be expected to be effective in reducing influenza transmission(22). Other than international travel restrictions, other strategies included local movement restrictions, attendance restrictions at schools and public venues, requirements to wear masks and reminders on personal hygiene measures. Although these strategies were separate from border restrictions, they would have a cumulative effect in reducing the number of influenza notifications, by reducing the number of onward local influenza infections from each infectious international arrival. The possibility was considered of an increase in influenza notifications due to increased testing for respiratory pathogens, unrelated to the closure of international borders. This possibility was examined briefly in this study.

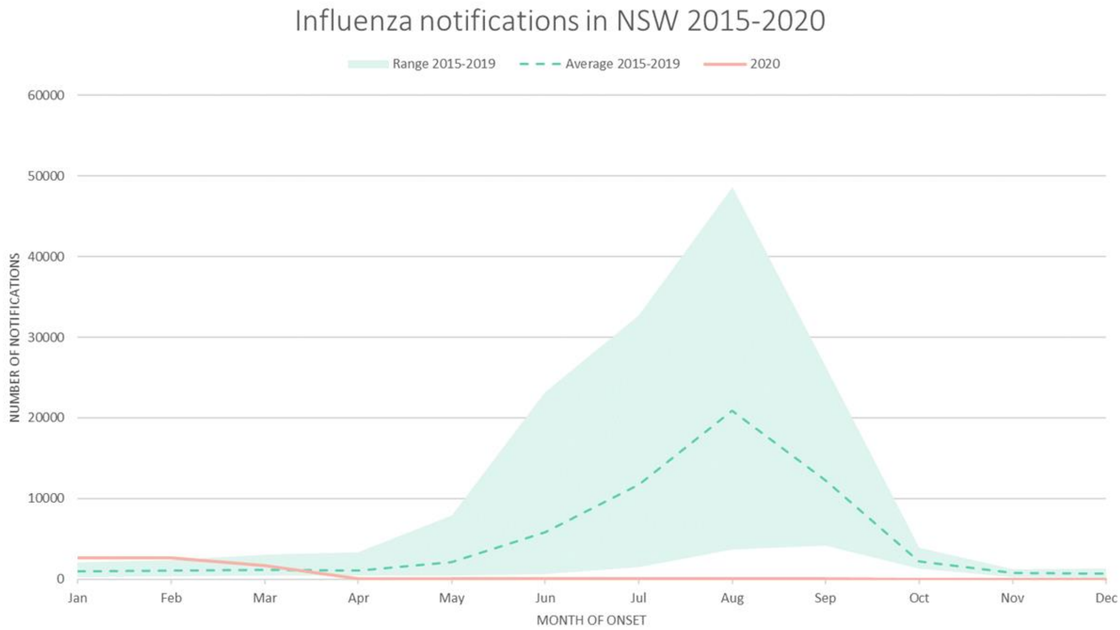
In 2020, there were 7,244 confirmed cases of influenza in NSW. This was 88% lower than the 2015-2019 five-year mean of 60,724 annual cases (Table i1). Of this annual total, 6,808 notifications had onset dates on or before 20 March, a year-to-date figure 48% higher than the 2015-2019 five-year average, and also above the 2015-2019 five-year range (Fig i1), despite the summer influenza outbreak in early 2019.

Table i1 – Influenza notifications in NSW 2015-2019 5-year mean vs 2020

	2015-2019 5-year mean	2020	% change 2015-2019 mean to 2020
Total influenza notifications	60,724.2	7,244	-88
Year-to-date notifications at 20 March	2,744.6	6,808	48
Notifications from 21 March to 31 December	57,979.6	436	-99

Notifications of influenza fell within the normal range in March 2020, and below the normal range from April onwards for the remainder of the year (Fig i1). There was no evidence of the typical winter influenza peak. The 436 influenza notifications from 21 March to 31 December was a 99% reduction compared to the mean number of notifications for the same time period in 2015-2019.

Fig i1 – Notifications of confirmed influenza cases in NSW by date of onset, 2015-2019 vs 2020



Cases of influenza are not routinely investigated on an individual basis by public health staff in NSW(18). Therefore, the proportions of overseas-acquired and locally-acquired cases are not known.

Table i2 - Characteristics of influenza notifications in NSW 2015-2019 vs 2020 (21 March – 31 December each year)

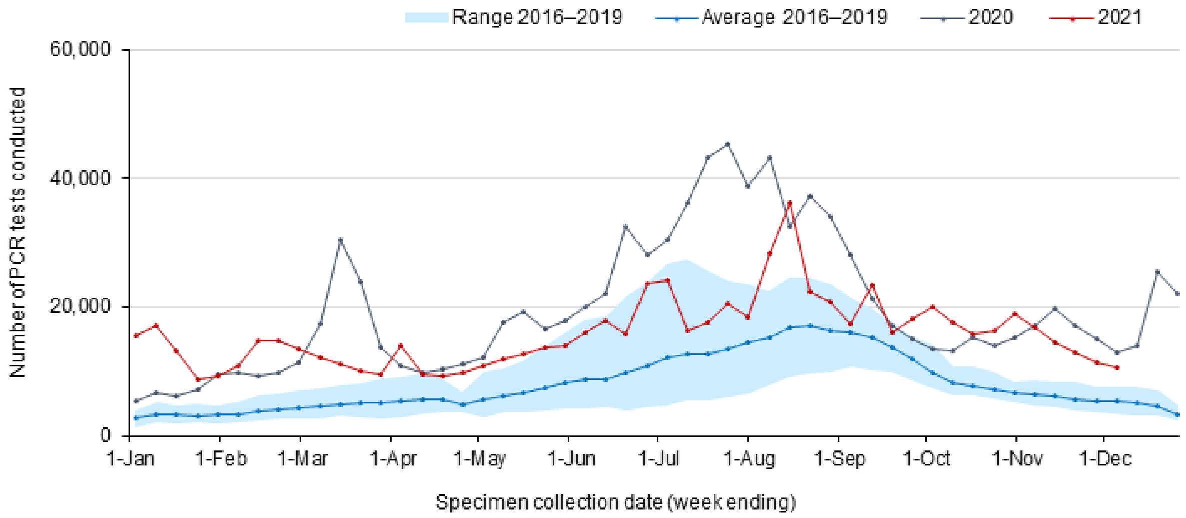
	21 March – 31 December 2015-2019	21 March – 31 December 2020
Median age (years) at notification	30	48
- Proportion of cases under 10 years of age	27.3%	11.5%
Influenza virus subtypes (percentage)		
- Influenza A	66	85
- Influenza B	34	14
- Dual influenza A and B infection	<1	1
- Subtype unknown	<1	<1

In addition to examining the annual incidence of influenza, this project identified several changes in the demographic distributions of confirmed cases and in the proportions of influenza virus subtypes notified after 20 March each year from 2015 to 2020. The median age at notification in 2020 was 48, 18 years higher than the median age at notification in 2015-2019. This is associated with a relative reduction of notifications in children under 10 years of age, from 27.3% to 11.5%. The proportion of cases with influenza A was also higher in 2020, accounting for 85% of all confirmed influenza notifications, an increase of 19% from the mean proportion after 20 March in 2015-2019.

There were small changes in the gender and geographical distributions of new influenza notifications in NSW after 20 March 2020 (Appendix Table a1). There were no notifications of influenza in any individual living in remote areas of NSW in 2020 (Remoteness Area classification 4 and 5). In the years 2015-2019, this accounted for <1% of all influenza notifications.

It is important to note that the reduction in influenza notifications in NSW was despite historically high numbers of diagnostic tests for influenza having been performed in 2020 (Fig i2). This was due to concurrent influenza testing of respiratory specimens collected for COVID-19 testing (Personal communication: HPNSW Respiratory / VPD Team). Influenza testing numbers are monitored in NSW through a network of 14 public and private sentinel laboratories.

Fig i2 – Influenza testing in NSW 2020, compared against data from 2016-2019 and 2021
Source: Internal influenza testing data, HPNSW



As hypothesised, there was a decrease in the number of influenza notifications in NSW after the closure of international borders, likely due to factors summarised. The reduction observed in NSW was marked, to only 1% of the 2015-2019 five-year mean notifications from 21 March to 31 December. This adds to the evidence from the summer influenza study that international travel plays a pivotal role in the epidemiology of influenza in NSW. In terms of the demographic changes, the decrease in mean age and the reduction of notifications in children was more likely to be due to the closure of educational facilities as part of the public health control measures, rather than any restrictions at international borders (Personal communication: HPNSW Respiratory / VPD Team). The significance of the changes in gender and geographical distributions of influenza notifications is unknown.

The fall in the incidence of influenza was not only seen in NSW, but throughout Australia, and in many international jurisdictions(23-26). In terms of Australia as a whole, it was thought that similar to the situation observed in NSW, the closure of international borders prevented any circulating viral strains from the northern hemisphere from entering the country after 20 March(23). The 14-day mandatory quarantine period for new arrivals was implemented in all States and Territories, and was longer than the combined typical incubation and infectious periods for influenza. This was thought to have been effective in minimising community transmission of any imported disease. The magnitude of the reduction in NSW also relates to the avoidance of the annual winter peak that would usually occur during these months.

Internationally, several additional factors were postulated for the sharp reduction in influenza cases despite many countries having more relaxed border policies compared to those in Australia(23, 24, 26). Firstly, it was thought that the 2019 to 2020 winter influenza season in the northern hemisphere was already atypical in terms of its dynamics(26). Usual seasons begin with an early influenza A peak, followed by a lower level of influenza B transmission. In late 2019, the influenza season started with a higher peak of influenza B, followed by influenza A transmission that continued into the start of the COVID-19 pandemic. This would have also been the final major introduction of the influenza virus from the northern hemisphere to Australia, which may explain the higher proportion of influenza A observed in NSW in 2020.

Worldwide, the introduction of behavioural changes introduced for COVID-19 control may have added to the disruption to usual influenza transmission patterns(22-28). Another hypothesis is that there was increased emphasis on immunisation against influenza during the first months of the COVID-19 pandemic(26). This may have led to the proportion of people susceptible to influenza being smaller than previous years. It has also been suggested that there is viral competition between the influenza and SARS-CoV-2 viruses(26). This hypothesis remains to be explored.

Tuberculosis

In NSW, all cases of confirmed *Mycobacterium tuberculosis* complex infection, regardless of disease activity or site of infection, are notifiable(11). There is no obvious seasonal pattern in notifications. Data from 2015-2019 show that 91% diagnosed with tuberculosis in NSW were overseas born, providing evidence that the importation of infection is relatively common (Ref: Internal document).

In general, there is substantial variation between individuals in terms of the progression of disease after infection. Only 5-10% individuals infected with *M. tuberculosis* develop active disease in their lifetimes(11). Therefore, there may be a substantial number of people with undetected asymptomatic infection in the community. In NSW, screening of at-risk contacts of new tuberculosis cases is recommended as a public health measure, and leads to detection of additional asymptomatic cases. There is also a border screening program for migrants and refugees who have arrived from specific countries and who had not received full clearance from pre-migration tuberculosis screening. The number of people tested for tuberculosis through this program declined from the second quarter of 2020 onwards, from 548 in the first quarter of 2020 to 263 in the fourth quarter (Ref: Internal document).

The hypothesis for tuberculosis in this study is that the number of notifications would be either unchanged by the international travel restrictions, or decrease after these restrictions were implemented. Given the usual time lag between infection and diagnosis for tuberculosis, the closure of international borders would not be expected to have an impact on the detection of infections in overseas born individuals already in NSW. This is supported by NSW epidemiological data showing that prior to 2020, for cases acquired overseas, the mean interval between arrival in Australia and diagnosis of tuberculosis was two to three years (Ref: Internal report). The possible decrease hypothesised would arise from reduced testing of asymptomatic individuals, in the context of interruptions to screening activities related to immigration. It was also thought that an additional decrease in the incidence of tuberculosis in 2020 may be observed unrelated to international travel, due to a general reluctance to attend healthcare facilities for investigations and potential diagnosis (Personal communication: HPNSW Tuberculosis / RHD Team).

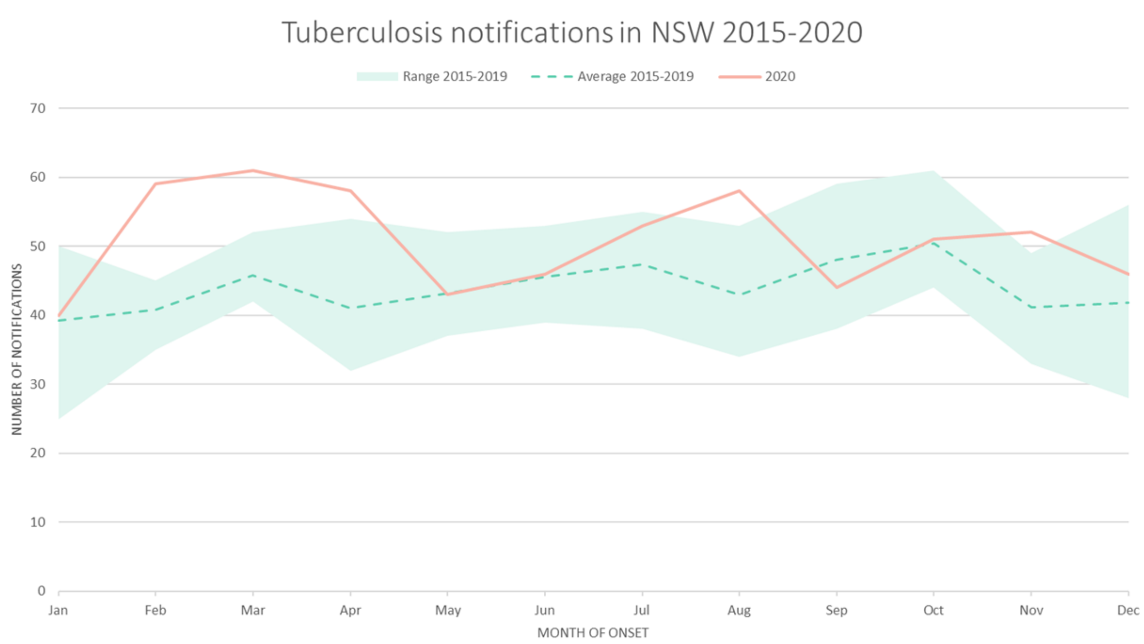
Examining the data for 2020, notifications of tuberculosis did not decrease after the closure of international borders. The 611 notifications of confirmed and probable cases for the full year of 2020 were 16% higher than the 2015-2019 five-year mean (Table tb1). The year-to-date notifications at 20 March were 32% higher than the 2015-2019 five-year mean, with a peak from February to April that was above the five-year range (Fig tb1). The number of notifications after 20 March was also higher than the 2015-2019 five-year mean, by 11%.

Table tb1 - Tuberculosis notifications in NSW 2015-2019 5-year mean vs 2020

	2015-2019 5-year mean	2020	% change 2015-2019 mean to 2020
Total tuberculosis notifications	527.4	611	+16
Year-to-date notifications at 20 March	114	151	+32
Notifications from 21 March to 31 December	413.4	460	+11

Despite notifications falling in May, tuberculosis notifications in 2020 remained at or above the five-year average for most months for the remainder of the year. The number of tuberculosis notifications from 21 March to 31 December was 11% higher than the 2015-2019 average for this period.

Fig tb1 – Notifications of confirmed tuberculosis cases in NSW by date of onset, 2015-2019 vs 2020



Notifications of tuberculosis in NSW are followed up individually. Despite this, the "place of acquisition" field in state notifiable disease databases was only completed for 16% of confirmed and probable cases with onset dates from 2015 to 2020. The "country of birth" field was substantially more complete, for greater than 99% of these cases. Therefore, the country of birth was used in this analysis as an indicator of whether the place of infection was more likely to be overseas or local. Using country of birth is also consistent with other epidemiological analyses of tuberculosis undertaken in NSW Health (Ref: Internal documents). However, this is likely to over-estimate the proportion of true overseas-acquired cases. The proportion of overseas born cases after international border closure in 2020 was slightly higher than that in the same period in the five years from 2015 to 2019. The significance of this change is difficult to interpret in the absence of additional data, and may represent normal variation.

Table tb2 - Characteristics of confirmed tuberculosis notifications in NSW 2015-2019 vs 2020 (21 March – 31 December each year)

Place of birth	Percentage of cases 21 March – 31 December 2015-2019	Percentage of cases 21 March – 31 December 2020
Overseas	91	94
Australia	9	6
Unknown	<1	<1

There were small differences in the distribution of age, gender and geographical location in the tuberculosis cases with onsets after 20 March 2020, compared to those with onsets between 21 March and 31 March in the preceding five-year period (Appendix Table a2). Once again, this difference may represent the usual variation in notification statistics.

These findings do not support the hypothesis of a reduction in tuberculosis notifications after international border closure. However, there is support for the hypothesis that as a condition where there is usually long period of latency between acquiring and detecting the infection, the incidence of tuberculosis would not be affected immediately by restrictions in international travel. The rise in cases in 2020 may reflect an increase in immigration from countries with higher prevalence of tuberculosis, such as India, in the years prior to 2020 (Ref: Internal documents). In addition, the public health messaging around COVID-19 may have prompted clinicians and patients to request more diagnostic investigations for chronic respiratory symptoms (Personal communication: HPNSW TB / RHD Team). An additional factor raised by public health staff is that many of the individuals diagnosed with tuberculosis in 2020 had suffered high levels of stress due to the COVID-19 pandemic, and this may have triggered reactivation of latent infection.

Another limitation to this analysis is the use of date of onset for each case, rather than the date of notification. As discussed, this was chosen for consistency across the conditions examined in this analysis, and to align with similar analyses from other jurisdictions. As discussed, the date of onset was determined by interviewing the case, and eliciting the date of symptom onset. If this information was not available, then the date of laboratory specimen collection was used as a proxy. As discussed, tuberculosis is a condition that often has an insidious onset, or is detected on asymptomatic screening. Therefore, this date is not an accurate indicator of the time of initial infection, and would represent a wide variety of timepoints in the disease trajectory of each individual case.

The tuberculosis trends in NSW in 2020 did not match those seen in international jurisdictions during a similar period. In Germany, notifications of tuberculosis from January until early August 2020 had decreased by 11.6% from the expected number of weekly cases(5). This was partially attributed to a decrease in immigration, although it was also acknowledged that tuberculosis infections often have a complex course, and the driving factors for eventual presentation and diagnosis require more detailed investigation. On a global scale, it was noted that in many under-resourced jurisdictions, the infrastructure for diagnosing tuberculosis was redirected to COVID-19 testing, leading to tuberculosis being under-diagnosed(29).

Measles

Australia achieved measles elimination status, as determined by the WHO, in 2014(30). While local transmission has occurred in NSW since this date, it is usually assumed that there is an epidemiological link to an overseas source of infection. Local outbreaks of secondary and subsequent generations of cases do occur, especially in settings where vaccination coverage is lower.

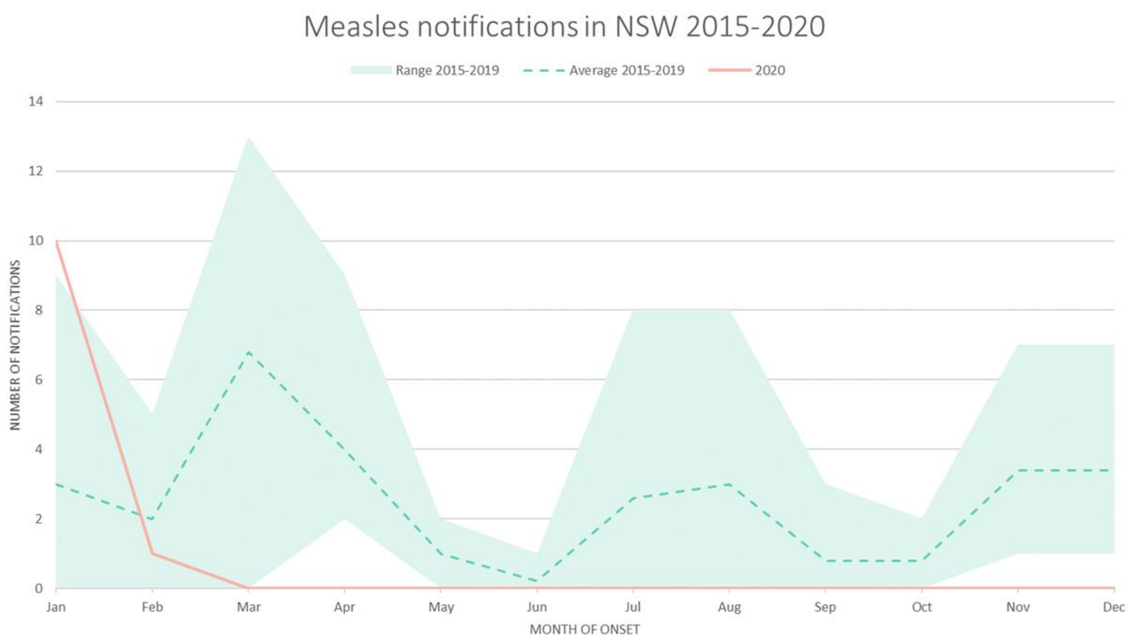
Based on this pre-pandemic epidemiology, the hypothesis for measles in this study is that the notifications of measles in NSW would be substantially lower after the closure of international borders. This is especially given that most of the infectious period for an infected case would occur during mandatory quarantine (Fig x2), thereby reducing the opportunities for community transmission. Noting that overseas introductions of measles can lead to local outbreaks, the prevention of a single potential source case could lead to the avoidance of many secondary cases. Additionally, other public health measures introduced to control COVID-19 that are unrelated to international travel, such as physical distancing and the temporary closure of schools and public venues, would be expected to have a synergistic effect on reducing the likelihood of onward local transmission from any imported infections(31).

There were 11 confirmed cases of measles notified in NSW in 2020 (Table mv1). This was a 60% reduction compared to the 2015-2019 five-year average (27.6 notifications). Of note, all 11 cases had onset dates prior to international border closures on 20 March (Fig mv1). This year-to-date number of measles notifications is 38% higher than the average as at 20 March for the 2015-2019 five-year period (8 notifications).

Table mv1 – Measles notifications in NSW 2015-2019 5-year mean vs 2020

	2015-2019 5-year mean	2020	% change 2015-2019 mean to 2020
Total measles notifications	27.6	11	-60
- Overseas-acquired measles cases as proportion of total	54%	9%	
Year-to-date notifications at 20 March	8	11	+38
Notifications from 21 March to 31 December	19.6	0	-100

Fig mv1 - Notifications of confirmed measles cases in NSW by date of onset, 2015-2019 vs 2020



Of the measles cases notified in NSW in 2020, only one of 11 (9%) was determined to have been overseas acquired, with a corroborative travel history. By contrast, in the five-year period of 2015-2019, an average of 54% annual cases were overseas acquired. It was possible to determine a source of infection for only two of the remaining ten cases, and neither of these cases had a source associated with overseas exposures. All 11 cases resided in metropolitan areas.

The epidemiology of measles cases in 2020, prior to international border closures, was contrary to expectations (Ref: Internal communication). There was a preponderance of locally acquired cases without clear epidemiological links to potential sources with overseas exposures. It was hypothesised by NSW public health experts that infections were spread by unidentified source cases in the community who have acquired their infections overseas.

There were zero measles cases after international border restrictions came into effect. This supports the hypothesis that local transmission of measles in NSW is not sustained without imported cases. Given that there were zero overseas acquired cases during this time, this may also point to high rates of population immunity in NSW, an overall reduction in the worldwide circulation of measles during the pandemic, or low rates of testing for measles in the hotel quarantine system.

The trend in measles notifications in NSW in 2020 mirrored those in other jurisdictions both domestically and internationally. In a review of the epidemiology of selected notifiable conditions across Australia from January to June 2020, it was noted that the latest case of confirmed measles notified in Australia entered the National Notifiable Diseases Surveillance System (NNDSS) in February 2020, prior to international border closures(7). The WHO Western Pacific Region Measles-Rubella Bulletin reported confirmed and compatible measles cases by month of rash onset until 31 December 2020(32). This showed a sharp reduction in measles cases between February and April 2020, and with the lower numbers sustained for the remainder of 2020. Across Europe, there was also a decrease in measles notifications(31). However, concerns were raised about the performance of the measles surveillance mechanisms in several European jurisdictions, in the context of competing demands on communicable disease information systems from the pandemic.

Hepatitis A

In NSW, as is the case in most of Australia, local transmission of hepatitis A occurs mainly in common-source foodborne outbreaks and outbreaks among specific subgroups, such as men who have sex with men(33). Outside of these settings, most cases of hepatitis A in NSW are overseas acquired.

Given this pattern, the hypothesis for hepatitis A in this study is that there would be a reduction in hepatitis A notifications after international travel restrictions were in place, unless a local outbreak occurred from a source such as an imported food item. However, hepatitis A has a relatively long incubation period, meaning that there is the possibility that infections may not be detected during the mandatory quarantine period. Additionally, the infectious period for hepatitis A extends well beyond the 14 days of quarantine (Fig x2), meaning that it would be possible for there to be onward local transmission from an index case with an overseas source. Therefore, there may still be continuing low levels of hepatitis A notifications.

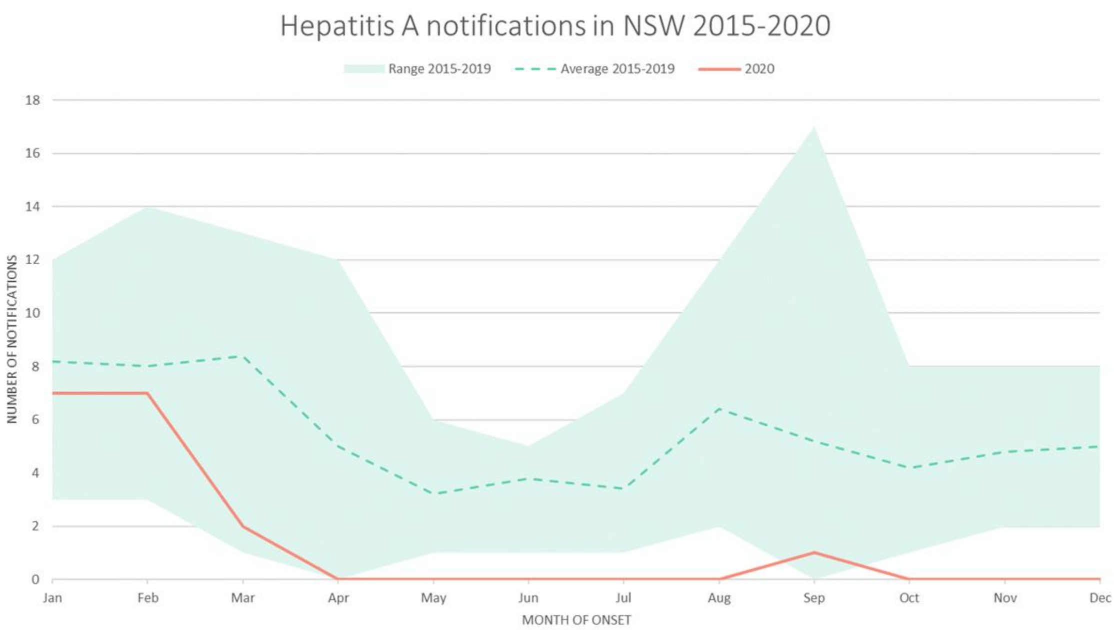
There was a total of 17 confirmed hepatitis A infections in NSW in 2020, which represents a 74% decrease from the 2015-2019 five-year mean (Table h1). Notably, 15 (88%) of these 2020 cases had dates of onset prior to international border closure on 20 March. This year-to-date notification number was 34% lower than the 2015-2019 five-year average, but still within the 2015-2019 five-year range (Fig h1).

Table h1 – Hepatitis A notifications in NSW 2015-2019 5-year mean vs 2020

	2015-2019 5-year mean	2020	% change 2015-2019 mean to 2020
Total hepatitis A notifications	65.6	17	-74
- Overseas-acquired hepatitis A cases as proportion of annual total	63%	88%	
Year-to-date notifications at 20 March	22.6	15	-34
- Overseas-acquired hepatitis A cases as proportion of all year-to-date notifications at 20 March	73%	93%	
Notifications from 21 March to 31 December	43	2	-95

Hepatitis A notifications fell in March 2020, with one notification after 20 March. For the remainder of the year, there was one notification, occurring in September. These two cases represent a 95% reduction in the number of hepatitis A cases from 21 March to 31 March 2020, compared to the mean for same period in 2015-2019. Hepatitis A notifications were below the five-year range for most of the months from May to December.

Fig h1 – Notifications of confirmed and probable hepatitis A cases in NSW by date of onset, 2015-2019 vs 2020



Data are available on the likely place of acquisition for most cases of hepatitis A from 2015 to 2020. Before the closure of international borders, the percentage of overseas-acquired cases in 2020 was 88%, which was higher than the average proportion of overseas-acquired hepatitis A cases for the 2015-2019 period of 73%. In these five years, there was a consistent drop in overseas acquired hepatitis A notifications in the second and third quarters of the year, possibly reflecting the international travel patterns of the population. As there were only two cases of hepatitis A in 2020 after the closure of international borders, the proportion of overseas-acquired cases in this period was not examined.

Given the small number of hepatitis A notifications after 20 March 2020, additional comparative analyses in terms of age, gender and place of residence were not performed. Both cases were adults residing in metropolitan areas. One acquired his infection in a Middle Eastern country. The other case had a locally acquired infection that was linked through whole genome sequencing to consumption of a frozen food product implicated in a hepatitis A outbreak prior to 2020.

As hypothesised, the closure of international borders resulted in fewer notifications of hepatitis A in 2020. The absence of any additional local common-source outbreaks allowed the effects of international travel restrictions to be observed clearly. It appears that for hepatitis A, these restrictions could have been more effective than anticipated. There was a reduction of arrivals of cases with an overseas source, to the extent that despite the potential for local transmission, there were no notifications of this occurring after the border closure. This could reflect transmission dynamics that rely on imported infections to drive ongoing local transmission, which may not have been observable when there had been greater numbers of overseas-acquired infections. These observations would fit with the thinking among local public health practitioners that hepatitis A is not endemic to NSW.

In 2020, reductions in the notifications of hepatitis A were also reported in other jurisdictions. Western Australia reported a 67% reduction in the rate of hepatitis A notifications per 100,000 population in 2020, compared to the average of the preceding five years(17). In Germany, notifications of hepatitis A between early March 2020 and early August 2020 were 36.7% lower than expected during this period(5).

Typhoid

Typhoid is not considered to be endemic to Australia(34). Most cases notified in NSW are in returned international travellers(35). There is a usual summer peak in typhoid notifications in NSW, in January and February, that is thought to reflect international travel patterns. However, delayed notification of typhoid can occur due to chronic bacterial carriage.

Based on baseline seasonal trends, the hypothesis for typhoid in this study is that a reduction of notifications would already be observed from March, as part of the usual decrease in cases at this time. In 2020, additional decreases in typhoid notifications would be expected after the closure of international borders. However, local transmission also occurs in NSW, usually as secondary infections from index cases with an associated international travel history(35). The typical infectious period for typhoid extends beyond the mandatory 14-day quarantine period (Fig x2), meaning that an individual who acquires their infection overseas would be able to infect others in the community after release from quarantine. There are also individuals who demonstrate prolonged bacterial carriage and shedding after acute infection, and can be an asymptomatic source of local infection over a longer period. It is also possible for contaminated food items to be imported and cause local outbreaks. Therefore, international travel restrictions would not be expected to interrupt NSW typhoid notifications completely.

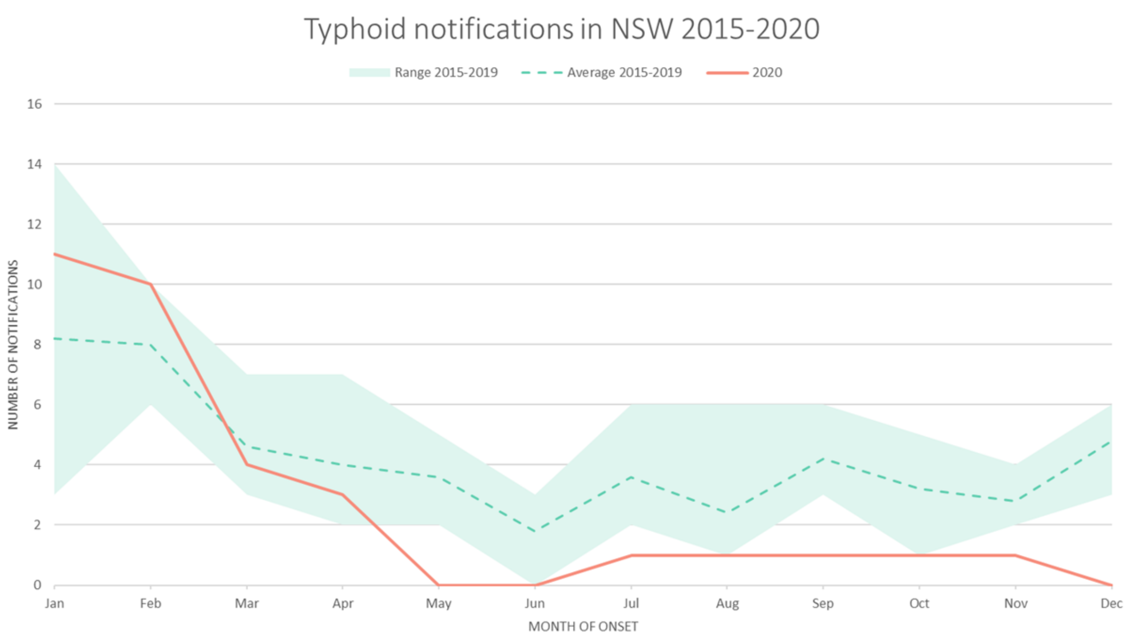
In 2020, there were 33 confirmed notifications of typhoid in NSW, representing a 36% reduction from the mean number of annual notifications for the five years 2015-2019 (Table t1). Of these cases, 24 (72%) had onset dates prior to international border closures on 20 March. As a comparison, by 20 March each year in 2015-2019, there were on average 19.4 typhoid notifications.

Table t1 – Typhoid notifications in NSW 2015-2019 5-year mean vs 2020

	2015-2019 5-year mean	2020	% change 2015-2019 mean to 2020
Total typhoid notifications	51.2	33	-36
- Overseas-acquired typhoid cases as proportion of annual total	94	79	
Year-to-date notifications at 20 March	19.4	24	+24
- Overseas-acquired typhoid cases, as proportion of all year-to-date notifications at 20 March	92	96	
Notifications from 21 March to 31 December	31.8	9	-72
- Overseas-acquired typhoid cases, as proportion of all cases with onset 21 March to 31 December	95	33	

Despite higher than usual numbers at the start of 2020, by March, the number of typhoid notifications fell below the five-year mean for 2015-2019 (Fig t1). By May, this number was below the five-year range, where it remained until the end of 2020. There were 9 notifications of typhoid between 21 March and 31 December 2020, which was a 72% reduction from the five-year mean number of notifications between 21 March and 31 December 2015-2019.

Fig t1 – Notifications of confirmed typhoid fever cases in NSW by date of onset, 2015-2019 vs 2020



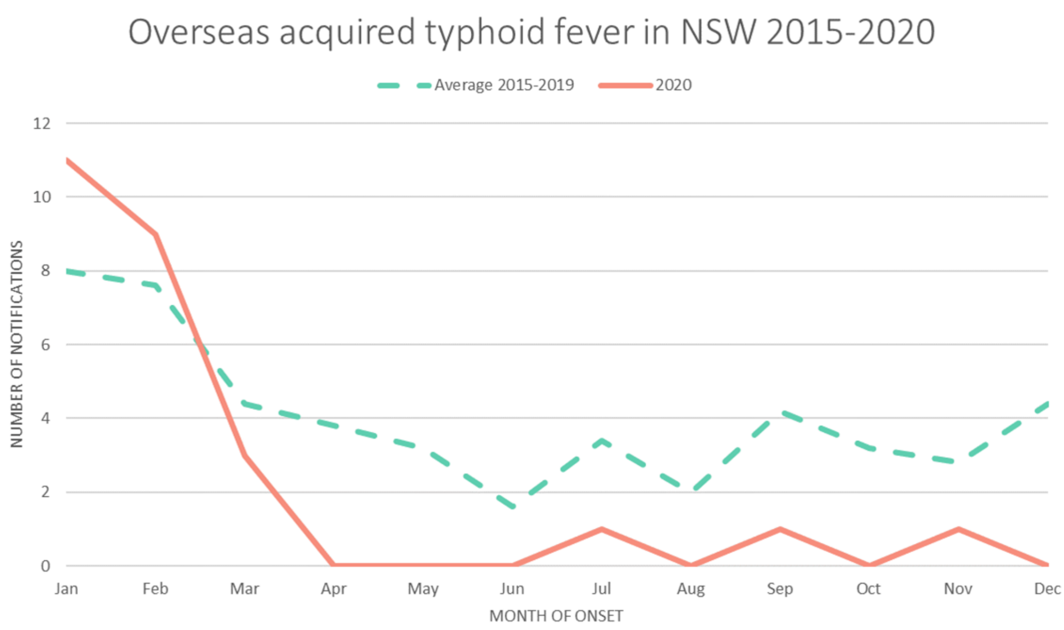
All cases of typhoid fever in 2020 were investigated by public health staff, and the source of infection was determined to be outside of Australia for 26 (79%) cases, attributed to several countries across Asia. This classification of place of infection is likely to be accurate, given that upper limit of a typical incubation period is the same length as the mandatory hotel quarantine period for COVID-19 (Fig x). Therefore, cases detected in the community would be more likely to be acquired locally, or related to chronic carriage of an infection acquired overseas. There was a notable difference in the temporal distribution of these overseas-acquired cases before and after the closure of international borders.

The proportion of all typhoid fever cases that was acquired overseas before 20 March was 96%, whereas this proportion decreased to 33% after 20 March.

In 2015-2019, the average proportion of overseas-acquired cases of typhoid fever was 94%. As expected, this was more consistent with the typhoid cases in 2020 prior to international border closure. It appears that the number of overseas-acquired typhoid infections would normally decline from March onwards in a typical year (Fig t2). However, the magnitude of this decline was greater in 2020.

There were no appreciable changes in the gender, age and geographical distribution of new typhoid notifications in NSW after 20 March 2020 (Appendix table a3).

Fig t2 – Notifications of confirmed overseas-acquired typhoid fever cases in NSW by date of onset, 2015-2019 vs 2020



The trend of typhoid notifications in 2020 fit with the hypothesis, and is consistent with most cases of typhoid in NSW being acquired overseas. However, as expected, due to prolonged shedding of viable bacteria in some individuals, the international travel restrictions did not prevent all cases of local typhoid transmission within NSW. This was reflected in the six locally acquired cases after the international border closure. Two of these cases were found to have acquired their infections from household contacts who were chronic carriers. The other four cases were thought to have acquired their infection from household contacts with histories of international travel to countries with higher typhoid prevalence earlier in 2020.

In other jurisdictions, similar reductions in typhoid notifications in 2020 were seen. In Western Australia, the 2020 rate of typhoid notifications per 100,000 population was 46% of the mean rate from 2015-2019(17). Across Australia as a whole, there was a 15% reduction in the number of typhoid notifications from 1 January to 30 June 2020, compared to the 5-year mean for the first six months of the year in 2015-2019(7). It was not possible to make comparisons with international jurisdictions where typhoid was also non-endemic, because of differences in reporting *Salmonella* Typhi specifically.

Dengue

NSW is not considered to be an area of local dengue transmission currently(36). Local transmission can occur in Australia, but this has been limited to the Torres Strait Islands and north Queensland. This is related to the distribution of competent mosquito vectors, *Aedes aegypti* and *Aedes albopictus*. In NSW, both species are only detected occasionally as isolated incursions at international ports. There have been no known cases of local dengue transmissions associated with these incursions. In NSW, dengue cases meeting both the CDNA confirmed and probable case definitions are investigated and included in the state case counts. Prior to 2020, most cases reported overseas exposures in dengue-endemic countries, with a small number of cases acquiring their infections in Queensland.

Given this epidemiology of dengue in NSW, the hypothesis in this study is that the international border restrictions would lead to a decrease in the number of travellers from endemic countries, which would in turn reduce the number of dengue notifications. However, low numbers of dengue notifications may still occur through the testing of returned travellers in the quarantine system. There could also have been individuals becoming infected in areas of Australia where there may be local transmission, but travel restrictions across state borders were imposed at various points in 2020, and was likely to have decreased interstate travel(37).

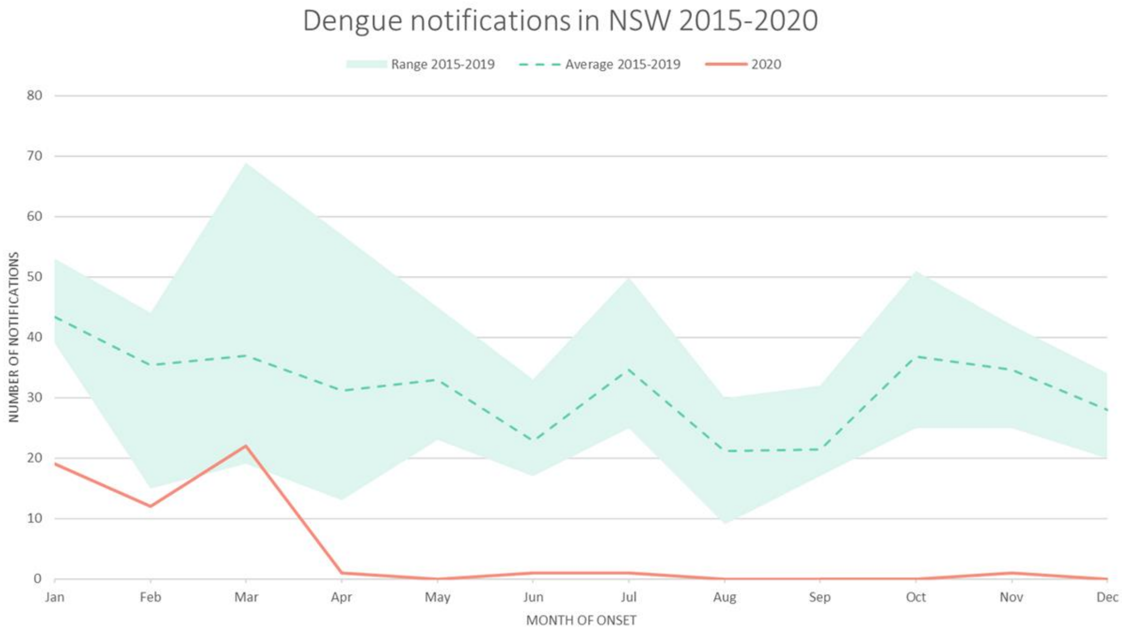
There were 57 confirmed or probable cases of dengue in NSW in 2020 (Table d1). This was a reduction of 89% from the 2015-2019 five-year mean for the full year.

Table d1 – Dengue notifications in NSW 2015-2019 5-year mean vs 2020

	2015-2019 5-year mean	2020	% change 2015-2019 mean to 2020
Total dengue notifications	379.4	57	-89
Year-to-date notifications at 20 March	102	49	-52
Notifications from 21 March to 31 December	277.4	8	-97

Notably, the number of dengue notifications to date at the closure of international borders was already 52% lower than the mean number of notifications to 20 March in 2015-2019 (Fig d1). This number fell sharply between March and April, and remained low until the end of 2020. There was a total of eight dengue notifications from 21 March to 31 December 2020, which was a 97% reduction from the mean number of dengue notifications between these dates in 2015-2019.

Fig d1 - Notifications of confirmed or probable dengue cases in NSW by date of onset, 2015-2019 vs 2020



The eight dengue cases in NSW with onset dates after 20 March 2020 were all adults, aged between 27 and 59. Six were male and two were female. All had NSW residential addresses classified as metropolitan (Remoteness Area class 1), however, three cases reported having longer term residence in southeast Asia. Due to small absolute counts of these cases, no comparative analyses between 2015-2019 and 2020 were performed on demographic characteristics.

There were no Queensland-acquired cases. One case acquired his infection in the Pacific region, and all others acquired their infections in Asia (Appendix Table a5). As expected with international arrivals being restricted to Australian citizens and residents, the proportion of Australian-born cases after 20 March 2020 (75%) was higher compared to that in the same period of the year from 2015-2019 (39%; Appendix Table a4). However, given small numbers of cases, this comparison needs to be interpreted with caution.

These findings support the hypothesis of a reduction in dengue notifications after international border restrictions were implemented. However, there is also evidence that there was under-testing in the hotel quarantine system, given that some cases specifically reported having symptoms in hotel quarantine, but were not tested until they sought additional medical care independently after release from quarantine (Ref: Internal documents; Appendix Table a5). This means that the true number of dengue cases in NSW in 2020 may have been higher.

The epidemiology of dengue in NSW in 2020 was reflected in national trends. In the study of notifications received by the NNDSS from January to June 2020, the total number of dengue notifications during this period was found to have fallen by 79% compared to the same period in the five years preceding(7). In January and February 2020, prior to the international border closure, the number of dengue notifications captured by the NNDSS was already lower than that in previous years, falling further from April onwards. The number of locally acquired cases in Australia was within the normal range, with one case from April to June. In Central Queensland, the Public Health Unit recorded zero cases of dengue from 1 April to 30 September 2020, compared to a mean of six cases in the same period in the previous five years(6).

Internationally, the trend in 2020 varied, depending on a range of factors, including the endemicity of dengue in each jurisdiction, the timing of the most recent outbreak, and the disruptions to usual dengue surveillance and control activities(38). Among jurisdictions where dengue notification data had been examined, Germany was the most comparable with NSW in that all its cases were imported. The study of German data showed that there was a 75% reduction in dengue notifications between early March and early August 2020, compared to the expected incidence over this period(5). Among endemic countries with direct flights to Australia, there is variation in local dengue epidemiology and traveller factors(39). Therefore, it would be difficult to apply this information to the analysis of returned travellers in NSW.

Chikungunya

There have been no reported cases of local chikungunya transmission Australia(40). However, competent vectors can be found in the country. The distribution of *Aedes aegypti* and *Aedes albopictus* is discussed under dengue. In NSW, the chikungunya case definition requires laboratory evidence only. All confirmed cases require public health investigation, which includes taking a travel history.

The hypothesis for chikungunya in this study is similar to that for dengue. However, there would not be a possibility of infections acquired elsewhere in Australia. A decrease in chikungunya notifications would be expected after the international border closure, due to a decrease in travellers arriving from endemic countries. There is a relatively short incubation period (Fig x2). Therefore, it would be expected that infected individuals are likely to develop symptoms prior to travel to Australia. Those who develop symptoms severe enough for investigation may choose to delay travel, or be denied boarding at the airport of origin. This could mean that the changes to international travel may bring chikungunya notifications to zero in NSW.

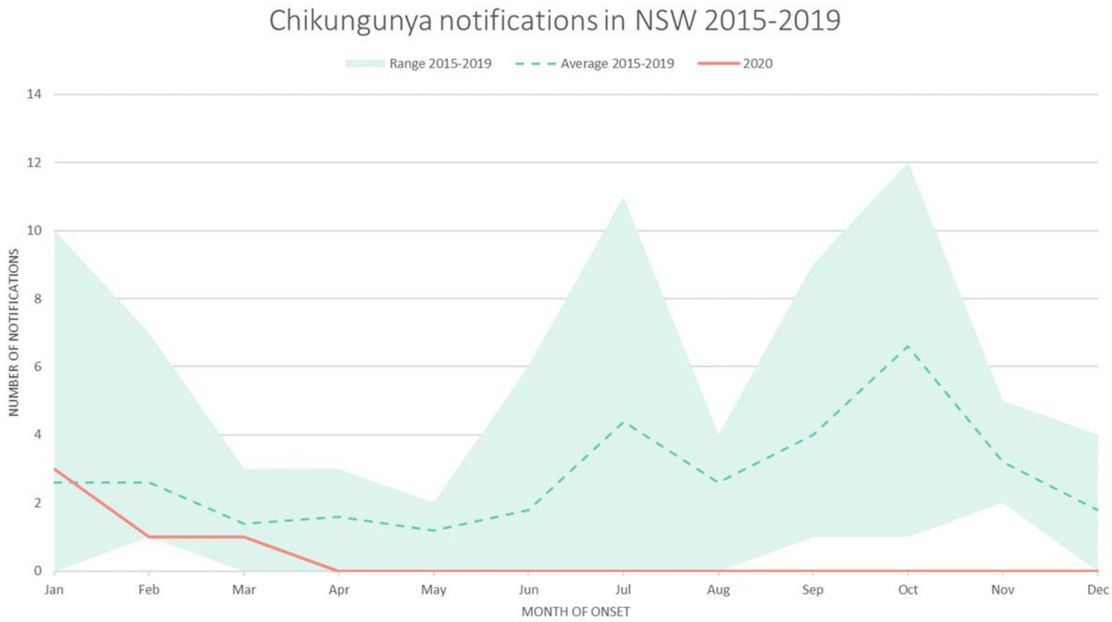
All five confirmed or probable chikungunya cases notified in NSW in 2020 had onset dates before 20 March (Table c1). This annual total was 85% lower than the 2015-2019 five-year mean annual total of 33.8 cases.

Table c1 – Chikungunya notifications in NSW 2015-2019 5-year mean vs 2020

	2015-2019 5-year mean	2020	% change 2015-2019 mean to 2020
Total chikungunya notifications	33.8	5	-85
Year-to-date notifications at 20 March	6	5	-17
Notifications from 21 March to 31 December	27.8	0	-100

The 2015-2019 five-year mean for year-to-20 March notifications was affected by unusually high notifications in early 2015. The 2020 year-to-date notifications for the same time period were within the 2015-2019 five-year range (Fig c1). After the closure of international borders, there were no further cases of chikungunya in NSW.

Fig c1 - Notifications of confirmed or probable chikungunya cases in NSW by date of onset, 2015-2019 vs 2020



Given that there were no cases of chikungunya in NSW after the closure of international borders, no additional analyses of chikungunya notifications in 2020 were undertaken.

The trends observed in chikungunya notifications support the study hypothesis. However, from anecdotal evidence, there may also be a reduction of testing for chikungunya among returned travellers (Personal communication: HPNSW staff). It would be expected that symptomatic cases of chikungunya would be unwell at some point within a 14-day mandatory quarantine period (Fig x). However, it was felt that testing for chikungunya in febrile arrivals from endemic countries was not routinely requested in the hotel quarantine system, where the predominant focus was on detection of COVID-19.

In Australia, there were 25 cases of chikungunya with onset dates between 1 January and 30 June 2020 notified to the NNDSS(7). Interestingly, there were also 25 notifications in the same six-month period in 2019, without any travel restrictions in place. However, the number of notifications in 2020 did represent a 37% reduction from the national five-year mean for this six-month period in 2015-2019. The publicly available Victorian notification data also show a lower number of chikungunya notifications (11 cases) in 2020 compared to the five years immediately preceding (range 16-41;(41)). Globally, there is a lack of analyses available for chikungunya in non-endemic countries in 2020. Reporting from endemic countries in 2020 was variable, and difficult to interpret without awareness of local factors. Therefore, this information was not used to inform analyses in this study.

Malaria

Australia was declared to be free of endemic malaria in 1981(14). Since then, there have been no documented cases of local malaria transmission in NSW, despite the presence of competent mosquito vectors(42). Notifications of overseas-acquired malaria have occurred across each *Plasmodium* species known to infect humans. The confirmed case definition for malaria in NSW requires laboratory evidence only. All confirmed cases are investigated with travel histories taken(13).

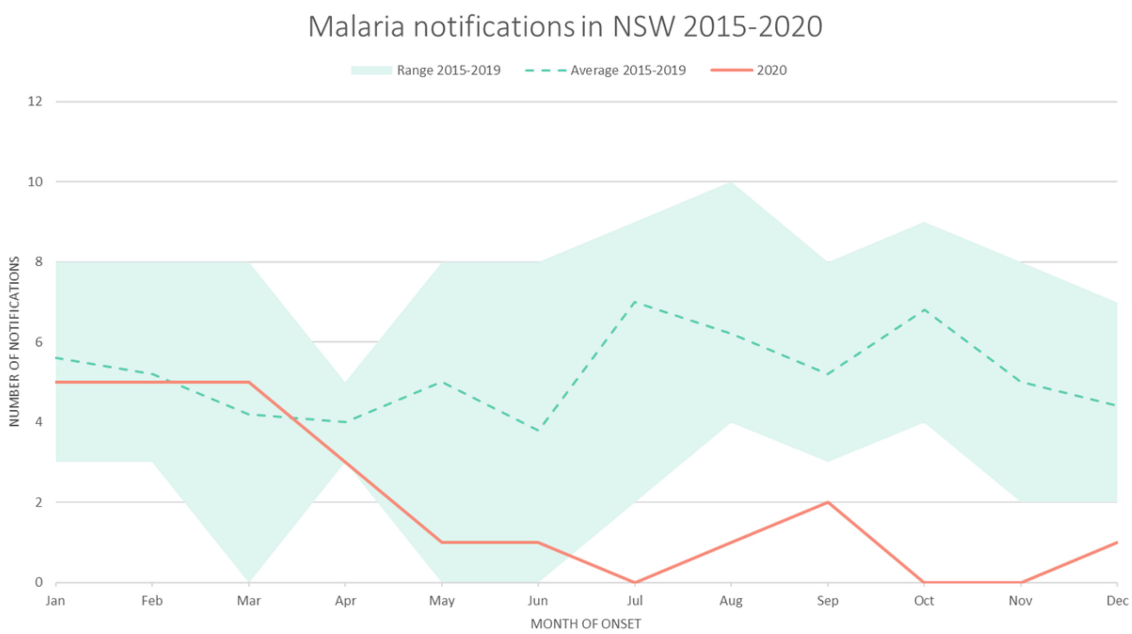
In this study, the overall hypothesis for malaria is that there would be a reduction in notifications following international travel restrictions, due to a reduction in travel from endemic countries. However, this is expected to vary across *Plasmodium* species given differences in natural histories (Table x2, Fig x3). For infections with *P. vivax* and *P. ovale*, where there is the potential for latency, there may not be an appreciable reduction in notifications, given that the infected individual may have arrived in NSW prior to the international border closure. By contrast, *P. falciparum* has a shorter incubation period, and tends to cause more severe illness, thus there is a higher likelihood that the symptoms themselves may interfere with international travel. This means that a greater reduction of *P. falciparum* malaria would be expected, compared to other species, with the travel restrictions. It is more difficult to analyse changes in *P. malariae* malaria, because of low notification numbers each year in NSW. There was only one known case of *P. knowlesi* in NSW, notified in 2009. Therefore, *P. knowlesi* malaria is not examined in this study.

In 2020, there were 24 confirmed cases of malaria notified in NSW, which was 62% lower than the five-year mean for 2015-2019 (Table m1). Of these cases, 14 had onset dates prior to March 20, 2020, representing a 5% increase from the 2015-2019 year-to-date mean. Notifications of malaria declined after March, and was below the 2015-2020 five-year mean from April onwards (Fig m1). The ten cases of malaria between 21 March and 31 December 2020 was an 80% reduction in notifications compared to the mean for the same period of the year from 2015-2019.

Table m1 – Malaria notifications in NSW 2015-2019 5-year mean vs 2020

	2015-2019 5-year mean	2020	% change 2015-2019 mean to 2020
Total malaria notifications	62.4	24	-62
Year-to-date notifications at 20 March	13.4	14	+5
Notifications from 21 March to 31 December	49.2	10	-80

Fig m1 - Notifications of confirmed or probable malaria cases in NSW by date of onset, 2015-2019 vs 2020



In the demographic characteristics of malaria cases notified from 21 March to 31 December each year, it can be seen that prior to 2020, there was a higher proportion of males (71%) compared to females (29%; Table m2). This was unchanged in 2020, with 70% male cases and 30% female cases. The median age in this period of 2020 was older (43 years) than the median in the corresponding period of 2015-2019 (35.5 years). After the border restrictions in 2020, there were no Australia-born malaria cases. In terms of geographical distribution, there was only one case of malaria from regional and remote NSW after international border closure. It is difficult to make any generalisations about the geographical trend based on low numbers.

Table m2 - Additional characteristics of malaria notifications in NSW 2015-2019 vs 2020

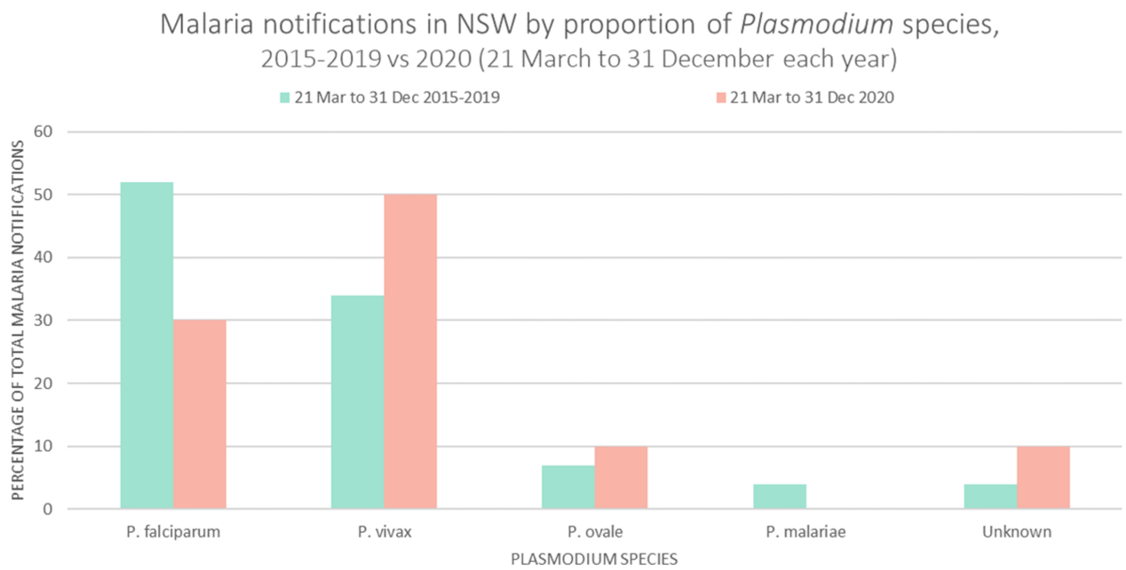
	21 March – 31 December 2015-2019	21 March – 31 December 2020
Median age (years) at notification	35.5	43
Gender (proportion)		
- Female	29	30
- Male	71	70
Country of birth (proportion)		
- Australia	20	0
- Overseas	80	100
Location of residence (proportion)		
- Metropolitan NSW	72	80
- Regional NSW	21	10
- Remote NSW	<1	0
- Unspecified NSW	1	0
- Elsewhere in Australia	<1	0
- Overseas	4	0
- Unknown	<1	10

In terms of the *Plasmodium* species identified from confirmed malaria cases, there was a higher proportion of *P. vivax* infections (50%) after the international border closure in 2020 compared to the same period in 2015-2019 (Table m3; Fig m2). Of the cases between 21 March and 31 December each year from 2015 to 2019, 34% had *P. vivax* malaria. The opposite trend was seen for *P. falciparum*, with 30% in 2020, and 52% in 2015-2019. There were no appreciable differences in the proportion of *P. ovale* cases after 21 March 2020 (10%) compared to 2015-2019 (7%). There were no *P. malariae* cases since February 2020.

Table m3 - Malaria notifications in NSW by species 2015-2019 vs 2020 (21 March – 31 December each year)

Plasmodium species	Mean number of cases 21 March – 31 December 2015-2019	Percentage of cases 21 March – 31 December 2015-2019	Number of cases 21 March – 31 December 2020	Percentage of cases 21 March – 31 December 2020
P. falciparum	25.4	52	3	30
P. vivax	16.8	34	5	50
P. ovale	3.6	7	1	10
P. malariae	1.8	4	0	0
Unknown	2	4	1	10

Fig m2 – Malaria notifications by proportion of species, 2015-2019 vs 2020



The decrease in malaria notifications in NSW after international travel restrictions was consistent with a decrease in international arrivals from endemic countries. This supports the study hypothesis. The hypothesis about the larger relative reduction in *P. falciparum* malaria compared to *P. vivax* and *P. ovale* was also corroborated by the notification data. However, given the low total numbers of malaria notifications after the border closure, the significance of this change in the relative proportion of *Plasmodium* species needs to be interpreted with caution.

With international arrivals being restricted to Australian citizens and residents, an increase in the proportion of Australian-born cases of an overseas-acquired illness would be expected. However, in 2020, a paradoxical decrease was observed. The number of cases born in Australia between 21 March and 31 December in the years 2015-2019 was 20%, whereas there were zero Australia-born cases of malaria after 21 March 2020. This difference may be related to the increase in median age of malaria cases between these two time periods under comparison. After discussion with senior staff in HPNSW, it was thought that these trends may reflect the decrease in the number of young adults travelling to countries where malaria is endemic, and returning to Australia after being infected overseas.

The trend in NSW for notifications of malaria was similar to that observed in several other malaria non-endemic jurisdictions. In Australia, the number of malaria cases notified to the NNDSS between 1 January and 30 June 2020 was 28% lower than the 5-year average for the first six months of 2015-2019(7). Malaria was one of the conditions that showed the largest relative decreases (76.9%) in cases reported in the US in 2020(8). In Germany, between epidemiological weeks 10 and 32, 2020 (early March to early August), the number of malaria notifications was 73.0% lower than expected(5).

Discussion

By reducing the total number of international arrivals overall, the Australian international border restrictions have led to a general decrease in the importation of selected infections. However, the effect of these restrictions varied by condition. The 2020 trends observed were largely influenced by the natural history of each infection, and the transmission patterns in NSW prior to the pandemic.

For conditions where there is no known local transmission in NSW, such as dengue, chikungunya and malaria, the relationship between international travel restrictions and the trends observed after 20 March 2020 is relatively straightforward. By virtue of reducing the number of arrivals from regions where these conditions are endemic, we can hypothesise that there would be fewer cases of overseas acquired infections. These hypotheses were corroborated by the trends in notifications observed.

This study also examined conditions that are not considered endemic to NSW, but can be transmitted locally, such as measles and typhoid. As hypothesised, there were marked decreases in notifications for both conditions following the closure of international borders, given that local transmissions require primary cases with imported infections. Due to the possibility of chronic carriage for typhoid, imported infections continued to cause secondary infections in the community despite international travel restrictions. However, given the reduction in the number of imported cases, this secondary transmission occurred at a lower rate. In contrast, there is no chronic phase for measles, and imported cases are more likely to cause large outbreaks of secondary transmission. These factors may explain the effectiveness of the international travel bans in interrupting local measles transmission in NSW.

Hepatitis A is another condition where the international travel restrictions had a notable impact on NSW trends. As hypothesised, with a reduction of imported cases, there was a decrease in the number of notifications. However, the suppression of local infections to one case linked to a contaminated food item supports the theory that hepatitis A is not endemic in NSW, and that local transmission is sustained by importation from either international arrivals or contaminated food items.

Influenza is another condition with an unexpectedly sharp decrease in notifications after the closure of international borders. Both overseas-acquired infections and local transmission occur in NSW normally, and it is difficult to determine the extent to which either international travel restrictions or NSW-specific public health measures impacted the overall outcome observed. Given that many jurisdictions internationally had observed similar reductions in the incidence of influenza without similar international travel restrictions, it may be difficult to attribute the suppression of influenza in NSW to the reduction of international travel(23, 24). However, the relative decrease in the proportion of influenza B cases detected after 20 March suggests that changes in the importation of influenza viruses may have contributed to the epidemiology of influenza in NSW in 2020.

Tuberculosis presented a different trend to expectations. Despite being a condition where there is a high proportion of imported cases in NSW, there was a paradoxical increase in notifications after the implementation of international travel restrictions. The discrepancy between observed and expected trends in 2020 was thought to be due to the lengthy lag time between infection and diagnosis, and was a reflection of international travel and migration patterns from the years prior to 2020. Therefore, the effects of the 2020 restrictions on tuberculosis may only become apparent in subsequent years.

In addition to general changes in international travel, factors specific to a condition, such as its natural history, may also play a role in the trends observed in 2020. The likelihood of being febrile or having other symptoms at the time of departure may be a more significant consideration in the context of the changing nature of international travel. Symptomatic individuals may be more reluctant to travel, and airlines may be more reluctant to allow symptomatic passengers to embark, thus selecting for travellers who are at lower risk of importing an overseas-acquired infection, especially those with shorter incubation periods, such as influenza, dengue or chikungunya.

The presence of a latent or asymptomatic phase also appears to be an important factor in local transmission patterns after importation was limited. When comparing hepatitis A and typhoid, it can be observed that the chronic carriage of typhoid contributed to its ongoing local transmission, whereas this did not occur with hepatitis A. Similarly, the different species of *Plasmodium* also demonstrate that those that can cause latent infection are more likely to be detected after the international travel restrictions. This characteristic of *Mycobacterium tuberculosis* is one of the likely factors in the paradoxical increase in cases despite a reduction in international arrivals.

Border restrictions also changed the nature of international travel in other ways. The requirement to obtain exemptions for international departures meant that fewer people travelled overseas for leisure, leading to fewer leisure travellers returning to Australia(1). Data on repatriation flights were not publicly available for this study, but it would be reasonable to hypothesise that their availability and schedules may have also altered travel patterns. All these factors would have changed the distribution of source countries and the risk profiles for importing infectious diseases among returned travellers.

In addition, with international arrivals being Australian citizens or residents, there was a greater likelihood that the traveller would have received routine childhood vaccinations against measles, or sought medical advice prior to departing Australia. This may have included recommendations for influenza, hepatitis A or typhoid vaccinations, and chemoprophylaxis against malaria.

Another consideration is that in the hotel quarantine system for returned international travellers, the main diagnostic focus for any febrile episodes is on detecting COVID-19. There may be under-testing of other infections that may cause similar symptoms within this timeframe, such as influenza, dengue, chikungunya or malaria (Personal communication: HPNSW staff). Under-testing may also occur in the community, with fewer symptomatic people seeking medical care due to reluctance to attend healthcare facilities during a pandemic, or with fewer medical practitioners considering travel-related infections in their differential diagnoses (Personal communication: HPNSW staff).

In many cases, it is also difficult to separate out the effects of international travel restrictions from those of local public health measures. For example, as already discussed for influenza, the trends seen would have resulted from a combination of multiple intertwined factors. The international travel restrictions would have reduced the number of introductions of the virus to NSW. The public health measures, designed to control another disease with the same route of transmission, would have then decreased the potential for any chains of local infection from being established following an international introduction(23, 26). Therefore, it would be necessary to take into account a range of additional contextual factors when considering any public health strategies in response to changes in international travel policy. Future analyses that may potentially be useful would include examinations of the epidemiology of infectious diseases with reference to a measure of the degree of local restrictions, such as the Oxford Stringency Index, at a given time(43).

Limitations specific to the analysis included the poor availability of information on place of acquisition of infection. This is not routinely collected for all notifiable conditions in NSW, and for many conditions, it is also difficult to determine with a high degree of certainty. This has meant that analysis by the proportion of overseas-acquired cases was not possible for all conditions. Where this analysis was performed using a proxy indicator for place of acquisition, such as the country of birth, in the case of tuberculosis, this may have resulted in misclassification.

Another limitation to the analyses able to be performed in this study was the small numbers of notifications for specific subgroups within a selected condition. For many of the conditions, although there were sufficient annual notification numbers between 2015 and 2020 to compare overall incidence for the calendar year, the number of notifications after the international border closures decreased markedly, such that it was not possible to carry out meaningful comparisons between the

21 March to 31 December periods from year to year. In addition, there were small numbers of cases for each *Plasmodium* species for malaria, which meant that changes in the relative proportions of species notified were difficult to interpret.

As quarantine-free international travel returns in NSW, it would be important to monitor developments in the local epidemiology of infectious diseases. It is not known whether trends for notifiable conditions will return to pre-pandemic patterns. Several additional factors may contribute to trends observed in the initial months after border reopening. Restrictions will ease first for Australian citizens and residents. This is likely to create biases in the demographics of international arrivals. The removal of the requirement to quarantine on arrival may have an impact on the detection and initial control of overseas-acquired infections, in that new arrivals may not seek medical attention as readily, and would also have more opportunities for onward transmission in their infectious periods. Conversely, this may also improve the detection of conditions that are under-tested in the hotel quarantine system. The reinstatement of outbound travel may also have an impact on the epidemiology of notifiable conditions in NSW, as that this may lead to more travellers returning after overseas trips for leisure, and may introduce infections more likely to be associated with particular destinations or activities. Additional considerations that may emerge include overseas-acquired infections introduced in NSW through interstate travel. While international border restrictions were imposed uniformly on all jurisdictions of Australia, States and Territories have adopted different approaches and timelines for lifting travel restrictions across international and state borders.

Conclusion

International travel restrictions were introduced for the control of COVID-19, but they have also contributed to changes in the epidemiology of other notifiable conditions in NSW. In themselves, they have reduced the number of people arriving in NSW with an overseas-acquired infection. The restrictions have also led to changes in patterns and behaviours around international travel, which may have affected the epidemiology of imported infections. Concurrent local restrictions on activity and movement may have had a synergistic effect in reducing the number of transmissions ultimately resulting from each imported infection.

This study highlights the usefulness of considering international travel-related factors when investigating the local epidemiology of infectious diseases. In some ways, the conditions introduced by the international travel restrictions provided a window for examining local transmission dynamics, with the minimisation of noise from imported infections. These findings related to local patterns may contribute to the broader understanding of the endemicity of particular conditions, such as hepatitis A, in NSW, which would inform future public health control strategies. The findings may also serve as a reminder that the measures introduced for the control of one infection may impact the transmission of other conditions. This was seen to be mostly positive in the conditions reviewed in this study, in terms of overall reductions in notifications. However, there may also be negative consequences, such as potential under-testing of unwell international arrivals in hotel quarantine.

The reopening of international borders leads to the population of NSW having more exposure to pathogens circulating overseas. Consequently, overseas-acquired infections may be more likely to have an impact on local epidemiology. Therefore, it would be important to continue monitoring global trends in infectious diseases beyond COVID-19, and to ensure preparedness to respond to a range of potential imported threats.

Part 2: Other notifiable conditions in NSW in 2020

Background and methodology

In addition to the notifiable conditions presented in Part 1, a brief descriptive review was undertaken of the 2020 notification trends of other notifiable conditions in NSW. The aim of this part of the project was to gain a broad overview of changes to the epidemiology of other notifiable conditions in NSW, in the context of the social and behavioural changes that took place in 2020 in response to the COVID-19 pandemic. It was hypothesised that the events of 2020 would have had a variety of collateral impacts on trends seen in other notifiable conditions, either directly through changes in opportunities for transmission, or indirectly through changes in seeking healthcare or diagnostic testing. This part of the project did not have a specific focus on travel.

Data on each notifiable condition collected as part of routine public health surveillance in NSW, and stored in the Notifiable Conditions Records for Epidemiology and Surveillance (NCRES) database, were examined. Conditions were selected for inclusion in the review if there were notifications confirmed or probable cases in at least three months of each year in the five-year period of 2015-2019. Three additional conditions, giardiasis, campylobacteriosis and hepatitis C, were excluded from analysis due to incompleteness in notification data from diagnostic laboratories in the first six months of 2020. For selected conditions, a full de-identified line list of cases for the years 2015-2019 were extracted using RStudio(15).

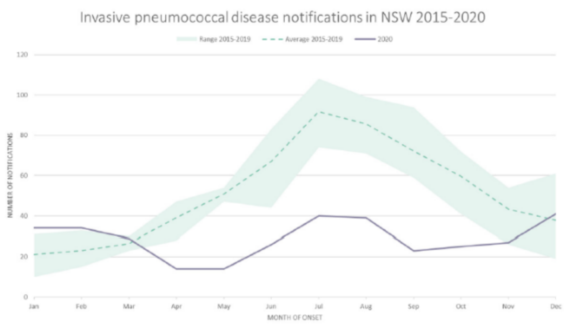
For each of the selected conditions, the number of notifications of confirmed or probable cases per month was plotted. The five-year range and mean for each month was also included on the same graph for comparison. The date of onset was chosen for each case to allow comparability to other studies, as this was also the date chosen by authors at the Australian Government Department of Health to analyse 2020 trends in the National Notifiable Disease Surveillance System (NNDSS) data(7). In NSW, this date is determined across the disease surveillance information systems as either the date of symptom onset reported by the case, or the date of first specimen collection.

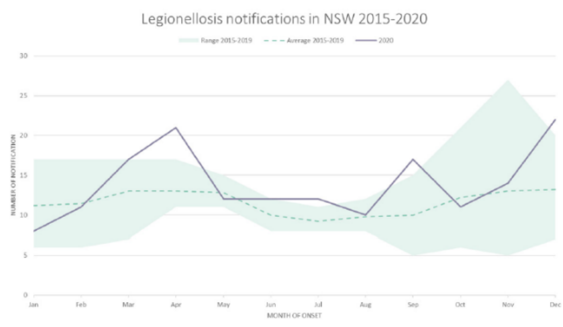
Each NSW notifiable condition graph was described visually, with a focus on any overall trends, and notable changes in notification numbers after restrictive measures for COVID-19 control were implemented in March 2020. The restrictive measures under consideration included both those related to travel, and those impacting on everyday activities and behaviours in general. Specific patterns noted in 2020 were discussed with the relevant communicable diseases teams in HPNSW to gain insights about the hypothesised contributory factors, with a focus on the effects of COVID-19. Where available, other NSW literature providing additional information and hypotheses on the trends observed was reviewed.

Findings

Respiratory diseases

Fig nc1a (left) – Notifications of invasive pneumococcal disease in NSW, 2020 vs 2015-2019; Fig nc1b (right) – Notifications of legionellosis in NSW, 2020 vs 2015-2019





Notifications of invasive pneumococcal disease (IPD) appear to have been affected by the COVID-19 pandemic (Fig nc1a). The numbers of new notifications with an onset from January to March 2020 were above the five-year range but fell sharply below the five-year range in April. IPD notifications remained significantly below the five-year range until November, despite a modest rise in numbers over the winter months of July and August. Given that this is a condition that is primarily transmitted through respiratory routes and close contact, the hypothesis is that the control measures introduced for COVID-19 have also had an effect on the incidence of IPD (Personal communication: HPNSW Respiratory / VPD Team; (44)).

Notifications of legionellosis did not appear to be affected by the pandemic (Fig nc1b). Numbers of notifications remained within or above the monthly five-year-range throughout the year, with peaks in April, September and December. The absence of impact of social distancing measures on this respiratory infection may be due to its transmission being environmental only(45). There may also have been increased testing as a result of increased investigation into respiratory symptoms (Personal communication: HPNSW Respiratory / VPD Team).

Vaccine-preventable diseases

Fig nc2a (top left) – Notifications of pertussis in NSW, 2020 vs 2015-2019; Fig nc2b (top right) – Notifications of Hib in NSW, 2020 vs 2015-2019; Fig nc1c (bottom left) – Notifications of invasive meningococcal disease in NSW, 2020 vs 2015-2019; Fig nc1d (bottom right) – Notifications of mumps in NSW, 2020 vs 2015-2019

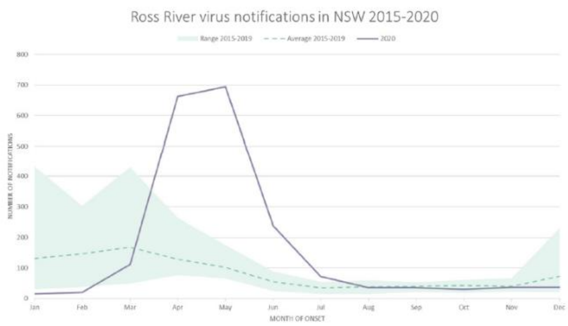
Notifications in each of the vaccine-preventable diseases reviewed appear to have been impacted by the COVID-19 pandemic in 2020.

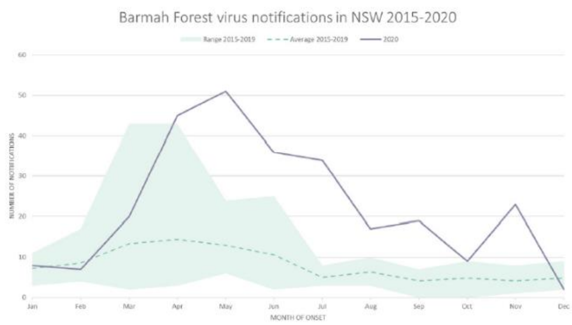
Both pertussis and invasive meningococcal disease (IMD) began 2020 in the lower part of the 2015-2019 five-year range (Fig nc2a and Fig nc2c). Pertussis fell below this range in April, and IMD did so in May. Notifications of both conditions remained below the five-year range for almost all of 2020. Notifications for mumps showed a similar pattern as those for pertussis and IMD from April onwards, despite beginning the year above the five-year range (Fig nc2d). This trend for all three conditions was hypothesised to be due to a reduction in disease transmission as a result of the social distancing measures introduced for COVID-19 control (Personal communication: HPNSW Respiratory / VPD Team). The transmission of all these conditions is primarily respiratory, through droplets or contact with respiratory secretions(46-48). This trend was particularly visible with pertussis, where as a condition with predominantly respiratory symptoms, testing for the investigation of symptoms would be expected to have remained at usual levels, or increased.

There were small numbers of notifications for *Haemophilus influenzae* type b (Hib), both historically and in 2020. This means that it is difficult to identify trends. However, it does appear that with the exception of a peak in the winter months between June and August, notifications for Hib were lower than expected from February 2020 onwards (Fig nc2b). Again, this may be due to a decrease in the transmission of respiratory diseases, despite potentially higher levels of testing(49).

Vector-borne diseases

Fig nc3a (left) – Notifications of Ross River virus infection in NSW, 2020 vs 2015-2019; Fig nc3b (right) – Notifications of Barmah Forest virus infection in NSW, 2020 vs 2015-2019





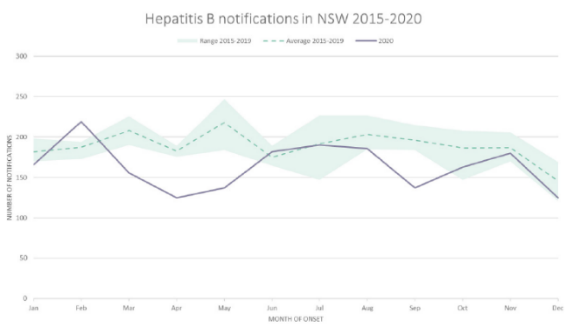
There were large increases in the number of notifications for Ross River virus (RRV) and Barmah Forest (BFV) virus in 2020 (Fig nc3a and Fig nc3b). This was despite a record low number of RRV notifications with onsets in January and February, and notifications within the normal range for BFV for those months.

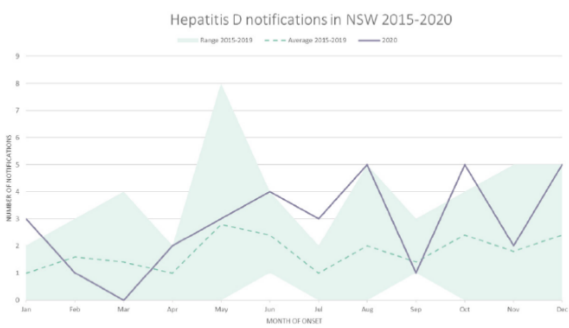
There was a rise in notifications for both diseases in March, followed by record numbers of cases with onsets in April and May. The *NSW Arbovirus Surveillance and Mosquito Monitoring Program 2019-2020* report described this peak, and attributed it to outbreaks of both diseases in coastal areas of NSW (Ref: Unpublished internal document). These outbreaks were postulated to have been driven primarily by environmental factors, such as heavy rainfall leading to a marked increase in mosquito numbers. However, the pandemic may have had an indirect role in exacerbating the extent of the outbreaks. More people may have been exposed to infected mosquitoes due to an increase in outdoor leisure activities, after options for indoor recreation became limited. Public health staff also reported difficulties in disseminating advice to the community on infection risk and preventative measures, due to competing COVID-19 messaging (Personal communication: HPNSW Environmental Health Team).

Notifications for RRV decreased from June, and returned to the five-year range in August. Similarly, notifications for BFV decreased in June, but remained above the five-year range for most of the remainder of 2020.

Bloodborne viral diseases

Fig nc4a (left) – Notifications of hepatitis B in NSW, 2020 vs 2015-2019; Fig nc4b (right) – Notifications of hepatitis D in NSW, 2020 vs 2015-2019





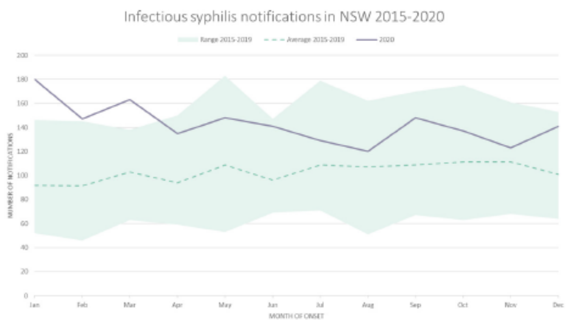
Hepatitis B notifications declined from March onwards (Fig nc4a). They were markedly below the five-year range from March to May, and again in September. Given that most hepatitis B diagnoses in NSW are made in individuals with chronic rather than acute disease, this reduction in notifications would most likely reflect a decrease in testing rather than infection (Personal communication: HPNSW BBV /

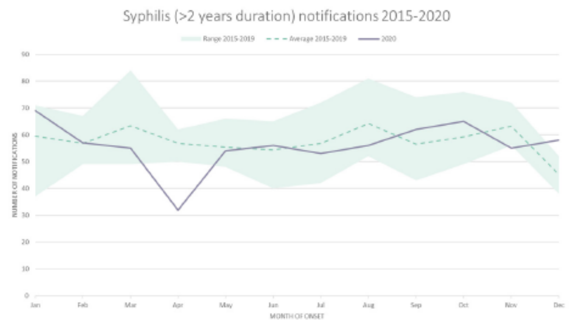
STI Team). This decrease in testing may be related to a reduction in people arriving from countries of high hepatitis B prevalence.

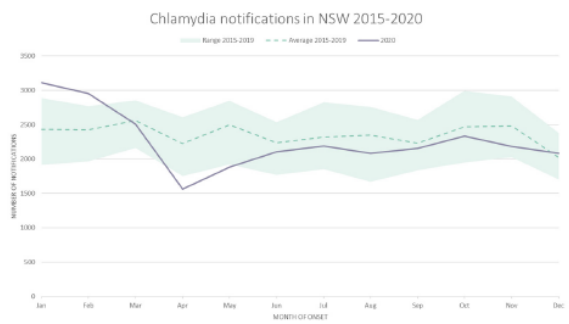
By contrast, hepatitis D did not appear to be affected by events related to COVID-19 (Fig nc4b). Notifications remained above the five-year average for most of 2020. This absence of a relationship with COVID-19 is not unexpected, given that most cases of hepatitis D in NSW would be detected through viral hepatitis screening tests, and therefore would not reflect the timing of the initial infection (Personal communication: HPNSW BBV / STI Team).

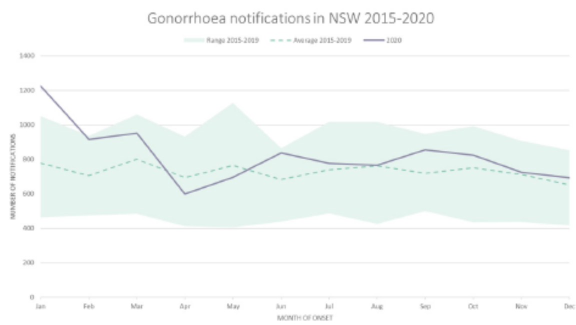
Other sexually transmitted infections

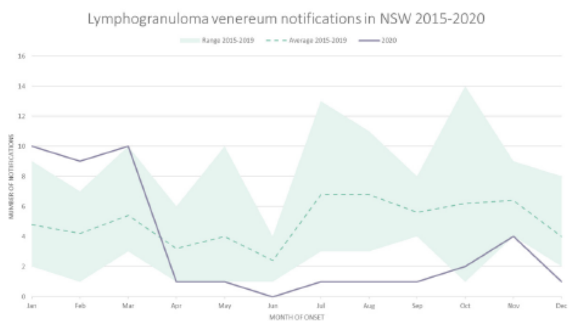
Fig nc5a (top left) – Notifications of infectious syphilis in NSW, 2020 vs 2015-2019; Fig nc5b (top right) – Notifications of syphilis infections of >2 years duration in NSW, 2020 vs 2015-2019; Fig nc5c (middle left) – Notifications of chlamydia in NSW, 2020 vs 2015-2019; Fig nc5d (middle right) – Notifications of gonorrhoea in NSW, 2020 vs 2015-2019; Fig nc5e (bottom left) – Notifications of lymphogranuloma venereum in NSW, 2020 vs 2015-2019











The notifications of all other sexually transmitted infections (STIs) appear to have been affected by the COVID-19 pandemic, with all conditions above the five-year mean in January, and with decreases observed particularly in April 2020.

Notifications of infectious syphilis, defined in NSW as a syphilis infection known to have been acquired within the previous two years, was above the 2015-2019 five-year range from January to March (Fig nc5a; (50)). This fell to within the five-year range in April, and remained within this range but above the five-year mean, for the remainder of 2020. For syphilis of longer than 2 years' duration, or where the duration of infection was unknown, the number of notifications dropped below the five-year range in April, but otherwise remained within this range throughout the year (Fig nc5b). Congenital syphilis notifications were not analysed, as these numbers were small and did not meet the inclusion criteria for this review.

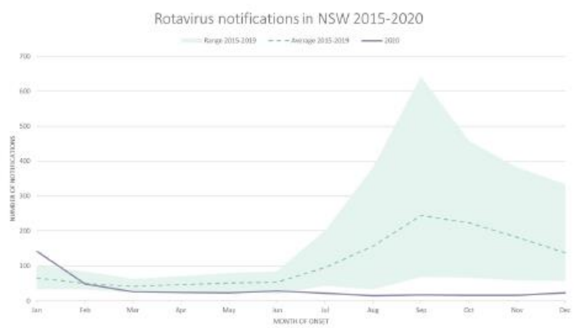
The *NSW Sexually Transmissible Infections Strategy Data Report* for 2020 stated that these trends for syphilis were still under additional investigation (Ref: Unpublished internal report). However, this report did describe some heterogeneity in the infectious syphilis trends between different Local Health Districts. The report also mentioned that the rates of infectious syphilis notifications in 2020 were higher in Aboriginal and Torres Strait Islander populations compared to non-Indigenous populations in NSW, despite the overall decrease in notifications in 2020.

Chlamydia, gonorrhoea and lymphogranuloma venereum (LGV) notifications were all above the five-year range in January, but had started to fall in February, prior to any pandemic restrictions (Fig nc5c, Fig nc5d and Fig nc5e). However, the notification of all three conditions fell sharply in April, with monthly chlamydia notifications below the five-year range. Both gonorrhoea and LGV notifications were below their five-year averages. From May onwards, notifications for chlamydia returned to the five-year range, albeit slightly lower than the five-year mean. From June onwards, gonorrhoea notifications climbed above the five-year mean, but within the five-year range. LGV notifications remained low after April, and was below the five-year range from June to September.

These STI trends were also discussed in the *NSW Sexually Transmissible Infections Strategy Data Report* (Ref: Unpublished internal report). The lower notification rates were attributed to fewer tests being carried out in 2020, with similar positivity rates from tests performed compared to previous years. For LGV in particular, an additional factor was that some of the laboratory resources required for the diagnostic process were reallocated for COVID-19 testing, leading to fewer notifications.

Enteric diseases

Fig nc6a (left) – Notifications of rotavirus infections in NSW, 2020 vs 2015-2019; Fig nc6b (right) – Notifications of hepatitis E in NSW, 2020 vs 2015-2019



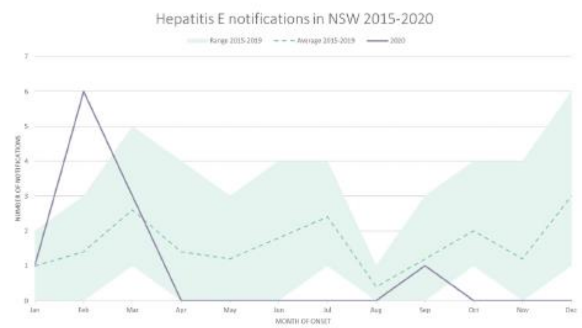
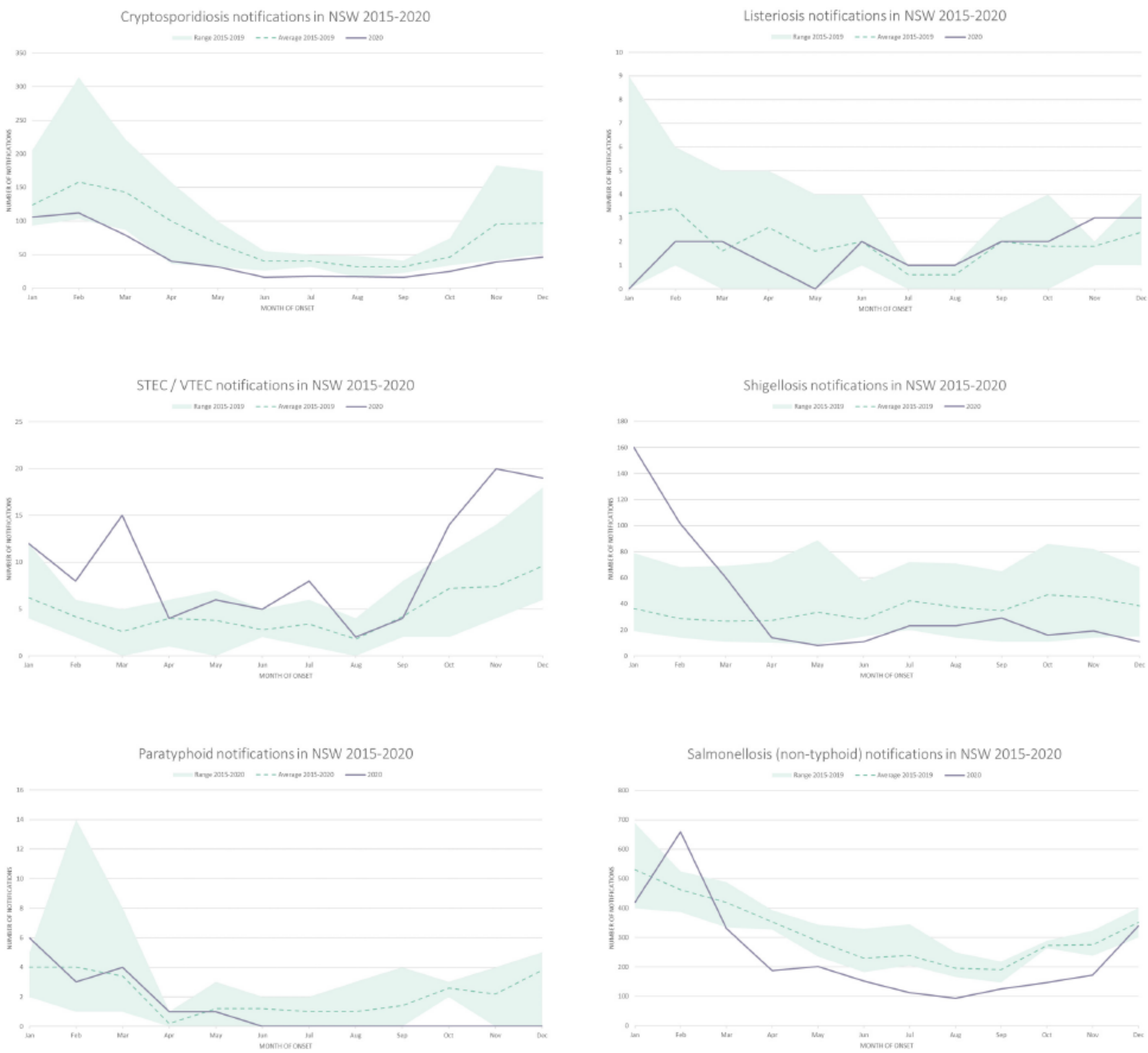


Fig nc7a (top left) – Notifications of cryptosporidiosis in NSW, 2020 vs 2015-2019; Fig nc1b (top right) – Notifications of listeriosis in NSW, 2020 vs 2015-2019; Fig nc1c (middle left) – Notifications of STEC/VTEC in NSW, 2020 vs 2015; Fig nc1d (middle right) – Notifications of shigellosis in NSW, 2020 vs 2015-2019; Fig nc7e (bottom left) – Notifications of paratyphoid infection in NSW, 2020 vs 2015-2019; Fig nc1f (bottom right) – Notifications of salmonellosis in NSW, 2020 vs 2015-2019



Most, but not all, of the notifiable enteric diseases in in NSW appear to have been affected by the COVID-19 pandemic.

Notifications of rotavirus was thought to be reduced by the closure of childcare centres, and the social distancing and hygiene measures introduced or reinforced as part of the pandemic response (Fig nc6a; Personal communication: HPNSW Enterics / Zoonotics Team). Despite notifications being above the five-year range in January, they fell to the lower end of the range by March, and remained within or below this part of the range for the remainder of the year.

There were outbreaks of both non-typhoidal salmonellosis and shigellosis at the beginning of 2020, leading to notifications above the five-year average (Fig nc7f and Fig nc7d). Notifications for both conditions fell in March and in April, with shigellosis notifications reaching the lower end of the five-year range, salmonellosis falling below the five-year range. This was hypothesised to be associated with decreased testing after the introduction of COVID-19 restrictions (Personal communication:

HPNSW Enterics / Zoonotics Team). People with symptoms of gastroenteritis were less likely to attend medical facilities for care. The small rise in shigellosis notifications in August and September were due to an outbreak (Personal communication: HPNSW Enterics / Zoonotics Team).

Cryptosporidiosis notifications remained at or below the lower part of the 2015-2019 range throughout 2020. This trend was also attributed to decreased testing for people with symptoms of gastroenteritis (Fig nc7a; Personal communication: HPNSW Enterics / Zoonotics Team).

There was a peak in overseas-acquired hepatitis E notifications in February 2020 (Fig nc6b). Following COVID-19 restrictions and international border closures, notifications fell to zero in April. However, there was one locally-acquired case in September 2020. Paratyphoid notifications followed a similar pattern, falling after March and reaching zero from June onwards (Fig nc7e). This was also attributed to the lack of overseas-acquired infections (Personal communication: HPNSW Enterics / Zoonotics Team).

The number of shigatoxigenic *E. coli* (STEC) or verotoxigenic *E. coli* (VTEC) notifications were above the five-year range in the beginning of 2020, but fell to within the normal range in April (Fig nc7c). The increase in notifications from October 2020 onwards was attributed to one of the major private laboratories beginning to include STEC/VTEC in the routine diagnostic panel for faecal specimens being investigated for infective pathogens (Personal communication: HPNSW Enterics / Zoonotics Team).

There were no appreciable changes in the trends of listeriosis notifications with COVID-19 restrictions (Fig nc7b). This may be due to the smaller number of notifications, which leads to difficulties in identifying trends.

Zoonotic diseases

Fig nc8a (top left) – Notifications of brucellosis in NSW, 2020 vs 2015-2019; Fig nc8b (top right) – Notifications of Q fever in NSW, 2020 vs 2015-2019; Fig nc8c (bottom left) – Notifications of leptospirosis in NSW, 2020 vs 2015-2019; Fig nc8d (bottom right) – Notifications of psittacosis in NSW, 2020 vs 2015-2019

A range of trends were seen among the four zoonotic diseases selected for review.

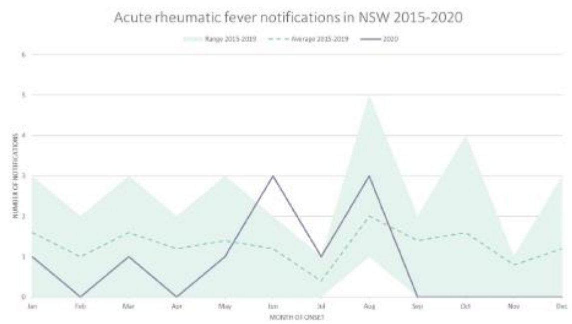
Case numbers were at or below the five-year average for most of the year for brucellosis and Q fever (Fig nc8a and Fig nc8b). A behavioural component was hypothesised for these observations (Personal communication: HPNSW Enterics / Zoonotics Team). For brucellosis, this may be due to fewer people participating in risk activities such as travelling to rural NSW for pig hunting. For Q fever, the decline in notifications with onsets after March was likely due to decreased pre-vaccination screening tests. There were reports that during periods of more stringent pandemic restrictions, people were more reluctant to attend healthcare facilities in person for the purpose of seeking preventative care, such as obtaining Q fever vaccinations. Despite this, it was suggested that the notification numbers did not fall below the five-year range for most of March to November because there was also an increase in testing for the purpose of investigating respiratory symptoms.

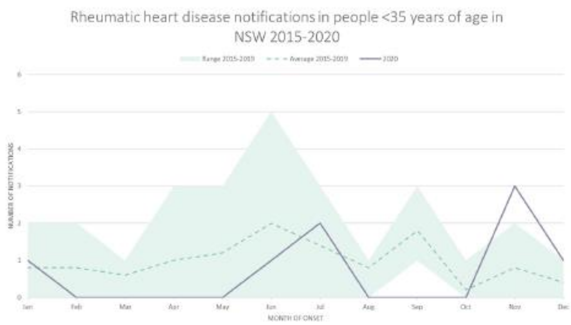
Notifications of leptospirosis appeared to be unaffected by the COVID-19 pandemic, tracking around the five-year average for most of 2020 (Fig nc9c). Where it fell below the five-year average between April and July, this was hypothesised to be due to the five-year data being skewed by outbreaks during those months in previous years (Personal communication: HPNSW Enterics / Zoonotics Team).

For psittacosis, notifications for 2020 were either above or at the higher end of the five-year range (Fig nc9d). There was a sharp rise in notifications in April, well above the 2015-2019 range. This trend was not thought to be related to the COVID-19 pandemic. The severe summer wildfire season in late 2019 and early 2020 caused significant stress among the wild bird populations in NSW, leading to a higher number of unwell wild birds in the environment, and an increased transmission of psittacosis to humans (Personal communication: HPNSW Enterics / Zoonotics Team). Also of note is that the absolute numbers of notifications are small, and may be unreliable for inferring trends.

Other notifiable communicable conditions

Fig nc9a (left) – Notifications of acute rheumatic fever in NSW, 2020 vs 2015-2019; Fig nc8b (right) – Notifications of rheumatic heart disease in people <35 years of age in NSW, 2020 vs 2015-2019





Two related conditions, acute rheumatic fever (ARF) and rheumatic heart disease (RHD) in people under 35 years of age, were also reviewed.

Notifications of ARF were lower than the five-year mean for most of the year, except the months of June to August (Fig nc9a). Given that a clinical assessment is required for the diagnosis of ARF, this decrease in notifications may represent a decrease in people accessing healthcare in person (Personal communication: HPNSW TB / RHD Team). There may have also been a small reduction in the transmission of Group A Streptococcus, with an increased promotion of handwashing and hand sanitiser use.

Similarly, from February onwards, the number of RHD notifications were below the five-year mean, with the exception of peaks in July and November (Fig nc9b). Again, among the surveillance staff in NSW, this was believed to be related to a reduction in detection of new cases (Personal communication: HPNSW TB / RHD Team). This may have been due to a combination of decreased presentations to healthcare, and suspension of some active surveillance activities. Routinely, the NSW RHD Program reviews hospital records at regular intervals for potential new cases of RHD that may require follow up. This accounts for the peaks in the RHD notifications. The higher peak in November may have been due to “catch-up” active surveillance activities. There was an additional hypothesis that in 2020, the competing demands related to the pandemic may have meant that the diagnosis of RHD was deprioritised in clinical diagnostic thought processes.

Conclusion

Public health measures introduced for COVID-19 were likely to have had an impact on the number of notifications received for a range of other conditions in NSW in 2020. This may have been through a direct reduction in transmission, as observed in rotavirus and in diseases with respiratory routes of transmission, such as IPD and pertussis.

For a range of other diseases, the effect of COVID-19 was attributed anecdotally to increased testing, which for many conditions, may be related to changes in healthcare seeking behaviours. Unfortunately, denominator data on the number of tests requested and performed are not routinely collected for most notifiable conditions in NSW. There may have been increased testing for diseases with respiratory symptoms due to the increased investigation of symptoms suggestive of COVID-19. There may have been decreased testing for STIs due to a greater reluctance to attend in-person appointments at healthcare facilities. The decreased presentations to healthcare facilities may have also led to a reduction in diagnoses where a clinical assessment is essential.

It is important to note that while this group of conditions were not specifically chosen for analysis of the impact of international border closures on notification trends in Part 1, many of these conditions have an association with international travel. For example, the reduction in notifications for hepatitis B, hepatitis E and paratyphoid may all be related to a decline in the importation of overseas-acquired infections.

The trends seen in NSW have mirrored those seen in the rest of Australia. An analysis was carried out for several notifiable conditions in the National Notifiable Diseases Surveillance System (NNDSS) in the first six months of 2020(7). In particular, there was a reduction in IMD, rotavirus and salmonellosis notifications from March onwards. At a national level, there was a similar reduction in tests being requested for chlamydia, with similar positivity rates as previous years in the tests that were carried out. For infectious syphilis, the national notifications fell below the five-year average from April onwards, which was unlike the trends seen in NSW. However, there has been an ongoing syphilis outbreak involving four other Australian states, and the developments in this outbreak may have affected the national trends.

There were also some similarities with the notifiable conditions trends from the Central Queensland Public Health Unit (CQPHU)(6). The CQPHU had reviewed their notifications data up to 30 September 2020 (ref). A decrease in the notifications of pertussis, rotavirus and cryptosporidiosis was also seen. There was an increase in notifications of RRV and BFV, but it is not known whether this was coincidental, or due to similar environmental factors as those found in NSW. Unlike NSW, there was an increase in the notifications of infectious syphilis, gonorrhoea and Q fever at CQPHU.

Further afield, the US Centers for Disease Control and Prevention (CDC) noted a decrease in the reporting of all infectious disease groups from 2019 to 2020, with the greatest relative decrease seen in respiratory diseases(8). This overall pattern was attributed to a combination of decreased disease transmission, and disruptions to surveillance and healthcare systems. In Germany, modelling was undertaken to generate expected notification numbers of each notifiable condition, against which observed notifications were compared(5). Observed notifications were lower than expected for all conditions except tick-borne encephalitis.

The results from this review indicate that the public health measures and behavioural changes as a result of the COVID-19 pandemic have had a notable impact on the trends of other notifiable conditions in NSW. Although some of these differences may have been related to restrictions in international travel, most differences were likely to have been multifactorial, stemming from changes to both the transmission of and testing for each condition, and changes in healthcare seeking behaviour.

Appendix 1 – Additional details of confirmed and probable cases notified

Table a1 - Additional characteristics of influenza notifications in NSW 2015-2019 vs 2020

	21 March – 31 December 2015-2019	21 March – 31 December 2020
Gender (proportion)		
- Female	54	49
- Male	46	50
- Transgender	<1	0
- Unknown	<1	1
Location of residence (proportion)		
- Metropolitan NSW	81	74
- Regional NSW	19	26
- Remote NSW	<1	0
- Unspecified NSW	<1	0
- Elsewhere in Australia	<1	<1
- Overseas	<1	0
- Unknown	<1	0

Table a2 - Additional characteristics of tuberculosis notifications in NSW 2015-2019 vs 2020

	21 March – 31 December 2015-2019	21 March – 31 December 2020
Median age (years) at notification	37	35.5
Gender (proportion)		
- Female	45	44
- Male	55	56
- Transgender	<1	0
- Unknown	<1	0
Location of residence (proportion)		
- Metropolitan NSW	92	94
- Regional NSW	6	6
- Remote NSW	<1	0
- Elsewhere in Australia	<1	0
- Unknown	1	0

Table a3 - Additional characteristics of typhoid notifications in NSW 2015-2019 vs 2020

	21 March – 31 December 2015-2019	21 March – 31 December 2020
Median age (years) at notification	26	25
Gender (proportion)		
- Female	52	56
- Male	48	44
Location of residence (proportion)		
- Metropolitan NSW	92	100
- Regional NSW	6	0
- Remote NSW	1	0
- Elsewhere in Australia	0	0
- Overseas	1	0

Table a4 - Additional characteristics of dengue notifications in NSW 2015-2019 vs 2020

	21 March – 31 December 2015-2019	21 March – 31 December 2020
Median age (years) at notification	40.5	42
Gender (proportion)		
- Female	49	25
- Male	51	75
- Unknown	<1	0
Country of birth (proportion)		
- Australia	39	75
- Overseas	34	13
- Unknown	27	12

Table a5 – Additional characteristics of dengue notifications in NSW after 21 March 2020

Age	Gender	Dengue serology requesting location	Likely country of acquisition	Additional notes
27	M	GP	Indonesia	Short term traveller
29	F	ED (self-presented)	Indonesia	Short term traveller
45	M	GP	Indonesia	Short term traveller
37	M	ED (self-presented)	Indonesia	Long-term resident of Indonesia; given exemption for home quarantine
59	M	ED (self-presented)	Fiji	Extended trip to Fiji; was febrile and taking antibiotics on flight and in hotel quarantine
46	F	GP	Singapore	Resident of Singapore; was unwell in hotel quarantine and was querying dengue
43	M	GP	Malaysia	Resident of Malaysia; was unwell in hotel quarantine
44	M	Hospital (referred by quarantine hotel)	India	Long trip to India; sent to hospital by quarantine hotel for suspected stroke on D4 after arrival

Appendix 2 – Recommendations for HPNSW from project

The findings of this project were presented to staff in both the Communicable Diseases Branch and the Public Health Response Branch of HPNSW on 20 November 2021. A set of recommendations for HPNSW from the project was requested for this presentation, and were discussed by the stakeholders present. The recommendations, as shaped by this discussion, are outlined here.

Recommendation 1: Integration of surveillance for COVID-19 and for other travel-related conditions

HPNSW should adopt surveillance strategies that incorporate both COVID-19 and other communicable diseases, with mechanisms to ensure effective communication between all teams that have responsibility for the public health management of notifiable conditions.

This would include developing a close collaboration between the Communicable Diseases Branch and the Public Health Response Branch. HPNSW should continue pre-existing surveillance activities for all notifiable conditions including COVID-19, with the addition of monitoring global developments in communicable disease trends and outbreaks through mailing lists, news bulletins, official online resources and academic sources.

Recommendation 2: Integration of testing for COVID-19 and for other travel-related conditions in symptomatic international arrivals

Health Protection NSW should encourage clinicians to consider testing for both COVID-19 and other relevant infectious conditions when patients present with a history of recent international travel. Testing for travel-related conditions was already part of routine clinical practice prior to the international border closures. Therefore, there may only be a need for a reminder to return to considering both COVID-19 and other travel-related conditions as potential clinical issues. This may be particularly relevant in hotel quarantine settings, where management guidelines could be considered to ensure that clinical assessment and testing includes a range of travel-related conditions.

Recommendation 3: Provision of appropriate health advice for both inbound and outbound international travellers, integrating messaging for both COVID-19 and other communicable diseases

HPNSW should review and resume pre-pandemic public health advice and messaging for returned international travellers and for individuals planning international departures.

Departures for short-term international trips are expected to increase with the lifting of international travel restrictions. This group of travellers is likely to account for some of the overseas-acquired infections notified in NSW after they return. This may be compounded by the fact that prevention of travel-related infections may not be front-of-mind, due to both the additional planning burden to comply with COVID-19 requirements at the destination country, and the relative lack of general travel health messaging in the public sphere in recent months.

Prior to the international border restrictions, HPNSW had already developed a range of resources to inform the public about travel-related health risks. Reviewing and recommencing this pre-existing public health messaging will remind international passengers of additional aspects of travel health beyond the statutory requirements that they need to meet for COVID-19. For outbound travellers, timely health advice can reduce the risk of travellers acquiring infections overseas, which will in turn reduce the importation of these infections.

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The impact of international travel restrictions on notifiable conditions in NSW in 2020

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1

Outline

- Acknowledgment of country
- Background
- Project part 1:
  - Results for each condition
- Project part 2:
  - Results for selected conditions
- Recommendations
- Discussion

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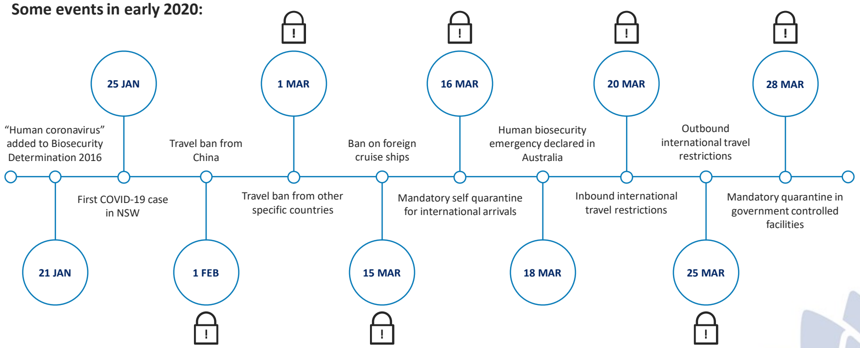
Background (1)

Some events in early 2020:



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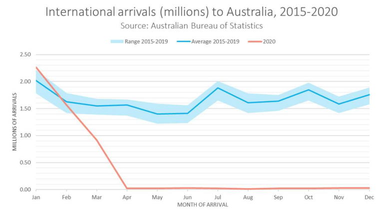
Background (2)

Other associated changes to:

- Traveller demographics
- Modes of travel
- Flight routes and schedules
- Airline policies
- Traveller behaviours
- Restrictions and policies in other jurisdictions



Transmissibility of imported infections affected by:

- 14-day quarantine on arrival
- Local public health measures in NSW

Project:

- How was the epidemiology of notifiable conditions in NSW affected by these international travel-related changes?
- Part of MAE

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Part 1 – Impacts of international travel restrictions (1)

Conditions selected:

- Influenza
- Tuberculosis
- Measles
- Hepatitis A
- Typhoid
- Dengue
- Chikungunya
- Malaria

- Epidemiology of a range of notifiable diseases in NSW after international border restrictions:
  - Focus on 20 March
  - Considers a broad range of international travel restrictions
- Selection of conditions based on:
  - Relevance to international travel
  - Notification numbers at baseline
- Hypotheses generated based on:
  - Pre-existing knowledge about the epidemiology of each condition in NSW
  - Natural history of each condition and how this relates to 14 days of mandatory quarantine
- Notification data from NCRES:
  - Date of onset used
  - NCIMS used to look up specific details
- Main comparisons:
  - Five-year mean counts full year 2015-2019
  - Five-year characteristics of cases 21 March to 31 December
  - Literature available for other jurisdictions

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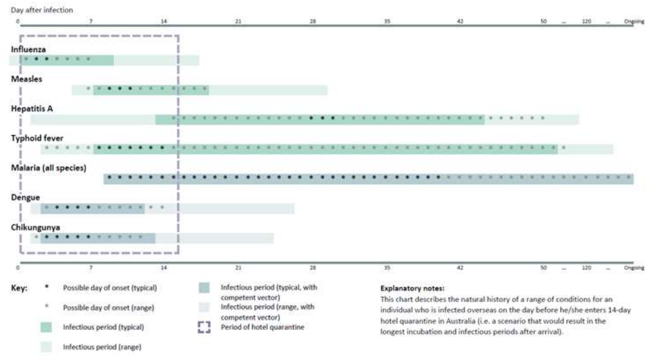
Part 1 – Impacts of international travel (2)



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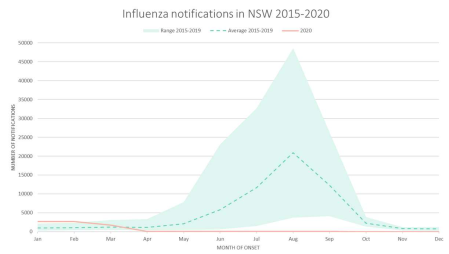
Influenza (1)



Hypothesis

Decrease in the number of notifications, due to:

- Reduction of imported infections
- Reduction of local transmission due to public health measures for COVID-19

Findings Observed

- Marked reduction in notifications after border closures, despite starting the year with higher than usual numbers, and despite very high testing rates
  - Absence of winter peak

Period	2020 count	Change from 2015-2019 mean
Full year	7,244	-88%
1 Jan to 20 Mar	6,808	+48%
21 Mar to 31 Dec	436	-99%

After international travel restrictions:

- Some changes in demographics and subtype distributions (next slide)

Beyond NSW:

- 47% decrease in notifications in Australia 1 Jan to 30 June 2020
- Dramatic reduction of influenza activity worldwide

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Influenza (2)

	21 March – 31 December 2015-2019	21 March – 31 December 2020
Median age (years) at notification	30	48
Influenza virus subtypes (percentage)		
- Influenza A	66	85
- Influenza B	34	14
- Dual influenza A and B infection	<1	1
- Subtype unknown	<1	<1

Older median age in 2020:

- Possibly more related to local public health control measures, such as the closure of educational facilities
- Associated with a relative reduction of notifications in children under 10 years of age

Higher proportion of influenza A:

- May be related to strains circulating internationally at time of border closure

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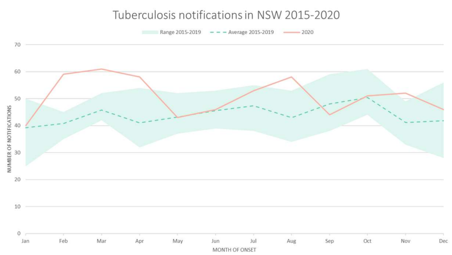
Tuberculosis



Hypothesis

Decrease in the number of notifications, due to:

- Reduction of imported infections
- Reduction of local transmission due to public health measures for COVID-19
- Reduction of onshore immigration screening activities

Findings Observed

Hypothesis **NOT** met: an increase in the number of notifications

Time period	2020 count	Change from 2015-2019 mean
Full year	611	+16%
1 Jan to 20 Mar	151	+32%
21 Mar to 31 Dec	460	+11%

After international travel restrictions:

- 94% cases were overseas-born (compared to 91% pre-travel restriction)
- Is the increase related to reactivation of latent disease in migrants arriving pre-2020?

Beyond NSW:

- 12% increase in notifications in Australia 1 Jan to 30 June 2020
- 11.6% lower than expected in Germany, March-August 2020
- 15.3% decrease in China in 2020, related to disruptions in testing and surveillance

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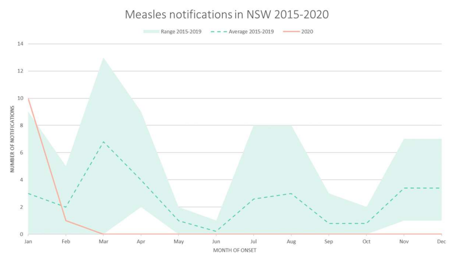
Measles



Hypothesis

- Decrease in the number of notifications, due to a decrease in imported cases
  - Potentially a large reduction in local cases if outbreaks are prevented
  - Potential synergistic reduction of local transmission due to public health measures for COVID-19

Findings Observed

- No notifications after border closures, despite starting the year with higher than usual numbers

Time period	2020 count	Change from 2015-2019 mean
Full year	11	-60%
1 Jan to 20 Mar	11	+38%
21 Mar to 31 Dec	0	-100%

Beyond NSW:

- Latest confirmed case of measles in Australia: February 2020
- Sharp reduction in measles cases in WHO Western Pacific Region from February 2020 onwards
- Concerns about measles surveillance systems in many international jurisdictions

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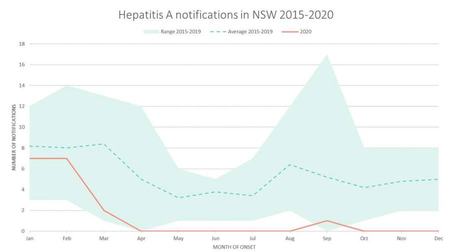
Hepatitis A



Hypothesis

- Decrease in the number of notifications, due to a decrease in imported cases
  - Still possible to have local common source outbreaks

Findings Observed

- Marked decrease in notifications after border closures

Time period	2020 count	Change from 2015-2019 mean
Full year	17	-74%
1 Jan to 20 Mar	15	-34%
21 Mar to 31 Dec	2	-95%

After international travel restrictions:

- 1 overseas-acquired case
- 1 locally acquired case: linked to previously implicated food item
- Does this reveal anything new about the local epidemiology of hepatitis A?

Beyond NSW:

- 43% reduction in notifications in Australia 1 Jan to 30 June 2020
- 36.7% lower than expected in Germany, March-August 2020

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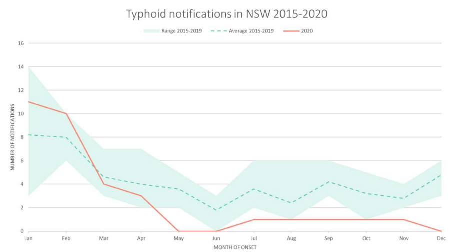
Typhoid



Hypothesis

- Decrease in the number of notifications, due to a decrease in imported cases
  - Some local transmission due to prolonged bacterial shedding and chronic carriage

Findings Observed

- Decrease in notifications after border closures, despite starting the year with higher numbers

Time period	2020 count	Change from 2015-2019 mean
Full year	33	-36%
1 Jan to 20 Mar	24	+24%
21 Mar to 31 Dec	9	-72%

After international travel restrictions:

- 3 overseas-acquired cases
- 6 locally acquired cases: all with household sources with recent travel history / thought to be chronic carriers

Beyond NSW:

- 15% reduction in notifications in Australia 1 Jan to 30 June 2020
- 54% reduction in notifications in WA in 2020

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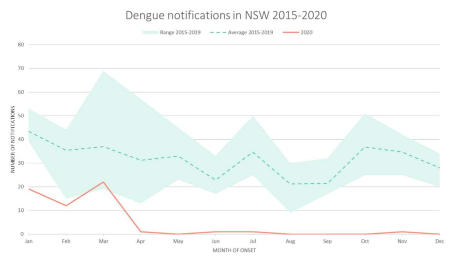
Dengue



Hypothesis

- Decrease in the number of notifications, due to a decrease in imported cases
  - No local transmission possible in the absence of competent vector

Findings Observed

- Marked decrease in notifications after border closures

Time period	2020 count	Change from 2015-2019 mean
Full year	57	-85%
1 Jan to 20 Mar	49	-52%
21 Mar to 31 Dec	8	-97%

- Under-testing in hotel quarantine may have contributed to reduction in notifications (see next slide)

Beyond NSW:

- 79% reduction in notifications in Australia 1 Jan to 30 June 2020
- Wide variability in trends observed in endemic countries due to a variety of factors

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Dengue cases after 20 March 2020 – Under-testing in quarantine hotels

Age	Gender	Dengue serology requesting location	Likely country of acquisition	Additional notes
27	M	GP	Indonesia	Short term traveller
29	F	ED (self-presented)	Indonesia	Short term traveller
45	M	GP	Indonesia	Short term traveller
37	M	ED (self-presented)	Indonesia	Long-term resident of Indonesia; given exemption for home quarantine
59	M	ED (self-presented)	Fiji	Extended trip to Fiji; was febrile and taking antibiotics on flight and in hotel quarantine
46	F	GP	Singapore	Resident of Singapore; was unwell in hotel quarantine and was querying dengue
49	M	GP	Malaysia	Resident of Malaysia; was unwell in hotel quarantine
44	M	Hospital (referred by quarantine hotel)	India	Long trip to India; sent to hospital by quarantine hotel for suspected stroke on D4 after arrival

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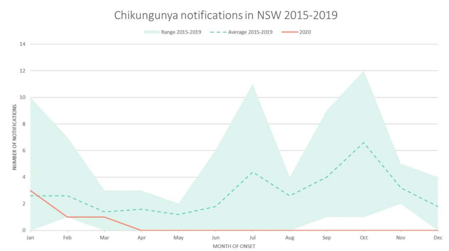
Chikungunya



Hypothesis

- Decrease in the number of notifications, due to a decrease in imported cases
  - No local transmission possible in the absence of competent vector

Findings Observed

- No notifications after border closures

Time period	2020 count	Change from 2015-2019 mean
Full year	5	-85%
1 Jan to 20 Mar	5	-17%
21 Mar to 31 Dec	0	-100%

- Unable to determine if there was under-testing in hotel quarantine (0 cases)

Beyond NSW:

- 37% reduction in notifications in Australia 1 Jan to 30 June 2020
- Poor availability of data globally:
  - Non-endemic countries: limited analyses performed
  - Endemic countries: variable reporting

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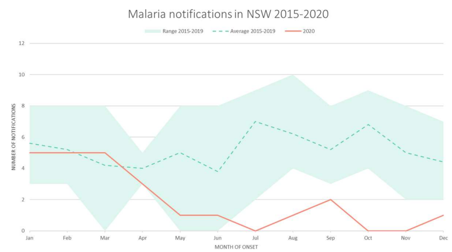
Malaria (1)



Hypothesis

- Decrease in the number of notifications, due to a decrease in imported cases
  - Local transmission unlikely

Findings Observed

- Marked decrease in notifications after border closures

Time period	2020 count	Change from 2015-2019 mean
Full year	24	-62%
1 Jan to 20 Mar	14	+5%
21 Mar to 31 Dec	10	-80%

- Differences in *Plasmodium* species notified (next slide)

Beyond NSW:

- 28% reduction in notifications in Australia 1 Jan to 30 June 2020
- 73.0% lower than expected in Germany, March-August 2020
- One of the conditions with the largest relative decreases in the US CDC data: 76.9%
- Much of the global reporting for 2020 was not undertaken or delayed

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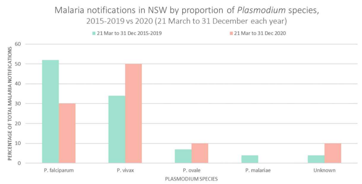
Malaria (2)



	21 March – 31 December 2015-2019	21 March – 31 December 2020
Median age (years) at notification	35.5	43
Country of birth		
- Australia	20	0
- Overseas	80	100

Plasmodium species trends:

- Reminder that longer periods of latency are possible with *P. vivax* and *P. ovale* infections
  - We would expect the border closures to have less of an impact on these infections, given that they could have been acquired well before the pandemic
  - This hypothesis was confirmed with our data

Demographic trends:

- With restrictions of arrivals to Australian citizens / residents, we would expect to see an **increase** in the proportion of Australian-born cases:
  - Especially for a disease that is exclusively overseas-acquired (was observed for dengue)
  - But we observed a **decrease** in the proportion of Australian-born cases
- Slightly older median age
- Does this point to a reduction in younger Australians taking short trips to endemic destinations?

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Part 2 – Other notifiable conditions in NSW

- Epidemiology of everything else in 2020!
  - o All other notifiable conditions in NSW, except:
    - Conditions where the usual counts are zero / small
    - Conditions where data were not readily available
- Brief overview of trends across the entire year:
  - o No demographic / subgroup breakdowns performed
- No focus on changes to international travel:
  - o But does not exclude the effect of international travel on the trends observed

- Main findings:
  - o Many conditions had a slight "return to normal" in November or December
  - o All STIs examined started 2020 above the 5-year mean, with decreases coinciding with the start of restrictions

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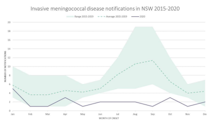
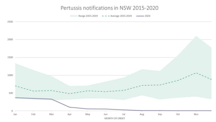
Other selected notifiable conditions (1)

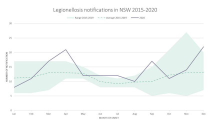
Respiratory diseases, vaccine-preventable diseases and vector-borne diseases



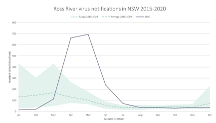
Invasive meningococcal disease
- Started year in lower part of 5-year range
- Below 5-year range from May to November



Pertussis
- Started year in lower part of 5-year range
- Below 5-year range from April onwards



Legionellosis
- Within or above 5-year range all year
- Peaks in April, September, December
- Data include all species of *Legionella*



Ross River virus infection
- Started year below 5-year range
- Increase in cases from March, with large peak in April and May
- Back in 5-year range from August onwards

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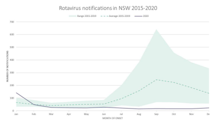
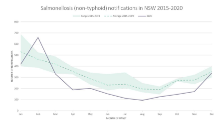
Other selected notifiable conditions (2)

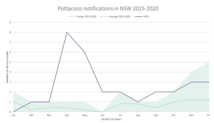
Enteric and zoonotic conditions



Rotavirus infections
- Started year above 5-year range
- Below 5-year mean from March onwards



Salmonellosis
- Early peak in February coinciding with outbreak
- Below 5-year range from March to November



Psittacosis
- Started year in lower part of 5-year range
- Above 5-year mean from February onwards, with peak in April to May
- Possible sequelae of bushfires

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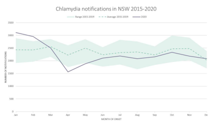
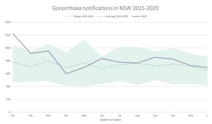
Other selected notifiable conditions (3)

Sexually transmitted infections



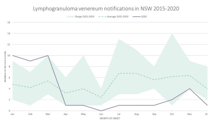
Chlamydia

- Started year above 5-year range
- Below 5-year mean from March to November
- May be due to a decrease in testing



Gonorrhoea

- Started year above 5-year range
- Within 5-year range from February onwards, without any notable reductions
- May still represent a decrease in testing



LGV

- Started year above 5-year range
- Sharp drop to below 5-year mean from April onwards
- Associated with redirection of laboratory resources

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Limitations and considerations

- Difficulty in separating the effects of international travel restrictions from those of local public health measures
  - Potential synergies between local and international strategies
- Potential biases from:
  - Changes in traveller demographics, destinations and activities
  - Repatriation flights are from specific countries: potentially different from our normal distribution
  - Under-testing for certain conditions in hotel quarantine
  - Changes in testing patterns
- Limitations of data:
  - Place of acquisition not available for all cases / conditions
  - Small numbers of cases after international travel restrictions

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Conclusions

- Many collateral effects from the international travel restrictions observed:
  - Mostly a reduction in incidence of other notifiable conditions
- Opportunity to examine:
  - Local transmission dynamics
  - The epidemiology of imported infections
    - Whether the condition has a latent state appears to be an important factor in the local epidemiology in the shorter term
- With international travel restarting:
  - Changes to the epidemiology of many conditions are expected, but difficult to predict
    - Local restrictions easing at the same time
    - Ongoing disruptions to travel patterns

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Recommendation 1

Integration of surveillance for COVID-19 and for other travel-related conditions

Health Protection NSW should adopt surveillance strategies that incorporate both COVID-19 and other communicable diseases, with mechanisms to ensure effective communication between all teams that have responsibility for the public health management of notifiable conditions.

- Example where this would be helpful: Monitoring seasonal influenza
- Overall benefits: Will allow efficient detection and response to emerging threats from imported infections in NSW
- Activities could include:
  - Improving processes for information sharing between PHRB and CDB
  - Expanding the use of genomic techniques for surveillance of a broader range of communicable diseases
  - Monitor global developments in communicable disease trends and outbreaks

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Recommendation 2

Integration of testing for COVID-19 and for other travel-related conditions in symptomatic international arrivals

Health Protection NSW should encourage clinicians to consider testing for both COVID-19 and other relevant infectious conditions when patients present with a history of recent international travel.

- Example where this would be helpful: Testing for dengue in febrile returned travellers
- Overall benefits: Will allow early detection of imported infections
- Activities could include:
  - Testing guidelines for unwell individuals in the hotel quarantine setting

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Recommendation 3

Provision of appropriate health advice for both inbound and outbound international travellers, integrating messaging for both COVID-19 and other communicable diseases

Health Protection NSW should review and resume pre-pandemic public health advice and messaging for returned international travellers and for individuals planning international departures.

- Example where this would be helpful: Measles messaging to both new arrivals and people planning international trips
- Overall benefits: Will remind international travellers about additional aspects of travel health beyond COVID-19 (and the legal requirements that they need to meet)
- Activities could include:
  - Reviewing the health-related written material currently given to international travellers on arrival currently to include general information about seeking healthcare for unwell returned travellers

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Thank you

Thank you for your attention

Special mentions:

- Supervisors:
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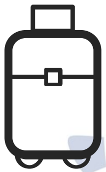
  - Elaine Tennant
  - Cameron Webb



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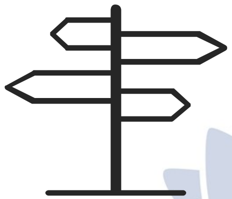
Discussions

- Individual conditions:
  - Tuberculosis – additional thoughts about the increase in notifications?
  - Hepatitis A – additional thoughts about local transmission patterns?
  - Questions about any other conditions?
- Overall findings and trends
- Recommendations



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Draft manuscript for submission to Communicable Diseases Intelligence

International travel restrictions and their impact on selected notifiable conditions in NSW in 2020

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Abstract

The introduction of international travel restrictions in March 2020, in response to the threat of COVID-19, has led to changes in the epidemiology of a range of other notifiable conditions in NSW. Compared to the five-year period of 2015-2019, there were sharp reductions in notifications in 2020 of influenza, measles, hepatitis A, typhoid, dengue, chikungunya and malaria. There was a paradoxical increase in the number of notifications of tuberculosis.

Keywords: International travel, notifiable conditions, NSW

Introduction

In response to the evolving global threat of COVID-19, limitations on international travel were introduced in Australia starting from February 2020(1). Subsequent updates to Commonwealth directions culminated in more widespread international travel restrictions, including restrictions on the arrival of all foreign nationals on 20 March 2020. These restrictions remained in place for the remainder of 2020. As a result, the number of overseas arrivals to Australia decreased steeply from January 2020 onwards(2).

This project aims to describe the epidemiology of eight notifiable conditions in NSW to examine the potential effects of border closures on notifications observed in 2020. The terms “international travel restrictions” and “international border closures” are used interchangeably in this project to refer both to the inbound and outbound travel restrictions themselves, and to the broader range of changes to international travel that resulted from these restrictions, including the 14-days of mandatory quarantine on arrival.

Methods

Eight conditions were selected based on consultation with senior public health staff within the NSW Ministry of Health. The following criteria were used:

1. Typical or known associations with travel or recent arrival to Australia
2. Sufficient number of baseline notifications to observe meaningful changes in 2020

Conditions were included for analysis according to expert hypotheses of associations between local notifications with international travel. The baseline rate of notifications was another deciding factor in the selection of conditions for analysis. Certain conditions have had zero or low numbers of notifications for the five years prior to 2020.

Individual line-listed data for each notifiable condition were extracted from the NSW Notifiable Conditions Records for Epidemiology and Surveillance (NCRES) database. This database stores de-identified information on all cases of most of the communicable conditions notified to NSW Health.

The general epidemiological trend in NSW for each condition was reviewed, with comparisons of notifications between 2020 and the five-year period from 2015 to 2019 inclusive. After examining the overall annual trend for the full calendar year, more detailed analyses were performed for cases with onsets in the period after 20 March of each year, as the main international border closure event occurred on 20 March 2020.

This project obtained approval from the Australian National University Human Research Ethics Committee (Protocol number 2021/463).

Results

For the eight conditions in this study, there was a total of 317,693 confirmed and probable notifications in NSW between 1 January 2015 and 31 December 2020.

Influenza

In 2020, there were 7,244 confirmed cases of influenza in NSW. This was 88% lower than the 2015-2019 five-year mean of 60,724 annual cases (Table 1). Of this annual total, 6,808 notifications had onset dates on or before 20 March, a year-to-date figure 48% higher than the 2015-2019 five-year average, and also above the 2015-2019 five-year range (Fig 1).

Table 1 – Influenza notifications in NSW 2015-2019 5-year mean vs 2020

	2015-2019 5-year mean	2020	% change 2015-2019 mean to 2020
Total influenza notifications	60,724.2	7,244	-88
Year-to-date notifications at 20 March	2,744.6	6,808	48
Notifications from 21 March to 31 December	57,979.6	436	-99

Notifications of influenza fell within the normal range in March 2020, and below the normal range from April onwards for the remainder of the year (Fig 1). There was no evidence of the typical winter influenza peak. The 436 influenza notifications from 21 March to 31 December was a 99% reduction compared to the mean number of notifications for the same time period in 2015-2019. This reduction in influenza notifications in NSW was despite historically high numbers of diagnostic tests for influenza having been performed in 2020.

Fig 1 – Notifications of confirmed influenza cases in NSW by date of onset, 2015-2019 vs 2020

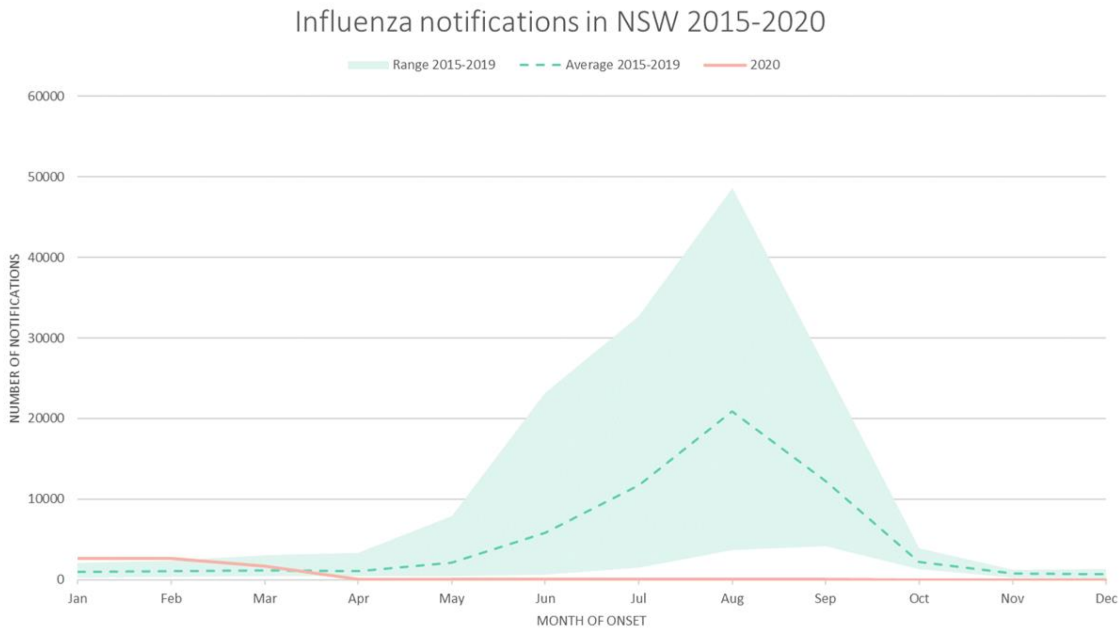


Table 2 - Characteristics of influenza notifications in NSW 2015-2019 vs 2020 (21 March – 31 December each year)

	21 March – 31 December 2015-2019	21 March – 31 December 2020
Median age (years) at notification	30	48
- Proportion of cases under 10 years of age	27.3%	11.5%

The median age at notification in 2020 was 48, 18 years higher than the median age at notification in 2015-2019, and was associated with a relative reduction of notifications in children under 10 years of age, from 27.3% to 11.5% (Table 2). This was more likely to be due to the closure of educational facilities as part of the public health control measures, rather than restrictions at international borders (Personal communication: HPNSW Respiratory Team).

The closure of international borders would have prevented circulating viral strains from the northern hemisphere from entering the country after 20 March(3). The 14-day mandatory quarantine period for new arrivals was longer than the combined typical incubation and infectious periods for influenza, minimising community transmission of any imported disease. The introduction of social restrictions and behavioural changes for COVID-19 control would have added to the disruption of local transmission(3-5). The reduction of notifications in NSW also relates to the avoidance of the annual winter peak.

Tuberculosis

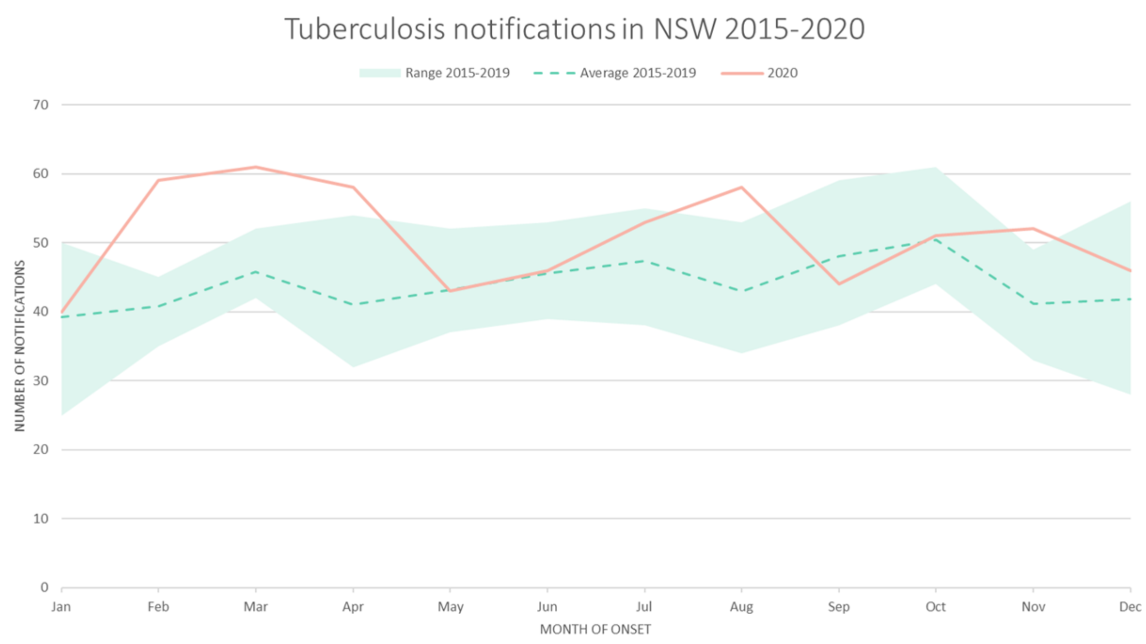
Notifications of tuberculosis in NSW did not decrease after the closure of international borders. The 611 notifications of confirmed and probable cases for the entirety of 2020 were 16% higher than the 2015-2019 five-year mean (Table 3). The year-to-date notifications at 20 March were 32% higher than the 2015-2019 five-year mean, with a peak from February to April that was above the five-year range (Fig 2). The number of notifications after 20 March was also higher than the 2015-2019 five-year mean, by 11%.

Table 3 - Tuberculosis notifications in NSW 2015-2019 5-year mean vs 2020

	2015-2019 5-year mean	2020	% change 2015-2019 mean to 2020
Total tuberculosis notifications	527.4	611	+16
Year-to-date notifications at 20 March	114	151	+32
Notifications from 21 March to 31 December	413.4	460	+11

Despite notifications falling in May, tuberculosis notifications in 2020 remained at or above the five-year average for most months for the remainder of the year. The number of tuberculosis notifications from 21 March to 31 December was 11% higher than the 2015-2019 average for this period.

Fig 2 – Notifications of confirmed tuberculosis cases in NSW by date of onset, 2015-2019 vs 2020



Given the usual time lag between infection and diagnosis for tuberculosis, the closure of international borders would not be expected to have an impact on the detection of infections in overseas born individuals already in NSW. NSW epidemiological data show that prior to 2020, for cases acquired overseas, the mean interval between arrival in Australia and diagnosis of tuberculosis was two to three years (Internal document). The rise in cases in 2020 may reflect an increase in immigration from countries with higher prevalence of tuberculosis, such as India, in the years prior to 2020 (Internal document). In addition, the public health messaging around COVID-19 may have prompted clinicians and patients to request more diagnostic investigations for chronic respiratory symptoms (Personal communication: HPNSW TB Team). Many of the individuals diagnosed with tuberculosis in 2020 had also suffered high levels of stress due to the pandemic, which may have triggered reactivation of latent infection.

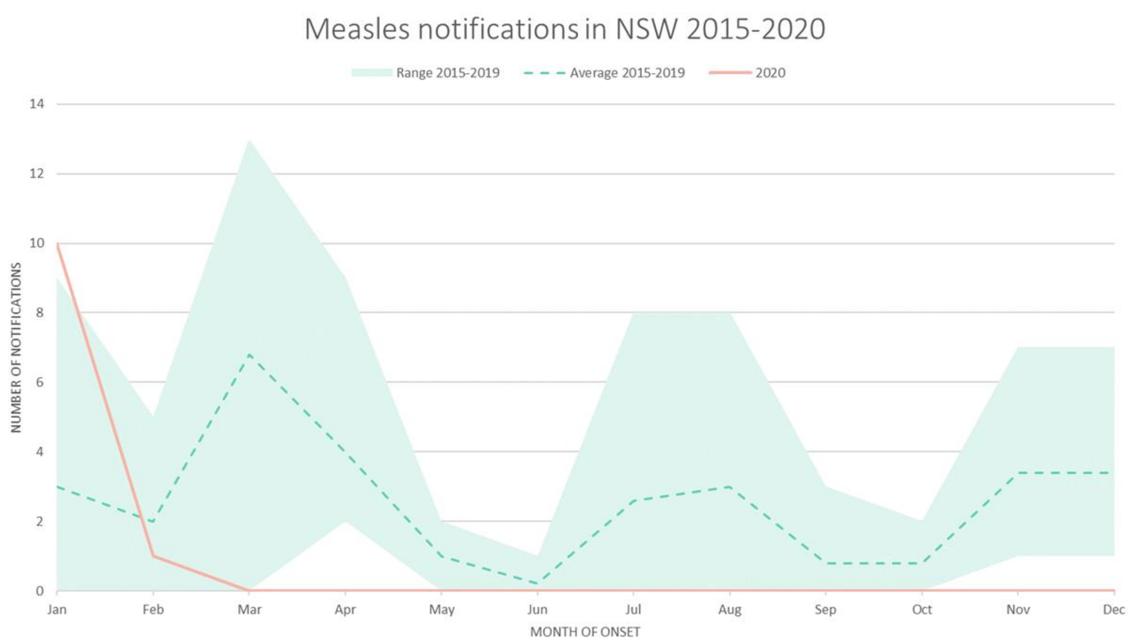
Measles

There were 11 confirmed cases of measles notified in NSW in 2020 (Table 4). This was a 60% reduction compared to the 2015-2019 five-year average (27.6 notifications). Of note, all 11 cases had onset dates prior to international border closures on 20 March (Fig 3). This year-to-date number of measles notifications is 38% higher than the average as at 20 March for the 2015-2019 five-year period (8 notifications).

Table 4 – Measles notifications in NSW 2015-2019 5-year mean vs 2020

	2015-2019 5-year mean	2020	% change 2015-2019 mean to 2020
Total measles notifications	27.6	11	-60
- Overseas-acquired measles cases as proportion of total	54%	9%	
Year-to-date notifications at 20 March	8	11	+38
Notifications from 21 March to 31 December	19.6	0	-100

Fig 3 - Notifications of confirmed measles cases in NSW by date of onset, 2015-2019 vs 2020



Of the measles cases notified in NSW in 2020, only one of 11 (9%) was determined to have been overseas acquired, with a corroborative travel history. By contrast, in the five-year period of 2015-2019, an average of 54% annual cases were overseas acquired. All 11 cases resided in metropolitan areas.

There were zero measles cases after international border restrictions came into effect. This supports the view that local transmission of measles in NSW is not sustained without imported cases. It may also reflect high rates of population immunity in NSW, an overall reduction in the global circulation of measles during the pandemic, and low rates of testing for measles in the hotel quarantine system (Personal communication: HPNSW staff).

Hepatitis A

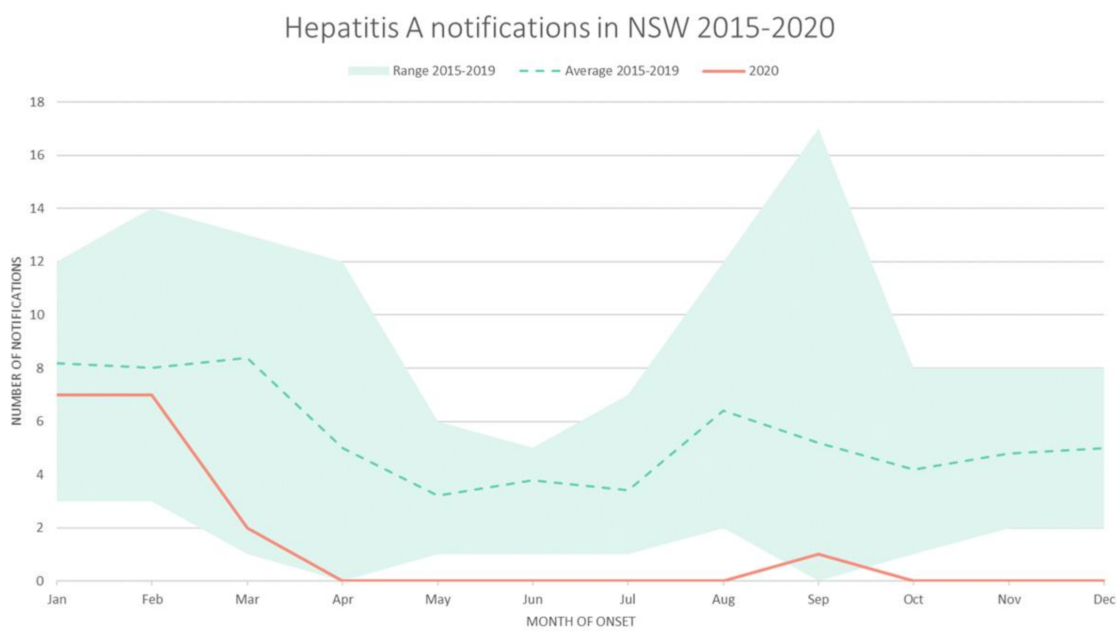
There was a total of 17 confirmed hepatitis A infections in NSW in 2020, which represents a 74% decrease from the 2015-2019 five-year mean (Table 5). Notably, 15 (88%) of these 2020 cases had dates of onset prior to international border closure on 20 March. This year-to-date notification number was 34% lower than the 2015-2019 five-year average, but still within the 2015-2019 five-year range (Fig 4).

Table 5 – Hepatitis A notifications in NSW 2015-2019 5-year mean vs 2020

	2015-2019 5-year mean	2020	% change 2015-2019 mean to 2020
Total hepatitis A notifications	65.6	17	-74
- Overseas-acquired hepatitis A cases as proportion of annual total	63%	88%	
Year-to-date notifications at 20 March	22.6	15	-34
- Overseas-acquired hepatitis A cases as proportion of all year-to-date notifications at 20 March	73%	93%	
Notifications from 21 March to 31 December	43	2	-95

Hepatitis A notifications fell in March 2020, with one notification between 21 to 30 March, and one notification in September. These two cases represent a 95% reduction in the number of hepatitis A cases from 21 March to 31 March 2020, compared to the mean for same period in 2015-2019. Hepatitis A notifications were below the five-year range for most of the months from May to December.

Fig 4 – Notifications of confirmed and probable hepatitis A cases in NSW by date of onset, 2015-2019 vs 2020



Before the closure of international borders, NSW data show that the percentage of overseas-acquired cases in 2020 was 88%, which was higher than the average proportion of overseas-acquired hepatitis A cases for the 2015-2019 period of 73%. As there were only two cases of hepatitis A in 2020 after the closure of international borders, the proportion of overseas-acquired cases in this period was not examined, and additional comparative epidemiological analyses were not performed.

The absence of any additional local common-source outbreaks allowed the effects of international travel restrictions to be observed clearly. Despite the potential for local transmission, there were no notifications of this occurring after the border closure. This could reflect transmission dynamics that rely on imported infections to drive ongoing local transmission, which may not have been observable when there had been greater numbers of overseas-acquired infections. These observations could suggest that hepatitis A is not endemic to NSW (Personal communication: HPNSW staff).

Typhoid

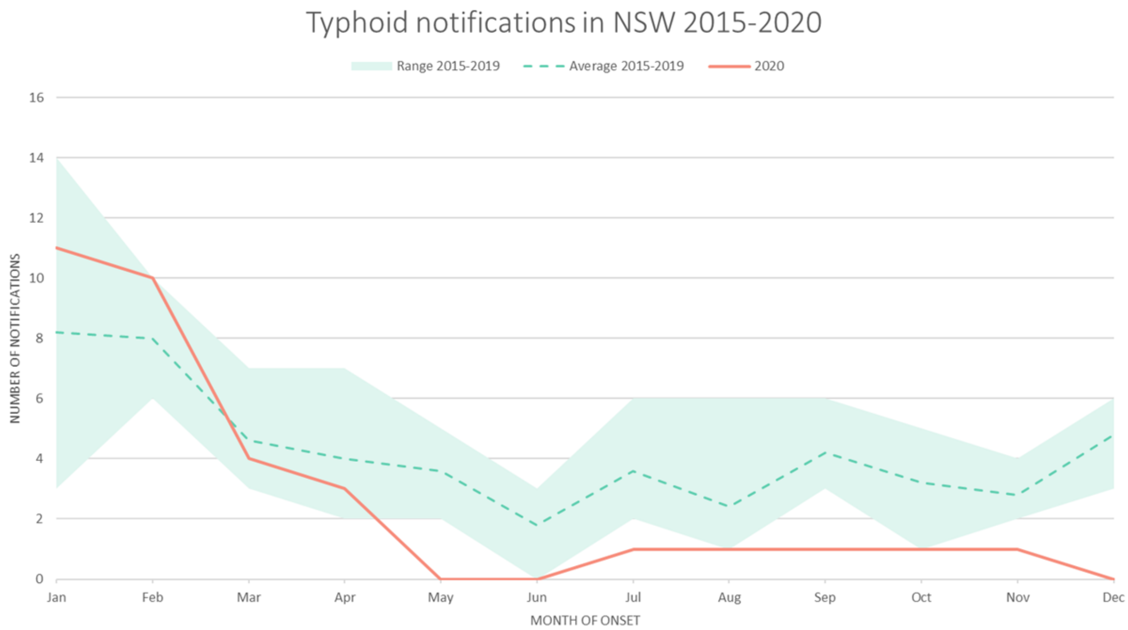
In 2020, there were 33 confirmed notifications of typhoid in NSW, representing a 36% reduction from the mean number of annual notifications for the five years 2015-2019 (Table 6). Of these cases, 24 (72%) had onset dates prior to international border closures on 20 March. As a comparison, by 20 March each year in 2015-2019, there were on average 19.4 typhoid notifications.

Table 6 – Typhoid notifications in NSW 2015-2019 5-year mean vs 2020

	2015-2019 5-year mean	2020	% change 2015-2019 mean to 2020
Total typhoid notifications	51.2	33	-36
- Overseas-acquired typhoid cases as proportion of annual total	94	79	
Year-to-date notifications at 20 March	19.4	24	+24
- Overseas-acquired typhoid cases, as proportion of all year-to-date notifications at 20 March	92	96	
Notifications from 21 March to 31 December	31.8	9	-72
- Overseas-acquired typhoid cases, as proportion of all cases with onset 21 March to 31 December	95	33	

Despite higher than usual numbers at the start of 2020, by March, the number of typhoid notifications fell below the five-year mean for 2015-2019 (Fig 5). By May, this number was below the five-year range, where it remained until the end of 2020. There were 9 notifications of typhoid between 21 March and 31 December 2020, which was a 72% reduction from the five-year mean number of notifications between 21 March and 31 December 2015-2019.

Fig 5 – Notifications of confirmed typhoid fever cases in NSW by date of onset, 2015-2019 vs 2020



The source of infection was determined to be outside of Australia for 26 (79%) cases, attributed to several countries across Asia. There was a notable difference in the temporal distribution of these overseas-acquired cases before and after the closure of international borders. The proportion of all typhoid fever cases that was acquired overseas before 20 March was 96%, whereas this proportion decreased to 33% after 20 March. In 2015-2019, the average proportion of overseas-acquired cases of typhoid fever was 94%. As expected, this was more consistent with the typhoid cases in 2020 prior to international border closure.

The trend of typhoid notifications in 2020 is consistent with most cases in NSW being acquired overseas. However, due to prolonged shedding of viable bacteria in some individuals, the international travel restrictions did not prevent all cases of local transmission. This was reflected in the six locally acquired cases after the international border closure. All were found to have acquired their infections from household contacts with histories of international travel to countries with higher typhoid prevalence prior to border closures.

Dengue

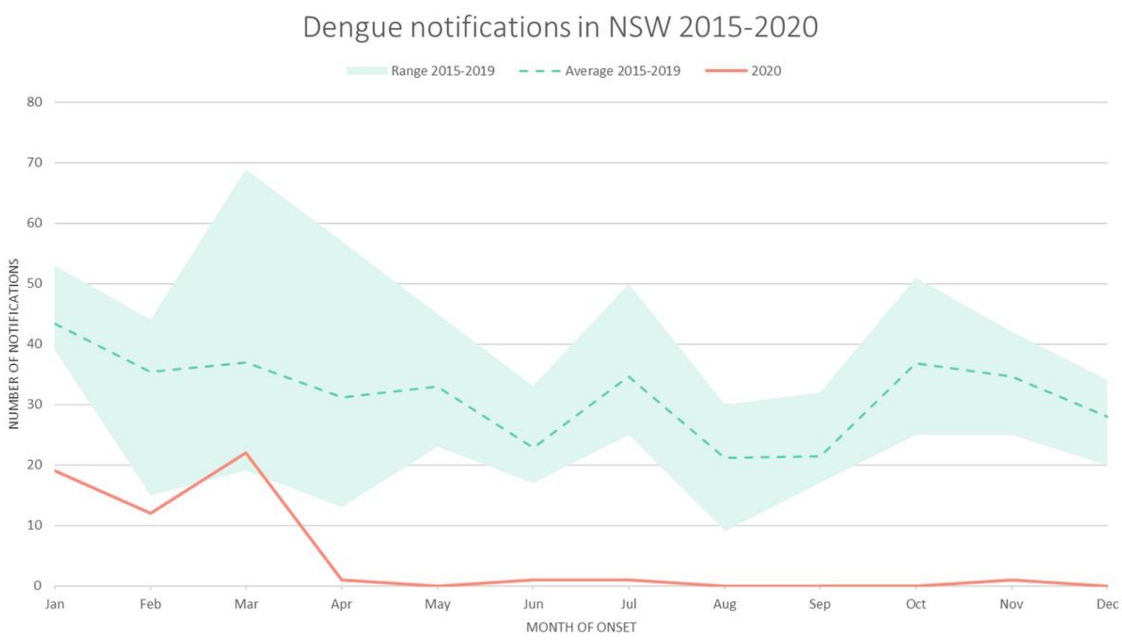
There were 57 confirmed or probable cases of dengue in NSW in 2020 (Table 7). This was a reduction of 89% from the 2015-2019 five-year mean for the full year.

Table 7 – Dengue notifications in NSW 2015-2019 5-year mean vs 2020

	2015-2019 5-year mean	2020	% change 2015-2019 mean to 2020
Total dengue notifications	379.4	57	-89
Year-to-date notifications at 20 March	102	49	-52
Notifications from 21 March to 31 December	277.4	8	-97

Notably, the number of dengue notifications to date at the closure of international borders was already 52% lower than the mean number of notifications to 20 March in 2015-2019 (Fig 6). This number fell sharply between March and April, and remained low until the end of 2020. There were a total of eight dengue notifications from 21 March to 31 December 2020, which was a 97% reduction from the mean number of dengue notifications between these dates in 2015-2019.

Fig 6 - Notifications of confirmed or probable dengue cases in NSW by date of onset, 2015-2019 vs 2020



The eight dengue cases in NSW with onset dates after 20 March 2020 were all adults, aged between 27 and 59. Six were male and two were female. All had NSW residential addresses classified as metropolitan (Remoteness Area class 1), however, three cases reported having longer term residence in southeast Asia. One case acquired his infection in the Pacific region, and all others acquired their infections in Asia. Due to small absolute counts of these cases, no comparative analyses between 2015-2019 and 2020 were performed on demographic characteristics.

There is also evidence that there was under-testing in the hotel quarantine system, given that some cases specifically reported having symptoms in hotel quarantine, but were not tested until they sought additional medical care independently after release from quarantine (Personal communication: HPNSW staff).

Chikungunya

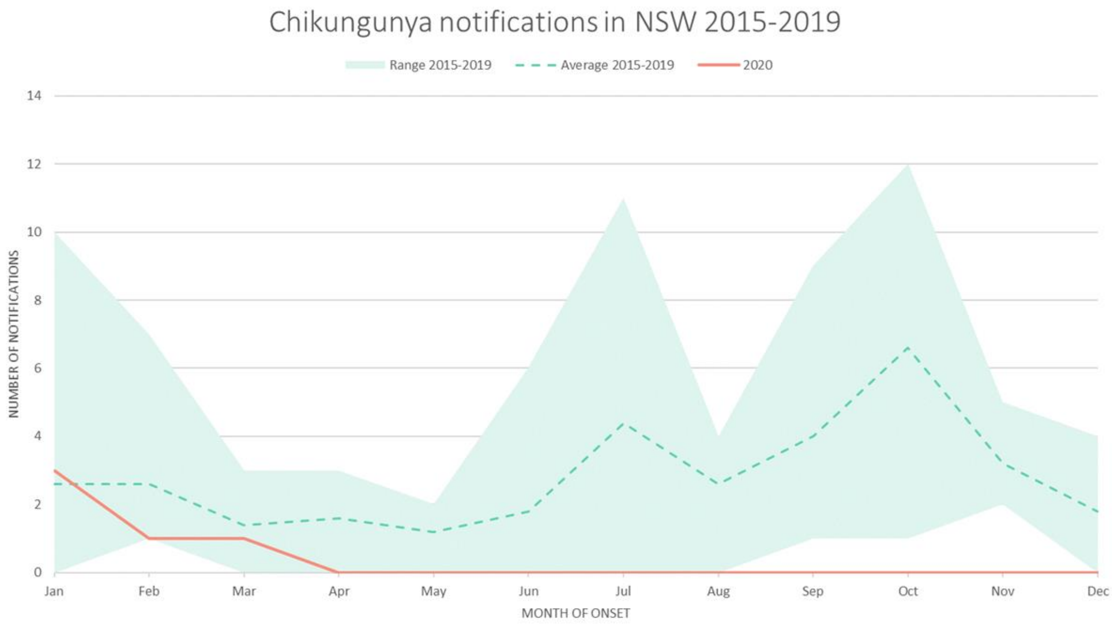
All five confirmed or probable chikungunya cases notified in NSW in 2020 had onset dates before 20 March (Table 8). This annual total was 85% lower than the 2015-2019 five-year mean annual total of 33.8 cases.

Table 8 – Chikungunya notifications in NSW 2015-2019 5-year mean vs 2020

	2015-2019 5-year mean	2020	% change 2015-2019 mean to 2020
Total chikungunya notifications	33.8	5	-85
Year-to-date notifications at 20 March	6	5	-17
Notifications from 21 March to 31 December	27.8	0	-100

The 2015-2019 five-year mean for year-to-20 March notifications was affected by unusually high notifications in early 2015. The 2020 year-to-date notifications for the same time period were within the 2015-2019 five-year range (Fig 7). After the closure of international borders, there were no further cases of chikungunya in NSW.

Fig 7 - Notifications of confirmed or probable chikungunya cases in NSW by date of onset, 2015-2019 vs 2020



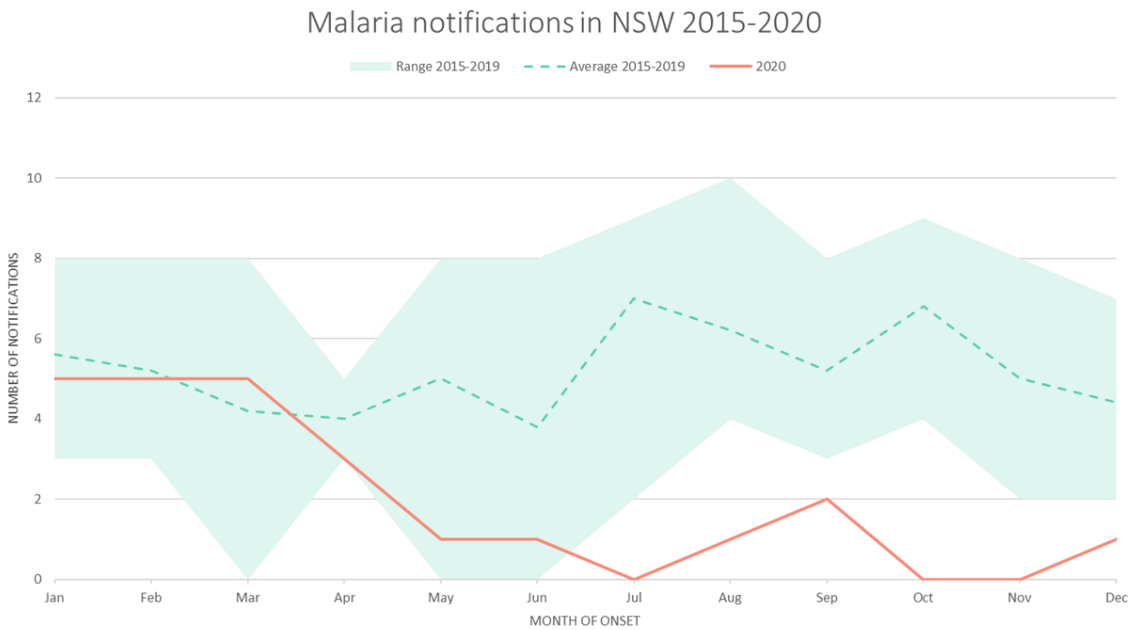
Malaria

In 2020, there were 24 confirmed cases of malaria notified in NSW, which was 62% lower than the five-year mean for 2015-2019 (Table 9). Of these cases, 14 had onset dates prior to March 20, 2020, representing a 5% increase from the 2015-2019 year-to-date mean. Notifications of malaria declined after March, and was below the 2015-2020 five-year mean from April onwards (Fig 8). The ten cases of malaria between 21 March and 31 December 2020 was an 80% reduction in notifications compared to the mean for the same period of the year from 2015-2019.

Table 9 – Malaria notifications in NSW 2015-2019 5-year mean vs 2020

	2015-2019 5-year mean	2020	% change 2015-2019 mean to 2020
Total malaria notifications	62.4	24	-62
Year-to-date notifications at 20 March	13.4	14	+5
Notifications from 21 March to 31 December	49.2	10	-80

Fig 8 - Notifications of confirmed or probable malaria cases in NSW by date of onset, 2015-2019 vs 2020



In the demographic characteristics of malaria cases notified from 21 March to 31 December each year, it can be seen that prior to 2020, there was a higher proportion of males (71%) compared to females (29%; Table m2). This was unchanged in 2020, with 70% male cases and 30% female cases. The median age in this period of 2020 was older (43) than the median in the corresponding period of 2015-2019 (35.5). After the border restrictions in 2020, there were no Australia-born malaria cases.

Table m2 - Additional characteristics of malaria notifications in NSW 2015-2019 vs 2020

	21 March – 31 December 2015-2019	21 March – 31 December 2020
Median age (years) at notification	35.5	43
Gender (proportion)		
- Female	29	30
- Male	71	70
Country of birth (proportion)		
- Australia	20	0
- Overseas	80	100

The *Plasmodium* species identified from confirmed malaria cases arriving after the international border closure was examined, but due to the small number of total cases, the conclusions drawn were more speculative.

The overall decrease in malaria notifications in NSW after international travel restrictions was consistent with a decrease in international arrivals from endemic countries. However, with international arrivals being restricted to Australian citizens and residents, an increase in the proportion of Australian-born cases of an overseas-acquired illness would be expected. In 2020, a paradoxical decrease was observed. The number of cases born in Australia between 21 March and 31 December in the years 2015-2019 was 20%, whereas there were zero Australia-born cases of malaria after 21 March 2020. After discussion with senior staff in HPNSW, it was thought that these trends may reflect the decrease in the number of young adults travelling to countries where malaria is endemic, and returning to Australia after being infected overseas.

Discussion

By reducing the total number of international arrivals overall, the Australian international border restrictions have led to a general decrease in the importation of selected infections. However, the effect of these restrictions varied by condition. The 2020 trends observed were largely influenced by the natural history of each infection, and the transmission patterns in NSW prior to the pandemic.

For conditions where there is no known local transmission in NSW, such as dengue, chikungunya and malaria, the relationship between international travel restrictions and the trends observed after 20 March 2020 is relatively straightforward. By virtue of reducing the number of arrivals from regions where these conditions are endemic, there were be fewer cases of overseas acquired infections.

Measles and typhoid are conditions that are not considered endemic to NSW, but can be transmitted locally(6, 7). There were marked decreases in notifications for both conditions following the closure of international borders, given that local transmissions require primary cases with imported infections. Due to the possibility of chronic carriage for typhoid, imported infections continued to cause secondary infections in the community despite international travel restrictions. However, given the reduction in the number of imported cases, this secondary transmission occurred at a lower rate. In contrast, there is no chronic phase for measles, and imported cases are more likely to cause large outbreaks of secondary transmission. These factors may explain the effectiveness of the international travel bans in interrupting local measles transmission in NSW.

Hepatitis A is another condition where the international travel restrictions had a notable impact on NSW trends. With a reduction of imported cases, there was a decrease in the number of notifications. However, the suppression of local infections to one case linked to a contaminated food item supports the theory that hepatitis A is not endemic in NSW, and that local transmission is sustained by importation from either international arrivals or contaminated food items.

Influenza is another condition with a sharp decrease in notifications after the closure of international borders. Both overseas-acquired infections and local transmission occur in NSW normally, and it is difficult to determine the extent to which either international travel restrictions or NSW-specific public health measures impacted the overall outcome observed. Given that many jurisdictions internationally had observed similar reductions in the incidence of influenza without similar international travel restrictions, it may be difficult to attribute the suppression of influenza in NSW to the reduction of international travel(3-5).

Tuberculosis presented a different trend. Despite being a condition where there is a high proportion of imported cases in NSW, there was a paradoxical increase in notifications after the implementation of international travel restrictions. The discrepancy between observed and expected trends in 2020 was thought to be due to the long lag time between infection and diagnosis, and was a reflection of international travel and migration patterns from the years prior to 2020.

In addition to general changes in international travel, factors specific to a condition, such as its natural history, may also play a role in the trends observed in 2020. The likelihood of being febrile or having other symptoms at the time of departure may be a more significant consideration in the context of the changing nature of international travel. Symptomatic individuals may be more reluctant to travel, thus selecting for travellers who are at lower risk of importing an overseas-acquired infection.

The presence of a latent or asymptomatic phase also appears to be an important factor in local transmission patterns after importation was limited. When comparing hepatitis A and typhoid, it can be observed that the chronic carriage of typhoid contributed to its ongoing local transmission, whereas this did not occur with hepatitis A. This characteristic of *Mycobacterium tuberculosis* is one of the likely factors in the paradoxical increase in cases despite a reduction in international arrivals.

In addition, with international arrivals being Australian citizens or residents, there was a greater likelihood that the traveller would have received routine childhood vaccinations against measles, or sought medical advice prior to departing Australia. This may have included recommendations for travel vaccinations, and chemoprophylaxis against malaria.

Fewer people travelled overseas for leisure, leading to fewer leisure travellers returning to Australia(2). It would be reasonable to hypothesise that the availability and schedules of repatriation flights may have also altered travel patterns. These factors would have changed the distribution of source countries and the risk profiles for importing infectious diseases among returned travellers.

Another consideration is that in the hotel quarantine system for returned international travellers, the main diagnostic focus for any febrile episodes is on detecting COVID-19. There may be under-testing of other infections that may cause similar symptoms within this timeframe. Under-testing may also occur in the community, with fewer symptomatic people seeking medical care due to reluctance to attend healthcare facilities during a pandemic, or with fewer medical practitioners considering travel-related infections in their differential diagnoses.

In many cases, it is also difficult to separate out the effects of international travel restrictions from those of local public health measures. For example, as already discussed for influenza, the trends seen would have resulted from a combination of multiple intertwined factors(5). The international travel restrictions would have reduced the number of introductions of the virus to NSW. The public health measures, designed to control another disease with the same route of transmission, would have then decreased the potential for any chains of local infection from being established following an international introduction. Therefore, it would be necessary to take into account a range of additional contextual factors when considering any public health strategies in response to changes in international travel policy.

Many of the trends observed in NSW in 2020 mirrored those in other jurisdictions in Australia, or across Australia as a whole. The decreases in cases of hepatitis A typhoid were observed in Western Australia when notifications per 100,000 population in 2020 were compared to those in 2015-2019(8). In Australia, notifications to the National Notifiable Diseases Surveillance System (NNDSS) from 1 January to 30 June 2020 were reviewed(9). There were reductions in notifications in influenza, measles, typhoid, dengue, chikungunya and malaria. The latest case of confirmed measles notified in Australia in 2020 entered the NNDSS in February 2020, prior to international border closures. Interestingly, the number of locally acquired cases in Australia was within the normal range, with one case from April to June.

As quarantine-free international travel returns in NSW, it is not known whether trends for notifiable conditions will return to pre-pandemic patterns. Several additional factors may contribute to trends observed in the initial months after border reopening. Restrictions will ease first for Australian citizens and residents. This is likely to create biases in the demographics of international arrivals. The removal of the requirement to quarantine on arrival may mean that new arrivals do not seek medical attention as readily, and would also have more opportunities for onward transmission in their infectious periods. Conversely, this may also improve the detection of conditions that are under-tested in the hotel quarantine system. The reinstatement of outbound travel may also have an impact on the epidemiology of notifiable conditions in NSW, as that this may lead to more travellers returning after overseas trips for leisure, and may introduce infections more likely to be associated with particular destinations or activities.

Conclusion

International travel restrictions were introduced for the control of COVID-19, but they have also contributed to changes in the epidemiology of other notifiable conditions in NSW. Concurrent local restrictions on activity and movement appear to have had a synergistic effect in reducing the number of transmissions ultimately resulting from each imported infection.

The conditions introduced by the international travel restrictions provided a window for examining local transmission dynamics, with the minimisation of noise from imported infections. These findings related to local patterns may contribute to the broader understanding of particular conditions in NSW, which would inform future public health control strategies. The findings of this study may also serve as a reminder that the measures introduced for the control of one infection may impact the transmission of other conditions.

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Learning to Count

4

Counting Salads

Salmonella Saintpaul Multi-Jurisdictional Outbreak Investigation 2021

Outbreak: List of Abbreviations

ACT	Australian Capital Territory
AHPPC	Australian Health Protection Principal Committee
ANU	Australian National University
BFSN	Bi-national Food Safety Network
CDC	(US) Centers for Disease Control and Prevention
CDNA	Communicable Diseases Network Australia
FSANZ	Food Standards Australia New Zealand
HGQ	Hypothesis generating questionnaire
HPNSW	Health Protection New South Wales
ICPMR	Institute for Clinical Pathology and Medical Research
MJOI	Multi-Jurisdictional Outbreak Investigation
NCBI	(US) National Center for Biotechnology Information
NFIRP	National Food Incident Response Protocol
NSW	New South Wales
NSWFA	New South Wales Food Authority
NT	Northern Territory
PHU	Public Health Unit
QHPHML	Queensland Health Public Health Microbiology Reference Laboratory
REDCap	Research Electronic Data Capture
SA	South Australia
SNP	Single Nucleotide Polymorphism
VFFS	Victorian Food Frequency Survey
WA	Western Australia
WGS	Whole Genome Sequencing

Outbreak Project: Prologue

My role

I was recruited to the *Salmonella* Saintpaul (MJOI) by a few MAE alumni, who promised that I would enjoy my time, learn many practical skills and be well supported. Besides, they told me, it was a rite of passage for an MAE. You cannot call yourself an epidemiologist without a foodborne outbreak under your belt. It was not an offer to be declined.

Speaking to other MAEs about what they had achieved in their foodborne outbreaks, I was daunted by all the descriptions of impressive accomplishments. At the same time, I could see that the NSW OzFoodNet team was relatively large, with people who had specialised skills, such as our biostatisticians. I also knew early that our lead epidemiologist preferred to draft sitreps and I was worried that I would not be given enough tasks or responsibilities in the MJOI to contribute meaningfully to the team, to fulfil the requirements of an MAE project, or just to measure up to all my predecessors. Through determined efforts to volunteer for as many opportunities as possible, I was eventually able to achieve the following:

- Attended and provided general secretarial support for NSW OzFoodNet Team meetings
- Attended OzFoodNet MJOI meetings
- Assisted with interviewing 32 confirmed and probable cases in NSW. I also completed the data entry for all cases I interviewed, into the NSW REDCap platform
- Assisted with data cleaning and management on the NSW REDCap platform
- Assisted other jurisdictional OzFoodNet teams with data entry into the Commonwealth REDCap platform
- Responded to Public Health Unit queries about individual cases of *S.* Saintpaul being followed up locally
- Performed literature reviews, initially focusing on whether there were any other records of *Salmonella* (any serovar) outbreaks where spring onions were implicated. I then performed an additional literature review on fresh produce outbreaks involving *Salmonella* Saintpaul (Appendix 4)
- Visited supermarkets to obtain ingredient lists of pre-packaged salad products, where ingredients had not been listed online
- Created diagrams, such as different versions of the food movement diagram (Fig 1 in this chapter) for internal use and presentation to MJOI stakeholders
- Compiled information on outbreak clusters under investigation
- Assisted with analysing data on time between symptom onset and specimen collection for NSW cases
- Assisted with management and analyses of retail loyalty card data obtained from Supermarket Chain A
- Performed binomial probability analyses on final dataset. The lead epidemiologist for the MJOI was responsible for the binomial probability analyses results included in the MJOI sitreps. I also performed these analyses for my own learning, with the opportunity to cross-check my results against those in the sitreps, and to discuss any discrepancies with the lead epidemiologist
- Attended and provided secretariat support for the MJOI expert panel meeting
- Drafted a report on health outcomes of cases to date in the MJOI for discussion at the expert panel meeting

- Drafted my first brief to the NSW Chief Health Officer about the current outbreak situation, and the stakeholders involved. However, sudden developments on the part of the jurisdictional food authorities meant that my draft brief had to be re-written by the Manager of the NSW OzFoodNet Team

Lessons learned

"Not every outbreak is COVID, " chuckled Neil, the lead epidemiologist for the MJOI.

I had just been allowed to participate in the MJOI with the NSW OzFoodNet Team, and gratefully offered to make myself useful in any way possible, including drafting daily sitreps. Neil found the idea of a daily sitrep for a *Salmonella* MJOI quite amusing. "Not every outbreak is COVID" soon became one of my main lessons from this project. I had originally come from general practice, where day-to-day, we are exposed to so many variations of "normal" that we can recognise the abnormal reasonably promptly. This was what I was missing in my experiences of outbreak management. This MJOI was my first outbreak after my work in the pandemic response, and I needed to develop entirely new frames of reference.

Another conversation from early in the MJOI that I can now laugh about occurred during a routine catch up with my field supervisor Jeremy. It was the week after I was recruited to help with the MJOI. He asked me how the investigation was going.

"I think it's almost done, actually," I told him. That was what I genuinely believed at the time. We had a food item with an identical whole genome sequence to the cases, and that food item had been recalled from the shelves. What more was there to do? If the investigation were a real-life game of Cluedo, the summary would be, "It was the spring onion, hidden inside the coleslaw, at Supermarket Chain A."

Little did I know that the MJOI would continue for another four months after that conversation, with more than 500 confirmed cases in total. What transpired challenged my ideas of a tidy point source foodborne outbreak, perhaps a wedding reception with a set menu and fixed guest list. In my mind, there would be a symmetrical epidemiological curve that had a neatly defined peak that decreased to zero quickly, and a couple of straightforward stories published in the media where the greatest controversy was just the privacy of the bride and groom. This investigation made me realise that on paper, I could write down the aims of a foodborne outbreak investigation. In real life, though, it was far more complicated to achieve those aims, or even to know at what point those aims had been reached. I went along with some of the investigative activities because they were interesting. It wasn't until later, when I had to return to my original draft of the outbreak report that I started to understand the rationale behind much of what I was asked to do, and how all of these seemingly disparate parts of the investigation were related to each other. It took a few discussions with OzFoodNet teammates and MAE supervisors before I really started to have the broader context of food safety regulation for fresh produce in mind when thinking about this investigation.

Another real life experience of a textbook concept during this MJOI was the "iterative process". Much of my experience in public health work before starting the MAE had been in research projects where activities occurred according to set ethics-committee-approved protocols. Sure, minor changes to questionnaires occurred, but the wholesale culling of questions for the shortened version of the hypothesis-generating questionnaire brought a cold sweat to my brow. Of course I could see why this was being done, and I could even reassure myself that the editorial decisions were made according to the data that we had already collected, and our preliminary analyses that were updated a few times a week. Yet there was constant worry that we would miss something important because of the cuts.

My teammates with decades of collective experience had to put up with never-ending questions from an anxious MJOI first-timer like me. “But I interviewed somebody last week who did eat that! Are you sure it’s not important?”

As with all my other MAE work, this outbreak project taught me about interacting with a range of actors. A particularly useful relationship to observe was that between jurisdictional public health teams and food authorities. By its very nature, an MJOI allowed me to have a glimpse into the different structures in each jurisdiction, and the advantages and disadvantages of each.

I was grateful for the friendly and collaborative pre-existing relationship between the NSW OzFoodNet Team and the NSW Food Authority. The frequent and open communication between the two teams gave me an enlightening understanding of the activities involved in a traceback investigation, and the challenges in following each component of each item to its source. Up until the MJOI, I had been blissfully unaware of the complex and tangled web of growers, distributors, processors and producers just for one supermarket salad. It boggled my mind that spring onions could be transported thousands of kilometres interstate so that they could be washed and chopped.

Finally, I learned the most current Domino’s Pizza menu, dozens of variations on home-made coleslaw, that people confuse leeks for spring onions, and that so many people are too embarrassed to admit to having toast for dinner.

Public health impact

Clearly, every MJOI is endorsed with the expectation that there will be potential for public health impact. We want to find out how and why the outbreak occurred, to try and prevent it from happening again. This expectation is not always met.

It was difficult for me to admit to myself that we did not achieve everything that we had set out to do in this MJOI, because in my mind, the most logical conclusions from our findings seemed clear. I was able to block out, quite selectively, any inconsistencies that remained. Yet all these outstanding questions had to be resolved to build a watertight case for public health intervention. While we did not reach that point, I would like to remain optimistic that what we had achieved would be a valuable contribution to demonstrating the challenges in investigating “stealth item” outbreaks, and its implications for improving the safety of fresh produce in Australia. We were also able to innovate, by using REDCap for cross-jurisdictional data management, and to the repertoire of investigative activities in an OzFoodNet MJOI with mapping and retail loyalty card data analyses. The media coverage of the coleslaw recalls in this outbreak may have alerted the public to the fact that *Salmonella* is not always about undercooked poultry and egg products, an assumption that I encountered frequently in my case interviews.

MAE core activity requirements

- Investigate an acute public health problem or threat
- Conduct a targeted literature search and synthesis of the relevant information

Acknowledgements

Without a doubt, as is the case for all my projects, I need to thank my supervisors, Jeremy McAnulty and Stephanie Williams.

I would like to thank the NSW OzFoodNet team in both the St Leonards and Hunter sites for welcoming me into their team for the MJOI and providing me with this invaluable learning opportunity. Special thanks must go to the MAE alumni in this team, Kirsty Hope, Katherine Todd, Hendrik Camphor and Charlee Law for recruiting me as soon as they identified that this outbreak would yield an excellent

MAE project, and for setting me up with OzFoodNet introductions and access permissions before I even knew what I was supposed to be doing. Thank you to Neil Franklin, our esteemed lead epidemiologist in this MJOI, for teaching me the difference between the COVID-19 response and a foodborne outbreak, and so much more besides. Neil has also had to put up with spending extra time to explain things to me when he was already busy coordinating so many actors and activities across the country. Thank you to Kim Lilly for giving me so many practical tips and tricks for my case interviews, and to Caitlin O'Neill for being the most supportive teammate. I need to thank Keira Glasgow for all her advice when I was feeling stuck with some of the aspects of writing up the project. I would also like to thank Russell Stafford and Robert Bell from the Queensland OzFoodNet team for being additional teachers. Assisting with the data entry for Queensland meant that I came up against a few new clinical scenarios. Russell and Robert were only too happy to offer advice.

I'd also like to thank the broader network of MAE scholars, alumni and staff. The fact that most people have completed a foodborne outbreak means that I have an embarrassment of options when it comes to asking for sounding boards for the project. Special thanks amongst this group must go to Ben Polkinghorne, Emma Field, Amalie Dyda and Elenor Kerr, for your invaluable advice and support.

Abstract

Background

A multi-jurisdictional outbreak investigation (MJOI) was initiated in January 2021 to investigate an outbreak of *Salmonella* Saintpaul infection across all jurisdictions of Australia. At the time of activating the MJOI, *S.* Saintpaul contamination was also found in two varieties of a pre-packaged coleslaw product, and in spring onions at the producer of the coleslaw product.

Methods

Additional information on symptoms and food exposures were collected from cases linked through whole genome sequencing (WGS). Binomial probability analyses were performed on food exposure frequencies, using data from both the Victorian Food Frequency Survey and a previous *Salmonella* Typhimurium multi-jurisdictional outbreak investigation as comparators. Environmental sampling was undertaken in multiple jurisdictions at multiple stages of the production and supply chains of all fresh produce coleslaw ingredients, including spring onion. Additional investigations were undertaken by jurisdictional food authorities for clusters of cases reporting specific similarities in exposures.

Results

During the outbreak period between 15 December 2020 and 18 May 2021, 585 confirmed and 38 possible cases were identified, concentrated in Queensland (37.6%) and NSW (36.6%). Food consumption information was obtained for 435 (74%) confirmed cases. Binomial comparison of consumption patterns revealed a range of fresh produce items with higher frequency among cases, including spring onion (40.9% of interviewed cases, $p<0.001$ against both comparator datasets). The initial coleslaw and spring onion samples were linked to the outbreak through WGS. There were no additional *S.* Saintpaul detections on environmental sampling. Additional strategies to explore the association further, such as cluster investigations, mapping of residential addresses and examination of retail loyalty card data, did not add useful information.

Conclusion

Despite strong genomic evidence implicating spring onions as the source of this large multi-jurisdictional *Salmonella* Saintpaul outbreak, there was little additional evidence in this investigation to establish the mechanism of bacterial contamination, or to demonstrate a sufficient strength of association, with fewer than half of the confirmed cases reporting exposure to spring onion. The challenges experienced in this investigation are important considerations for the regulation of the safety of fresh produce items, and future investigation of outbreaks of "stealth items" such as spring onions.

Introduction

Salmonellosis, the infection caused by *Salmonella enterica*, is a notifiable condition in all States and Territories of Australia(1). Among its subtypes, *Salmonella enterica* serovar Saintpaul was the causative organism for 15 foodborne outbreaks reported between 2001 and 2016 in Australia(2). The most recent multi-state outbreaks of *S.* Saintpaul were in 2015-2016 involving mung bean sprouts, and in 2006 involving rockmelon(3).

Outside of outbreaks, *S.* Saintpaul is an uncommon *Salmonella* serovar in Australia, accounting for 4% of all salmonellosis notifications in 2019 (Ref: internal document). It is only considered to be endemic in Queensland and the Northern Territory. To monitor local epidemiology, the Queensland Health Public Health Microbiology Reference Laboratory (QHPHML) routinely performs whole genome sequencing (WGS) on a subset of *S.* Saintpaul isolates that had been detected at their service (Personal communication with NSW OzFoodNet Team).

On 6 January, 2021, Queensland public health authorities notified counterparts in other Australian jurisdictions of an increase from baseline in *Salmonella* Saintpaul cases in Queensland in December 2020. In NSW, the organisation responsible for notifiable disease surveillance is Health Protection NSW (HPNSW), part of the NSW Ministry of Health. In response to this notification from Queensland, HPNSW staff reviewed the December 2020 NSW data by date of notification and identified 26 notifications of *S.* Saintpaul, instead of an average of approximately nine notifications for this period over the previous five years. There were also a significant number of *Salmonella enterica* specimens from December still awaiting typing to determine the serovar. On 8 January 2021, HPNSW initiated a NSW-wide investigation into this outbreak, as part of a routine process to gather more information on surveillance signals of potential concern. The main purpose of this preliminary investigation was to determine whether this outbreak was caused by a common source, and whether there were additional public health concerns. The investigation involved interviewing a random sample of the 26 confirmed *S.* Saintpaul cases notified to HPNSW in December 2020.

Coinciding with the investigations into the December outbreaks in Queensland and NSW, routine retailer-initiated testing detected contamination with *Salmonella* in a 400g container of Supermarket Chain A-branded ready-to-eat coleslaw on 4 January 2021, and on routine testing of the 800g version of the same product on 11 January 2021. Internal investigations undertaken by the retailer concluded that the affected products were distributed to Supermarket Chain A stores in NSW, Australian Capital Territory (ACT) and regional Victoria only. Food Standards Australia New Zealand (FSANZ) and State and Territory food authorities were notified of these findings. A recall to consumers was issued by Supermarket Chain A on 12 January 2021, for all Supermarket Chain A-branded coleslaw products with expiry dates from 12 January to 21 January inclusive. The serotyping results of the *Salmonella* isolated from both samples became available on 14 January 2021, and was notified to the NSW Food Authority (NSWFA) as *Salmonella* Saintpaul. These samples were eventually sequenced through whole genome sequencing (WGS), but these results were not available until later in January.

OzFoodNet is the Australian national network of State and Territory public health teams responsible for investigations of foodborne outbreaks, with a Commonwealth-based secretariat(4). Staff from both HPNSW and the Hunter New England Local Health District, who collaborate closely on foodborne outbreaks, represent NSW in OzFoodNet. The network follows agreed processes for conducting multi-jurisdictional outbreak investigations (MJOIs) of foodborne outbreaks affecting more than one State or Territory(5). MJOIs are undertaken with the collaboration of food authorities, laboratory representatives and other relevant agencies at both state and Commonwealth levels. At an OzFoodNet meeting convened on 14 January 2021, participants proposed an MJOI to investigate this NSW and

Queensland increase in *Salmonella* Saintpaul notifications, with potential links to the *S.* Saintpaul contamination identified in the Supermarket Chain A coleslaw products. Another initial finding of concern that supported a multi-state investigation was a high percentage of hospitalised cases observed in Queensland. At the OzFoodNet teleconference on 14 January 2021, Queensland representatives reported that 20 (53%) of the 38 confirmed cases interviewed to date had been admitted to hospital due to salmonellosis, compared to 33% in the 2006 multi-jurisdictional *S.* Saintpaul outbreak(3).

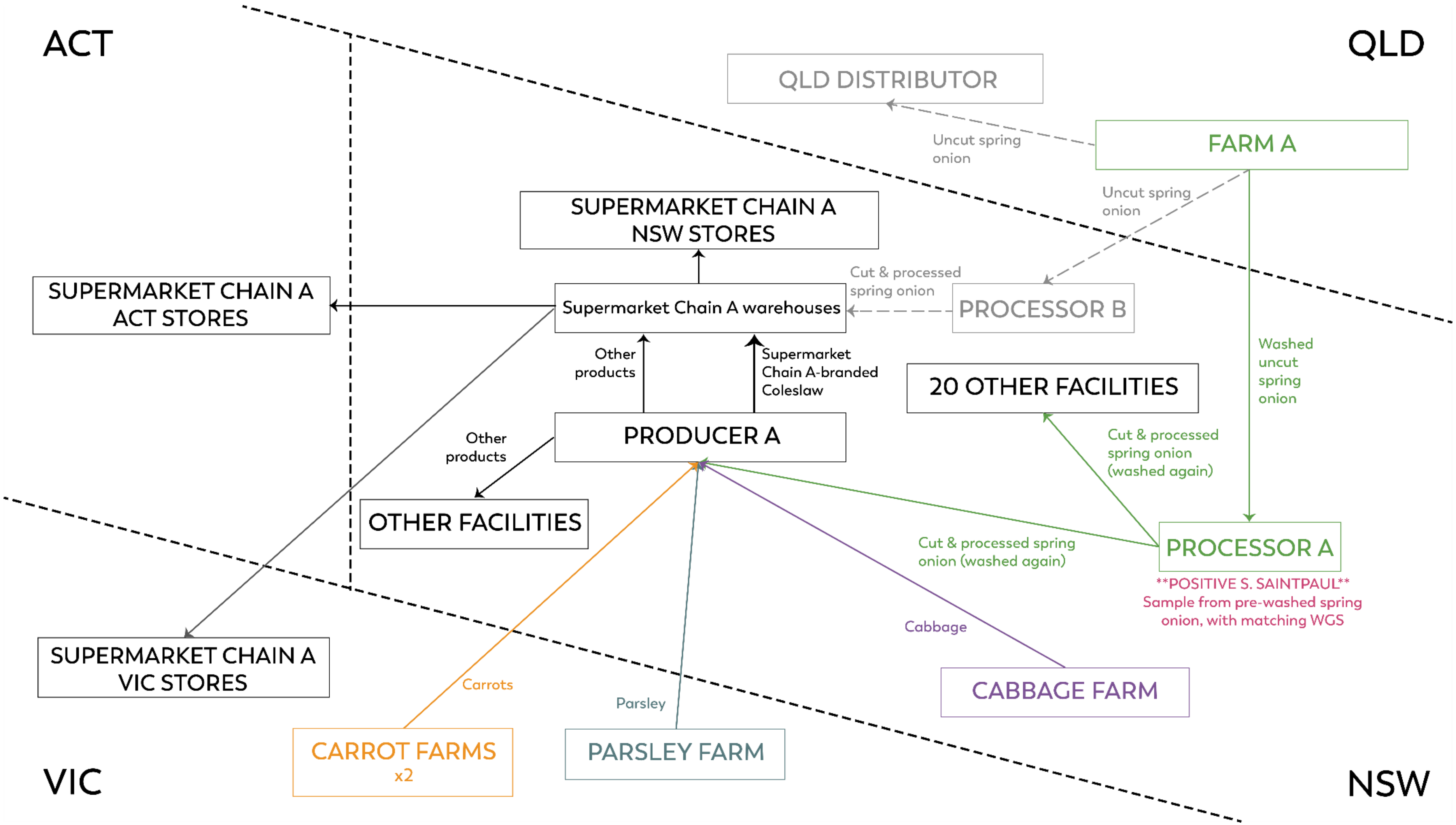
The Communicable Diseases Network Australia (CDNA) endorsed the MJOI on 15 January. NSW was designated as the lead jurisdiction for the epidemiological investigation, and Queensland as the lead jurisdiction for the laboratory investigation. This meant that NSW was responsible for coordinating the collection and analysis of national data.

The first OzFoodNet teleconference after the activation of the MJOI took place on 19 January 2021. However, on 17 January, *S.* Saintpaul contamination was detected in a sample from a sealed 5kg bag of washed and sliced raw spring onion by Producer A, the producer of the Supermarket Chain A coleslaw product (Fig 1). This sample had originated from Processor A, one of the processors of spring onions for Producer A, also based in NSW. Subsequent tracing of ingredients revealed that this batch of spring onions was grown in Queensland at Farm A, one of the main growers of spring onions in Australia, and transported directly to Processor A. On 22 January 2021, NSWFA issued a prohibition order to Processor A to prevent the company from sourcing spring onions from Farm A.

This MJOI occurred in the context of ongoing discussions about making changes to the regulation of fresh produce in Australia (Ref: Internal report). In recent years, there have been several foodborne outbreaks in Australia with hypothesised links to fresh produce. In 2013, FSANZ drafted a proposal to examine the safety of fresh produce items, and to develop regulatory measures(6). After industry consultation, this proposal was abandoned in favour of gathering additional information through continuing to use existing systems to monitor the safety of fresh produce and to respond to incidents. However, difficulties in establishing definitive evidence on sources of contamination in fresh produce outbreaks has limited the quality of food safety information to date.

The aim of this paper is to describe the events and actions undertaken in this MJOI, with a view to highlighting some of the challenges encountered. The learnings from this MJOI may be useful for informing future fresh produce outbreak investigations, especially those where identifying the mechanism of contamination is a particular priority.

Fig 1 – Main movements of fresh produce items discussed in report



Methods

Epidemiological investigation

Case-finding and information gathering

At the first OzFoodNet MJOI teleconference, epidemiologists agreed on case definitions as outlined in Table 1. These definitions remained unchanged during the investigation. The outbreak period was defined as on or after 15 December 2020, until 18 May 2021, ten days prior to the official conclusion of the MJOI. The outbreak genomic sequence was the sequence shared by the majority of outbreak cases, with variations of up to 3 single nucleotide polymorphisms (SNPs) deemed to be highly related. At the time, international travel restrictions were in place due to the COVID-19 pandemic. Therefore, OzFoodNet epidemiologists felt that it was unnecessary to restrict case definitions according to travel history. According to these case definitions, most individuals in the MJOI were initially probable cases with a *Salmonella* Saintpaul result only, and after WGS results became known, they were either reclassified as a confirmed case, or excluded from the investigation.

Table 1 – Case definitions used in the S. Saintpaul MJOI

Confirmed outbreak case:
• *Salmonella* Saintpaul infection in a person which is highly related to the outbreak sequence* by whole genome sequencing (phylogenetic analysis) AND • Specimen collection date on or after 15 December 2020 * NCBI Sequence Read Archive Accession SRR13493580
Probable outbreak case:
• *Salmonella* Saintpaul infection in a person AND • Specimen collection date on or after 15 December 2020 AND • In the absence of whole genome sequencing (phylogenetic analysis) **OR** • *Salmonella* infection in a person with an epidemiological link to a confirmed outbreak case AND • Specimen collection date on or after 15 December 2020 AND • In the absence of serotyping and/or whole genome sequencing (phylogenetic analysis)
Possible outbreak case:
• Gastrointestinal illness in a person with an epidemiological link to a confirmed or probable outbreak case

*The NCBI Sequence Read Archive Accession number is a reference number for a whole genome sequence that is assigned by the US National Center for Biotechnology Information (NCBI) after a new genomic sequence is submitted to its publicly available global repository of sequencing data(7).

Jurisdictional OzFoodNet teams agreed to interview all cases meeting the confirmed or probable case definitions. In NSW, case interviews were carried out by a combination of NSW OzFoodNet team staff and local Public Health Unit (PHU) staff. The Queensland OzFoodNet team chose to prioritise probable cases that they determined to be more likely to be related to the outbreak based on age and location of residence. Comparison with routine *Salmonella* Saintpaul surveillance data collected in Queensland showed that outbreak cases were more likely to be in paediatric age groups, residing in the south-eastern part of the State.

Prior to this MJOI, OzFoodNet had developed a standard hypothesis generating questionnaire (HGQ) for interviewing *Salmonella* cases that can be adapted by jurisdictional OzFoodNet teams for local investigations(8). For the investigation of *Salmonella* cases outside of MJOIs, jurisdictional teams may also use questionnaires developed for use in their State or Territory. In this *S.* Saintpaul outbreak, prior to the initiation of the MJOI, 17 probable cases (NSW, SA, WA) had already been interviewed using the OzFoodNet *Salmonella* HGQ, and 30 probable cases had been interviewed using the Queensland state-based questionnaire (Table 2).

Given the potential link to supermarket coleslaw products, and given that *S.* Saintpaul was known to be mostly implicated in outbreaks involving fresh produce in the global literature (Ref: Internal correspondence), OzFoodNet epidemiologists at the 19 January MJOI teleconference decided to adapt the existing OzFoodNet *Salmonella* HGQ to focus on fresh produce and pre-packaged salad items. This new MJOI HGQ was used from this teleconference by all jurisdictions except Queensland, where the pre-existing state-based questionnaire was adapted to align more closely with the MJOI HGQ. However, this Queensland questionnaire did not contain questions about pre-packaged, ready-to-eat salad tubs until its amendment on 29 January 2021. The NSW OzFoodNet team was responsible for updating the MJOI HGQ based on feedback from other MJOI participants. A brief literature review was also performed by the NSW OzFoodNet team to identify additional information to inform hypothesis generation (Appendix 4). Version 2 of the HGQ allowed the collection of data on retail loyalty card numbers, and on possible co-infected or secondary cases. The NSW OzFoodNet team added a question about consumption of broccolini to version 3 of the HGQ on 28 January, after receiving information about Farm A growing broccolini at the same time as spring onions. If there were a statistically significant association with broccoli consumption among cases, this could add to the evidence that the bacterial contamination occurred at the farm.

As more data became available and hypotheses became more refined later in the MJOI, and in response to feedback from case interviewers, a shorter version of the MJOI HGQ (version 5) was developed and implemented from 11 February 2021. The main deletions were questions about consumption of fresh produce items, given that these questions had already accounted for most of the HGQ. Items were retained if they were shown to be statistically significant on binomial probability analyses to date, or had been implicated in recent *Salmonella* outbreaks in the global literature.

Table 2 - HGQs used in S. Saintpaul MJOI

Date	MJOI HGQ version and main changes	Number of confirmed cases interviewed with HGQ	Other HGQ version	Number of confirmed cases interviewed with HGQ
Prior to 19/01/2021			OzFoodNet *Salmonella* HGQ	16
January 2021			Queensland *Salmonella* Saintpaul HGQ older versions	11
19/01/2021	MJOI HGQ v1: (Adapted from the OzFoodNet *Salmonella* HGQ) • Alternative names for spring onions added • Question about eschalot added • Pictures added for spring onion and eschalot (Appendix 5) • Deletion of most questions about meat and dairy products	41		
22/01/2021	MJOI HGQ v2: (Drafted and released in NSW only) • Co-infected or secondary cases added • Retail loyalty card number request added	51		
28/01/2021	MJOI HGQ v3: • Question about broccolini added • Formatting edits mostly	79		
29/01/2021			Queensland *Salmonella* Saintpaul HGQ v3.2 • Questions about packaged ready-to-eat coleslaw, pasta salad and potato salad added	10
03/02/2021	MJOI HGQ v4: • Formatting edits only	56		
Approx. 04/02/2021			Queensland *Salmonella* Saintpaul HGQ v3.3 • Retail loyalty card number request added	5

Date	MJOI HGQ version and main changes	Number of confirmed cases interviewed with HGQ	Other HGQ version	Number of confirmed cases interviewed with HGQ
			• Question about broccolini added	
11/02/2021	MJOI HGQ v5: • Reduction in the number of fresh produce questions • 3-day consumption history questions added to items of particular interest • Question added about sampling leftover salad items	69		
14/02/2021			Queensland *Salmonella* Saintpaul HGQ v4.0 • Reduction in the number of fresh produce questions • 3-day consumption history questions added to items of particular interest • Question added about sampling leftover salad items	9
			Queensland *Salmonella* Saintpaul HGQ version unknown	96
			Other unknown HGQ version	10

The data collected by each State or Territory from case interviews were entered into a central OzFoodNet database created using the Research Electronic Data Capture (REDCap) online platform, with identifiable demographic information removed. This was the first time REDCap was used for an active MJOI. WGS results were provided by QHPHML to the NSW OzFoodNet team in spreadsheet format. These were then uploaded into REDCap.

Epidemiological analyses

Cases were described by age, sex, clinical presentation and health outcomes. Interview data collected on food exposure frequencies were compared, using one-sided binomial probability analyses, against both the data from a previous *Salmonella* Typhimurium OzFoodNet MJOI and from the Victorian Food Frequency Survey (VFFS). The 2020 *S.* Typhimurium MJOI shared similarities with this *S.* Saintpaul MJOI in terms of the time of year and the geographical distribution of cases. The food item implicated in the 2020 *S.* Typhimurium outbreak was never determined with certainty, but was hypothesised to be related to fresh produce. Therefore, many of the food exposures included in the *S.* Saintpaul HGQ were similar to those in the *S.* Typhimurium HGQ. Interview data were made available for 290 interviewed NSW and Queensland cases.

The VFFS data were used as another comparator in addition to the *S.* Typhimurium HGQ data. It allowed comparisons against food consumption considered to reflect normal patterns. VFSS survey data represent the seven-day food exposures of healthy children and adults, collected through telephone interviews with Victorian residents conducted from 2014 to 2016 (Ref: Internal correspondence). These data were stratified by season, age group and gender. For the purposes of comparative analysis in this *S.* Saintpaul MJOI, the summer season data, collected from 500 individuals between November 2014 and January 2015, were used.

The binomial probability analysis is used to compare two proportions(9). It uses the binomial statistical distribution and gives a more exact estimation than a chi-squared test. In this case, using a one-sided binomial probability analysis means that the direction of difference in proportions is specified, focusing only on the likelihood that an exposure in the *S.* Saintpaul MJOI is greater than the same exposure in the comparator dataset. The difference in the proportion of interviewed confirmed *S.* Saintpaul MJOI cases with each statistically significant exposure, compared to the proportion of individuals in each comparator dataset with the same exposures, was used as a rough measure of effect size.

After the conclusion of the MJOI, binomial probability analyses were performed with the full outbreak dataset, with both the *S.* Typhimurium MJOI and VFSS datasets as comparators. For a range of food items, information was collected for consumption in both the seven days prior to symptom onset and the three days prior to symptom onset. In the binomial analyses, only seven-day exposure data were used, because the responses to this question were more complete. Seven-day exposure histories were also used in both the comparator datasets. The denominator used for each item was the sum of individuals who responded "yes" or "no" to each exposure, with those reporting "unknown" to the exposure excluded from the analysis.

Where two or more confirmed or probable cases reported similarities in exposure through a common place of purchase or item, this was designated as a possible cluster and additional action was undertaken. This involved alerting OzFoodNet teams in all other jurisdictions. The OzFoodNet NSW team, as the lead jurisdiction for epidemiology, reviewed the case interview data for additional information about these exposures, and performed free text searches through all outbreak data to date to identify any additional cases that may have had a related exposure. Jurisdictional food authorities were informed of any clusters with potential relevance to their areas, for additional investigations as appropriate (see Environmental investigation).

Mapping was undertaken based on the residential postcode of each case to detect any geographical clustering. This required the collection of postcode information centrally, which had not been undertaken in a previous MJOI. Maps were created by biostatisticians in the NSW team, using ArcGIS software.

In this MJOI, the usefulness of purchase data from a supermarket retail loyalty card program was explored. For this particular investigation, the analyses undertaken using this data did not have an impact on the final findings. This exercise is described in Appendix 2. In addition, conducting case-control study to support investigation findings was discussed both among OzFoodNet epidemiologists, and at a review by a panel of experts external to OzFoodNet. Although the NSW OzFoodNet team carried out many of the preparatory analyses to inform this study, the case-control study did not proceed, with reasons outlined in the Discussion section.

Laboratory investigation

Human notifications of salmonellosis were initially made by diagnostic laboratories in each State and Territory, in accordance with jurisdictional procedures for reporting notifiable conditions. Typing was then performed at each jurisdiction to determine the *Salmonella enterica* serovar. This process varied between jurisdictions. In NSW, identification of the Saintpaul serovar occurred through serotyping at the Institute for Clinical Pathology and Medical Research (ICPMR), the reference laboratory for bacterial foodborne pathogens. ICPMR subsequently performed WGS on *S.* Saintpaul isolates on an Illumina sequencing platform using its own protocols, prior to forwarding the sequence to QHPHML for further analysis. This process also occurred for environmental samples in NSW. However, in Victoria, typing occurred as part of the WGS process for all *Salmonella* samples, and was not a separate process prior to sequencing.

As Queensland was the lead jurisdiction for the laboratory investigation, QHPHML was responsible for determining or verifying the genomic sequence of each outbreak specimen, including both human and environmental samples. Each jurisdictional reference laboratory sent sequences from all *S.* Saintpaul isolates received during the outbreak period to QHPHML for comparison against the outbreak sequence and inclusion in the phylogenetic analysis of the MJOI overall. Phylogenetic trees of MJOI WGS results were drawn by QHPHML weekly, using the Fast Tree plugin in Geneious R11 software. The frequency and distribution of WGS isolates that did not fit within the outbreak cluster were reviewed by both the QHPHML and NSW OzFoodNet teams, for any indication that this outbreak involved more than one genomic cluster of *S.* Saintpaul.

Concerns were raised by some jurisdictions participating in the MJOI around the timeliness of the process between initial specimen collection and eventual distribution of WGS phylogenetic analysis results, given that these results were necessary to confirm or exclude probable cases. A separate investigation about the timeliness of WGS undertaken by the NSW OzFoodNet team is outlined in Appendix 3.

Environmental investigation

The jurisdictional food authorities of each State and Territory, as well as the corresponding body for New Zealand, form the Bi-national Food Safety Network (BFSN), with FSANZ as its secretariat(10). The NSWFA, in response to emergent laboratory results potentially linking human *Salmonella* Saintpaul cases to bacterial contamination of the widely distributed Supermarket Chain A-branded coleslaw products, triggered the BFSN National Food Incident Response Protocol (NFIRP) on 21 January 2021. The NFIRP is a set of agreed processes that facilitate inter-jurisdictional information sharing and communication in the event of a multi-jurisdictional foodborne incident investigation(11). As the NSWFA triggered the NFIRP, it took the role of the lead NFIRP jurisdictional food authority.

Each jurisdictional food authority undertook traceback investigations of potentially implicated food exposures within their State or Territory. This involved liaising with food businesses, conducting site inspections and collecting samples from food items for laboratory investigations.

Initially, traceback activities centred around the supply chain of the recalled Supermarket A-branded coleslaw products, with a focus on the cut spring onion ingredient, to find indications of the ultimate source and mechanism of contamination. As the epidemiological investigation progressed, environmental investigations expanded to explore other potential sources of contamination, such as similar salad products. For all pre-packaged salads from Supermarket Chain A, NSWFA obtained a list from the retailer of items that contained spring onions in its list of ingredients. NSWFA also traced other spring onion growers and suppliers to Supermarket Chain A, and shared this information to guide jurisdictional site inspections and environmental sampling.

Any potentially relevant food venue and food product clusters were also forwarded to the jurisdictional food authorities by the OzFoodNet epidemiologists. The food authorities liaised with venues to obtain detailed menus and information on the sourcing of menu items. Site visits took place for several venues identified, with environmental sampling performed during some visits. Where specific food items were of concern, food authority officials investigated the supply chains of ingredients.

To add to the evidence, the MJOI epidemiologists requested sampling of leftover pre-packaged salad products hypothesised to be the source of infection. The MJOI case questionnaire was amended on 11 February 2021 to ask cases who reported consuming pre-packaged salads whether there were any remaining portions of these food items that could be collected for laboratory testing (Table 2). However, due to the long delay between the consumption of these products and the identification of cases, none of the cases interviewed had retained any salad items of interest.

Stand down of MJOI

The *Salmonella* Saintpaul MJOI was stood down officially on 28 May 2021, after agreement from all OzFoodNet participants that additional outbreak investigations were unlikely to result in changes to the ongoing public health strategy. Routine public health surveillance activities were deemed to be adequate for monitoring *S.* Saintpaul infections from this point. The final date of the outbreak period, used for determining the case classification, was set to 18 May 2021, ten days prior to the closure of the investigation.

Ethics

This MJOI was endorsed by the CDNA, on behalf of the Australian Health Protection Principal Committee (AHPPC). This meant that the activities within the investigation fell under national legislation, including the *Biosecurity Act 2015* and the *National Health Security Act 2007*(5, 12, 13). Additionally, States and Territories undertook investigative activities under the relevant jurisdictional public health legislation, including the *Public Health Act 2010* in NSW(14). Therefore, approval from a Human Research Ethics Committee was not required. States and Territories de-identified each case before it was entered into the national MJOI dataset.

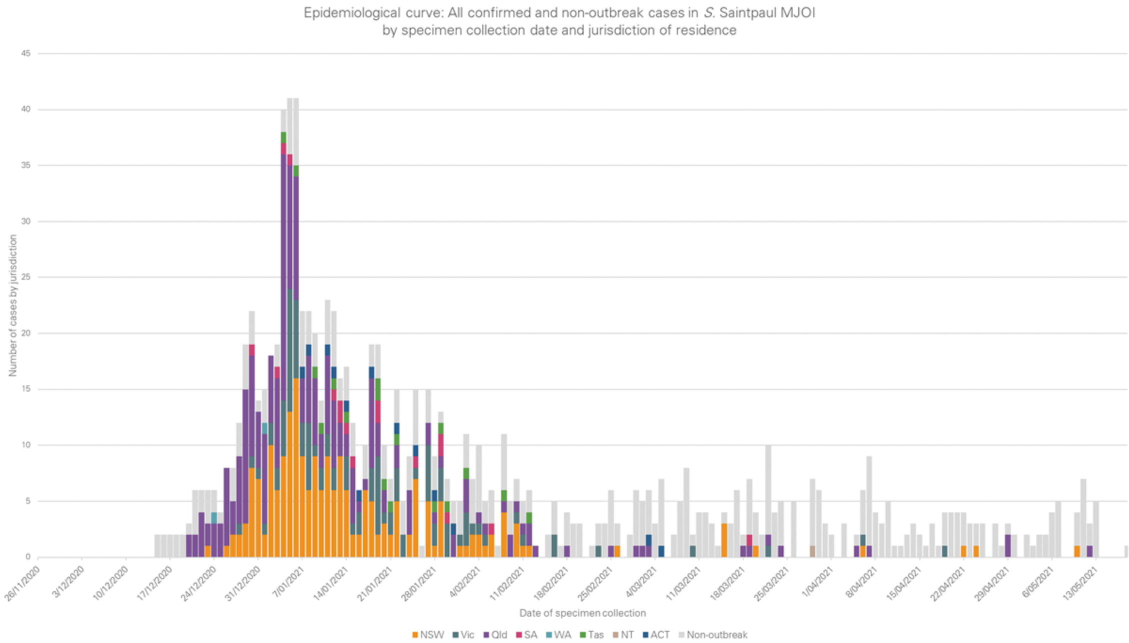
Results

Case-finding and demographics

There were 585 individuals who met the confirmed case definition, with specimen collection dates ranging from 20 December 2020 to 12 May 2021 (Fig 2). There were 38 possible cases, one of whom was identified as part of a restaurant cluster. The other possible cases were identified through retrospectively reviewing the interview data of confirmed cases to determine whether there were additional symptomatic individuals without testing results who were epidemiologically linked to the confirmed case. There were 404 individuals with *Salmonella* Saintpaul infections during the outbreak period who were eventually excluded from the investigation based on WGS results. There were no cases of possible human-to-human transmission identified by OzFoodNet epidemiologists.

Cases peaked between 4 January and 6 January 2021 based on date of initial specimen collection, with 35 to 38 cases daily. The number of cases with specimens matching the outbreak sequence decreased to zero to four cases per epidemiological week (defined as Monday to Sunday; median of three cases) from the middle of February onwards. Concurrently, the number of all *S.* Saintpaul detections decreased. Queensland reported that the state-wide notifications of *S.* Saintpaul had returned to baseline levels from the week ending February 21 onwards (Ref: Internal document). Due to the number of cases lost to follow up, and the delays in WGS results to allow case classification, OzFoodNet epidemiologists continued to monitor the epidemiological curve of all *S.* Saintpaul cases by date of initial specimen collection (Fig 2), alongside the curve of interviewed confirmed cases by date of symptom onset (Fig 3).

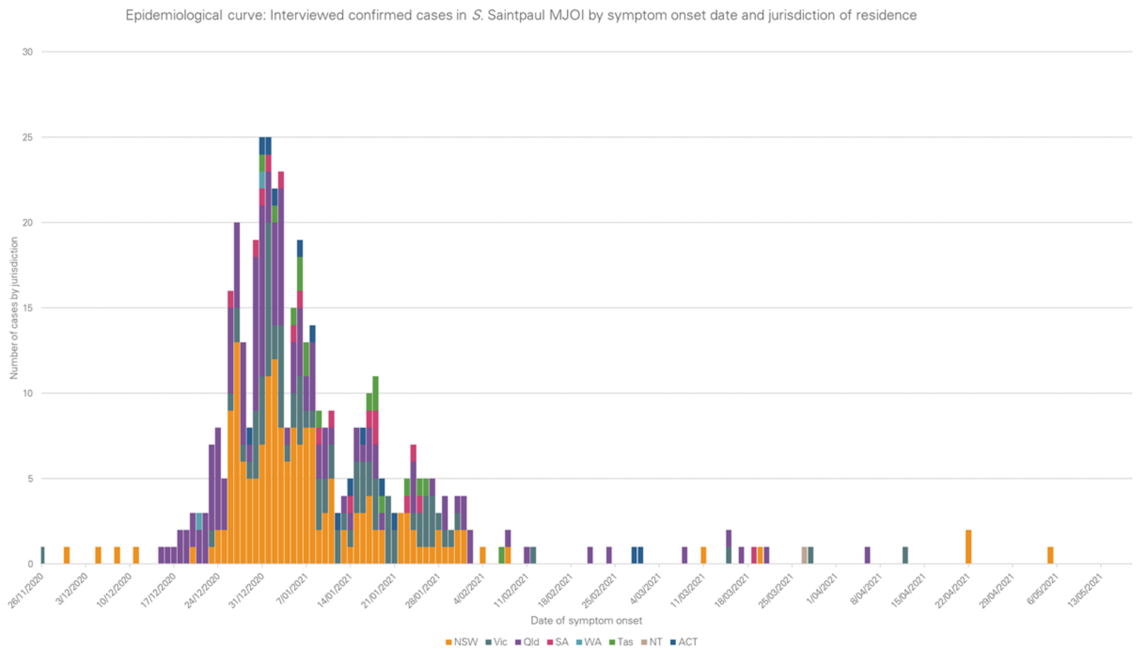
Fig 2 – All individuals with S. *Saintpaul infections during outbreak period (n=989), by date of initial specimen collection (Curve includes confirmed MJOI cases colour-coded by jurisdiction of residence (n=585), and excluded/non-outbreak individuals in grey (n=404))*



Of the 585 confirmed cases, 435 (74%) confirmed cases were interviewed. There were 150 (26%) WGS-confirmed cases who did not complete an interview, and were classified as lost to follow-up. An additional 174 individuals with *S.* Saintpaul infections were interviewed, but were later excluded from the investigation when their WGS results were shown to be unrelated to the outbreak cluster. Of note, 95 (63%) of the 150 confirmed cases who were lost to follow-up had specimen collection dates prior to the recall of the supermarket-branded coleslaw products on 12 January 2021, which may have reduced the frequency of this exposure reported in the MJOI.

The symptom onset dates for the 435 confirmed cases interviewed ranged from 26 November 2020 to 5 May 2021 (Fig 3). Cases were sporadic until 15 December 2020. The peak of onset dates was from 31 December 2020 to 3 January 2021, preceding the peak of specimen collection by approximately four days. Most cases had onset dates from late December to late January, with 31 (7% confirmed cases interviewed) reporting onset dates from 1 February 2021 onwards. In terms of the retailer recall of the Supermarket A-branded coleslaw products on 12 January, 128 (29% confirmed cases interviewed) had symptom onsets after this date. Although these products were not distributed to Queensland stores, the Queensland symptom onset dates showed a similar pattern, with 30 (23%) of 132 interviewed confirmed cases reporting symptom onsets after 12 January 2021.

Fig 3 – Interviewed confirmed MJOI cases by reported date of first symptom onset and jurisdiction of residence



In terms of demographics, 324 (55.4%) of all 585 confirmed cases were female and 260 (44.4%) were male (Table 3). The gender was unknown for one (0.2%) confirmed case lost to follow-up. The median age for confirmed cases was 34 years, with a range from 0 to 95 years. There were no notable differences in age and gender between the confirmed cases interviewed and those lost to follow-up.

Confirmed cases were reported from each State and Territory, with most of the confirmed cases residing in Queensland (Table 3; 220 cases, 37.6%) and NSW (214 cases, 36.6%). Of note, the three cases with residential addresses in Western Australia and the Northern Territory had spent their incubation periods in Queensland.

Mapping of confirmed cases did not reveal any localised spatial clusters of note. In terms of broader geographical patterns, the Queensland OzFoodNet team reported verbally that in general, there were more confirmed cases in this MJOI in south-eastern Queensland than observed during times of baseline notification activity, where there are more *S.* Saintpaul cases from the tropical northern parts of the state.

Table 3 - Demographic characteristics of confirmed S. Saintpaul cases

	Number of confirmed cases	Percentage of confirmed cases (N=585)	Number of confirmed cases interviewed	Percentage of confirmed cases interviewed (N=435)
Gender:				
- Female	324	55.4	244	56.1
- Male	260	44.4	191	43.9
- Unknown	1	0.2	0	0
Jurisdiction:				
- ACT	13	2.2	12	2.8
- NSW	214	36.6	174	40.0
- NT	1	0.2	1	0.2
- Qld	220	37.6	132	30.3
- SA	17	2.9	17	3.9
- Tas	17	2.9	16	3.7
- Vic	101	17.3	81	18.6
- WA	2	0.3	2	0.5

Symptoms and health outcomes

The duration of illness was able to be elicited for 406 of the 435 interviewed confirmed cases, and ranged from one to 23 days, with a median of ten days. Diarrhoea was the most common symptom reported (94.0%), followed by lethargy (85.1%) and abdominal pain (84.8%, Table 4). The number of cases asked about each symptom varied, due to the use of different versions of the HGQ.

Table 4 – Symptoms experienced by confirmed and interviewed S. Saintpaul cases

Symptom	Denominator (Number of confirmed cases asked about symptom)	Number of confirmed cases with symptoms	Percentage
Diarrhoea	432	406	94.0
Lethargy	369	314	85.1
Abdominal pain	427	362	84.8
Fever	425	301	70.8
Nausea	416	272	65.4
Headache	357	230	64.4
Joint or muscle pain	340	170	50.0
Vomiting	424	154	36.3
Bloody diarrhoea	383	129	33.7
No symptoms*	434	3	0.7

*Asked about at least one symptom, and replied no to all symptoms asked

Hospitalisation data were available for 432 (73.8%) of the 585 confirmed cases, through a combination of case interviews and hospital discharge summaries. Of all 585 confirmed cases, 126 (22%) were admitted to hospital at least overnight. The length of admission ranged from one day to 20 days. There were no deaths.

Food exposures

Analyses of reported food exposures focused on spring onions and pre-packaged salad items, with a view to confirm genomic findings with epidemiological evidence. Comparisons using binomial probability analyses were made against both the 2020 *S.* Typhimurium MJOI and the Victorian Food

Frequency Survey (VFFS). These analyses were performed at multiple points during the MJOI, and informed subsequent versions of the HGQ.

In the binomial probability analysis performed with the full set of outbreak data, exposures that were statistically significant across both the comparator datasets were onion, lettuce, spring onion, pre-made pasta salad, cabbage and pre-made potato salad (Table 5). Additional exposures that were statistically significant for at least one of the comparators were potato, egg, carrot, cucumber, parsley, pre-packaged coleslaw, honeydew melon, alfalfa sprouts and having made purchases at large Supermarket Chain B.

Notably, 40.9% of interviewed confirmed *S.* Saintpaul cases reported exposure to spring onion. This was 10.2% higher than in the VFSS (30.7% reporting exposure) and 11.4% higher than in the *S.* Typhimurium MJOI dataset (29.5% reporting exposure).

Table 5 - Statistically significant exposures in descending order of exposure frequency in S. Saintpaul MJOI

Exposure	*S.* Saintpaul MJOI cases exposed (%)	Proportion of VFSS respondents exposed	Binomial probability using VFSS data (p-value)	Percentage difference in *S.* Saintpaul and VFSS proportions	*S.* Typhimurium MJOI cases exposed (%)	Binomial probability using *S.* Typhimurium data (p-value)	Percentage difference in *S.* Saintpaul and *S.* Typhimurium proportions
General shopping exposure found to be statistically significant in one comparison only:							
Shopping at Supermarket Chain B	239/382 (62.6)	(No data)	N/A	N/A	66/146 (45.2)	**<0.001**	17.4
Food exposures found to be statistically significant in both comparisons:							
Onion	260/389 (66.8)	503/995 (50.6)	**<0.001**	16.2	91/139 (65.5)	**<0.001**	1.3
Lettuce	240/394 (60.9)	466/995 (46.8)	**<0.001**	14.1	104/251 (41.4)	**<0.001**	19.5
Spring onion	164/401 (40.9)	305/995 (30.7)	**<0.001**	10.2	72/244 (29.5)	**<0.001**	11.4
Pre-packaged pasta salad	79/306 (25.8)	51/996 (5.1)	**<0.001**	20.7	10/85 (11.8)	**<0.001**	14.0
Cabbage	98/390 (25.1)	210/998 (21.0)	**0.029**	4.1	26/139 (18.7)	**0.001**	6.4
Pre-packaged potato salad	39/311 (12.5)	27/998 (2.7)	**<0.001**	9.8	3/84 (3.6)	**<0.001**	8.9
Food exposures found to be statistically significant in one comparison only:							
Potato	269/345 (78.0)	811/996 (81.4)	0.955	-3.4	94/139 (67.6)	**<0.001**	10.4
Egg	295/397 (74.3)	761/995 (76.5)	0.860	-2.2	158/244 (64.8)	**<0.001**	9.5
Carrot	289/396 (73.0)	593/983 (60.3)	**<0.001**	12.7	182/243 (74.9)	0.827	-1.9
Cucumber	239/402 (59.5)	616/996 (61.9)	0.851	-2.4	134/253 (53.0)	**0.005**	6.5
Parsley	48/333 (14.4)	339/996 (34.0)	1.00	-19.6	14/145 (9.7)	**0.003**	4.7
Pre-packaged coleslaw	63/315 (20.0)	63/998 (6.3)	**<0.001**	13.7	32/144 (22.2)	0.845	-2.2
Honeydew melon	21/399 (5.3)	59/997 (5.9)	0.740	-0.6	0/85 (0)	**<0.001**	5.3
Alfalfa sprouts	9/403 (2.2)	22/997 (2.2)	0.533	0	1/149 (0.7)	**0.002**	1.5

Laboratory investigation

A total of 1129 specimens from 989 individuals were confirmed to be positive for *Salmonella* Saintpaul during the outbreak period. There were 1030 faecal, 46 blood and 50 urine specimens, and one additional specimen from a joint aspirate of the left shoulder. The site of collection for two specimens was unknown.

There were 585 individuals whose specimens matched the outbreak strain, designated by QHPHML as 210112-02. In addition, WGS identified 41 other genomic clusters, and 253 sporadic *S.* Saintpaul sequences not highly related to the outbreak strain. The relatedness of the specimens was presented on phylogenetic trees. The outbreak sequence was detected in 81% of all interviewed individuals with symptom onset dates prior to 16 February 2021. However, for interviewed individuals with onset dates from 16 February 2021 onwards, there was a notable shift in the WGS results, where the outbreak sequence accounted for 21% of all *S.* Saintpaul sequences until the conclusion of the MJOI.

Food industry investigations

Initial traceback investigations revealed that Producer A was the only producer of the implicated coleslaw products (Fig 1). The ingredients in these coleslaw products were raw spring onion, carrot, cabbage and parsley, and commercially produced mayonnaise. Four processors supplied ingredients to Producer A, although only Processor A supplied the spring onions used by Producer A in the period leading to the detection of *S.* Saintpaul in food samples. Processor A also supplied the same sliced raw spring onion product to twenty other facilities in NSW from 1 December 2020 to 22 January 2021, with a substantially wider distribution of other products containing spring onion. It was known that Processor A also distributed products to facilities other jurisdictions. Farm A is one of the largest among several other growers of spring onions in Queensland, with its produce distributed Australia-wide. At the time corresponding to the harvest of spring onions implicated in the *S.* Saintpaul MJOI, broccolini was also being grown and harvested from Farm A. Spring onions were either distributed directly to processing facilities, or to secondary suppliers. At the time of the MJOI, Supermarket Chain A also sourced spring onions from Farm A through one other supplier.

Environmental samples from a variety of settings in five jurisdictions (NSW, Queensland, South Australia, Tasmania, Victoria) were collected, representing a range of possible sources, including food items, food preparation surfaces, product packaging, and soil and water from farms. Of note, the initial site visits to Farm A took place on 18 and 19 January 2021, where extensive environmental sampling was undertaken. No *Salmonella* was detected from any of these environmental samples.

From all environmental investigations undertaken related to this outbreak, there were three samples positive for *Salmonella* Saintpaul, collected from food samples in NSW prior to the official commencement of the MJOI. Two of these samples were taken from each of the Supermarket A-branded 400g and 800g coleslaw products, and one sample was from the sealed 5kg bag of washed and sliced spring onion sampled at the producer of the Supermarket A-branded coleslaw products. All three samples underwent WGS, and results matched the outbreak sequence. No additional environmental *Salmonella* Saintpaul samples were detected.

Exposure cluster investigations

Seven exposures were identified as possible clusters, and referred by OzFoodNet teams to jurisdictional food authorities for further investigation. These clusters involved 76 cases who were confirmed or probable at the time of investigation, and one possible case (Appendix Table 1). Exposures included three dining venues, one food delivery service, one other pre-packaged salad item from Supermarket Chain A, and multiple branches of two fast food chains. Investigations into two of these clusters involved further environmental samples being collected. There were no *Salmonella* detections from either set of environmental samples. The findings of cluster investigations are detailed in Appendix 1.

During this MJOI, jurisdictional food authorities were notified of two additional possible restaurant exposures. Extensive environmental sampling was undertaken at one restaurant. Subsequent laboratory investigations on human and environmental samples from both venues revealed that they were not genomically linked to the outbreak.

Discussion

By the time of its conclusion, this outbreak was the largest involving *Salmonella* Saintpaul in Australia. WGS identified a single genomic outbreak cluster, linking 585 cases residing in all jurisdictions. This *Salmonella* Saintpaul MJOI was unusual for a foodborne investigation in that hypotheses about the most likely food sources were formed early, due to concurrent events involving a retailer. The detection of *Salmonella* Saintpaul contamination in two varieties of a supermarket coleslaw product was followed by the detection of the same organism in a sample of spring onions, one of the coleslaw ingredients. Subsequent testing through WGS then established genomic links between these three food items and outbreak cases. The binomial probability analyses of food and shopping exposures, the geographical distribution of cases, and the temporal relationship between product recall were all pieces of evidence supporting spring onion as the source of *S.* Saintpaul contamination at a point prior to reaching the producer of the coleslaw. The timing of symptom onsets among confirmed cases pointed to transient bacterial contamination occurring in mid to late December 2020. However, a more specific location and mechanism for this contamination could not be determined through additional investigations undertaken.

The epidemiological curve indicates that a common source for this outbreak was likely, with most confirmed cases having a symptom onset between 15 December 2020 and 2 February 2021. The peak onset dates of 31 December to 3 January are likely to be relatively accurate, with cases being able to use the significant dates of the New Year period to guide their recollection. The epidemiological curve for specimen collection dates mirrored that for onset dates closely. By the time of the Supermarket A-branded coleslaw recall on 12 January 2021, the number of new confirmed cases was already declining, without the recall leading to any additional appreciable declines in the epidemiological curve. Therefore, it is doubtful that the recall, of itself, had an impact on the outbreak. The possibility that there was transient bacterial contamination of spring onion in mid to late December could also account for the negative results of environmental sampling from Farm A on 18 and 19 January.

Binomial probability analyses of food items identified spring onions as being a statistically significant exposure against both comparator datasets, but not coleslaw. However, the two other pre-packaged salad items, pasta salad and potato salad, were statistically significant in both comparisons. Many brands of pre-packaged pasta and potato salads listed spring onion as an ingredient. Also of note was the statistically significant association with shopping at Supermarket Chain B, which did not sell any Supermarket A-branded products. These findings add to the hypotheses that spring onions were more likely to be the source of the outbreak, and that bacterial contamination occurred at a point upstream from both the production of the Supermarket A-branded coleslaw items and the distribution of spring onions to Supermarket Chains A and B.

The geographical distribution of confirmed cases added to the hypothesis that the source of bacterial contamination was upstream from the preparation of the supermarket-branded coleslaw products by Producer A. While these products were only distributed in NSW, ACT and regional Victoria, 37.6% of the confirmed cases came from Queensland, as well as a smaller proportion of cases with potential exposures in metropolitan Victoria, South Australia and Tasmania.

Although no spatial clusters were identifiable visually after mapping cases by postcode of residence, no statistical spatial analyses were performed. Therefore, there were no comparisons against the geographical distribution of *S.* Typhimurium MJOI cases, or of *S.* Saintpaul cases at baseline. Another geographical consideration is related to the time of year, with many cases reporting travel within Australia during their exposure periods. Therefore, the place of exposure may be distant from the place of residence. Retail loyalty card data assisted with verifying some supermarket locations, but these data were limited in their availability and completeness.

The statistically significant associations for onion, lettuce and cabbage found in binomial probability analyses against both comparator datasets may be attributable to these particular items being common ingredients in pre-packaged salads that contain spring onion. However, for many MJOI participants, the evidence supporting spring onion as the source of the outbreak was not sufficiently convincing, with the proportion of respondents who consumed spring onion was lower than half (40.9%) of all interviewed confirmed cases, and lower than those who reported consuming onion (66.8%) and lettuce (60.9%). This may be related to poor recall of spring onion consumption, to be discussed further in this section.

Pre-packaged coleslaw was only statistically significant in binomial comparisons against the VFSS data. The lack of a clear statistical association implicating coleslaw corroborates with other temporal and geographical evidence to suggest that Supermarket Chain A-branded coleslaw was not the common source of all cases in this outbreak.

In comparison with other recent *Salmonella* outbreaks in Australia, the demographic characteristics of confirmed cases were similar to those in the *Salmonella* Typhimurium MJOI that took place approximately one year prior. In both outbreaks, there was a slightly higher percentage of female cases, with a median age in the early 30s. This may reflect the fact that both outbreaks were thought to have been caused by fresh produce items, and this demographic pattern had also been observed in other fresh produce outbreaks in Australia (Personal correspondence: OzFoodNet NSW Team).

The median duration of illness (ten days) was longer than the seven days reported both in a previous *S.* Saintpaul MJOI in 2006 and in a review of all *Salmonella* outbreaks in Australia between 2001 and 2016 (2, 3). Despite initial concerns, the hospitalisation rate of 22% of 585 confirmed cases was lower than the 33% reported in the 2006 MJOI, but still higher than the 15% across all Salmonella outbreaks in 2001-2016.

Investigating a “stealth item”

The term “stealth item” has recently gained in popularity to describe food items such as spring onions that may be used in small quantities as garnish, and may not be noticed or recalled by the consumer(15). They are also often omitted from menu descriptions or product ingredient lists. As a result, the exposure to the item may only be reported by a small proportion of cases, which leads to difficulties in demonstrating an association between consumption and illness with a convincing measure of effect. In terms of comparison between cases and a selected population of controls, difficulties in recall may mean that there are similar levels of consumption reported. Statistically, to show a significant difference between two relatively similar proportions, a large sample size is usually required(16).

The challenges posed by foodborne outbreaks involving "stealth items" has been observed internationally. In 2008, the US Centers for Disease Control and Prevention (CDC) investigated a large *S.* Saintpaul outbreak with 1,500 cases(17). Several raw produce items were implicated, including varieties of tomatoes and peppers that were most commonly consumed in garnishes and condiments. No further strengthening of the evidence could be achieved, despite more than one case-control study being conducted during the investigation.

The low proportion of reported exposure to a "stealth item" was also a feature of this *S.* Saintpaul MJOI. By the end of the MJOI, 40.9% of the interviewed confirmed cases reported consuming spring onion. Many MJOI participants felt that an exposure reported by less than 50% of confirmed cases was not satisfactory evidence to drive subsequent public health actions.

At multiple points during the MJOI, the OzFoodNet epidemiologists considered the possibility of a formal case-control study to strengthen the evidence supporting the suspected food exposure. This was discussed at an expert panel review on 9 February 2021, with a panel made up of several other epidemiologists with experience in investigating foodborne outbreaks, a senior food authority representative, and a microbiologist from a jurisdictional genomic reference laboratory. The conclusions of this review were that a large sample size of approximately 100 cases and 300 controls would be needed to achieve adequate statistical power. Therefore, resources required to undertake this study were less likely to be justified by the yield expected from the results. There was already "moderate-high" evidence implicating spring onions as the most likely exposure, but additional details still lacking, such as mechanism of contamination, were unlikely to be uncovered through a case-control study (Ref: internal document). It was felt that it may be a more strategic use of resources by focusing on identifying and investigating potential clusters within the outbreak. An additional recommendation by the panel was to collect a broad range of environmental samples from all stages of the production and distribution chains of all coleslaw ingredients, and to explore the sampling of leftover food items from cases.

OzFoodNet epidemiologists also considered conducting a comparative statistical study between confirmed cases and excluded individuals already interviewed in the MJOI, as a less logistically demanding alternative to a formal case-control study. However, at the time of the expert panel review, there were insufficient numbers of excluded cases for adequate statistical power to be achieved. There may also have been bias introduced by jurisdictions that prioritised interviews for probable cases that fit certain demographic characteristics.

An important unresolved aspect of this investigation was the exact point of bacterial contamination, and how this contamination occurred. Establishing further details in this regard would assist in strengthening the overall evidence to implicate a food item. However, without additional detections through environmental sampling, it was not possible to find definitive answers to these questions. While many spring onion exposures identified in the MJOI could be traced to Farm A, it must also be noted that as one of the largest growers of spring onions in Australia, it would be reasonable to expect that any foodborne outbreak involving spring onion would have links to Farm A. This finding, in itself, would not lead to any conclusions about whether contamination occurred at the farm. Conversely, the absence of any findings from extensive environmental sampling over several visits to Farm A does not rule out the farm as the potential source of bacterial contamination. As discussed, there may have been transient contamination that was no longer detectable when sampling took place.

Similarly, cluster investigations did not add to the overall evidence in this MJOI. In some clusters, potentially common dishes could be identified. However, subsequent investigations, including environmental sampling, could not narrow exposures to a common ingredient within the dishes. Additionally, most cases in these clusters reported several other plausible exposures that may have resulted in their infection, meaning that it is difficult to establish whether the common exposure within the cluster is of relevance.

At an OzFoodNet teleconference on 18 March 2021, it was discussed that outbreak evidence pointed to the incidence of *S.* Saintpaul returning to baseline. The WGS data supported this assessment. Of WGS performed for all individuals with *S.* Saintpaul and with a symptom onset date after 16 February, a lower proportion of specimens matched the outbreak sequence. However, MJOI participants agreed that in the absence of sufficiently strong evidence about the source and mechanism of *S.* Saintpaul contamination, and with the outbreak sequence still being detected, albeit at a lower frequency, ongoing monitoring for new cases was still necessary to reach the conclusion that no further immediate public health actions were indicated. The MJOI data was reviewed again at another teleconference on 20 May 2021. By date of specimen collection, between 12 March and 18 May, there were 22 cases that matched the outbreak genomic sequence from five jurisdictions. No additional common exposures of concern were identified. It was thought that by this stage, these cases reflected the background level of infection caused by this particular genomic cluster, and that it was unlikely, even in the case of taking effective action against a known source, to eliminate the outbreak sequence of *S.* Saintpaul completely.

Investigation strengths

This MJOI also allowed novel methods for data management and analysis to be explored. Moving to the REDCap platform to store information on each case meant that jurisdictions were able to upload electronic records directly into a common database. The collection of postcode data for each case meant that spatial techniques such as mapping could be used, as another method for detecting potential epidemiological clusters. Additionally, this MJOI set an example of processes to collect and analyse retail loyalty card data from interviewed cases (Appendix 2).

Another strength of this MJOI was the pre-existing genomic surveillance activities for *S.* Saintpaul that had been carried out by QHPHML. This facilitated the interpretation of WGS data generated in this outbreak within the broader context of *S.* Saintpaul infections normally observed in Queensland.

The timing of this outbreak around the Christmas and New Year period may have affected data collection through case interviews, with many cases being able to use events at this time to guide their recollection of food exposures and medical care received. Cases may have also consumed more meals that were prepared outside of the home, with many cases able to produce receipts of food items ordered. However, where food was not prepared by the case, there may also be limited knowledge about the place of purchase, or the exact ingredients in each dish, particularly where it pertains to "stealth items".

An analytical strength of this investigation was using two different comparator datasets for the binomial probability analyses. Although there were advantages in using the *S.* Typhimurium MJOI data, collected using a similar HGQ, the population interviewed were people who also had salmonellosis, which could lead to bias in the results generated. The VFSS data are more complete and homogenous, with a larger sample size from a healthy population. However, these data may reflect differences in the availability of fresh produce items in Victoria compared to the more northern states. It may not have accounted for an increase in the variety and availability of pre-packaged supermarket salad items since 2015. Triangulating the results from both datasets was useful for reducing these limitations. In addition, less than half the items found to be statistically significant in binomial analysis against one dataset were also statistically significant against the other dataset. The binomial probabilities were very divergent for some items, such as potato and pre-packaged coleslaw. This may point to the difficulty in finding appropriate controls when analysing foodborne outbreak data. However, focusing on items that are statistically significant against both comparator datasets may narrow down the list of the most likely exposure sources.

Investigation limitations

In any investigation involving multiple jurisdictions, it would not be unexpected to find differences in local procedures. In this MJOI, a limitation was the different approaches taken to case interviews by jurisdictional teams. This meant that different versions of HGQs were circulating concurrently, with some versions omitting food items that were prioritised by others. Examples of omitted food items included pre-packaged salads from the earlier versions of the Queensland HGQ. This has meant that it was not possible to assess whether there may have been similar supermarket salad products associated with initial cases in Queensland.

Regional variation in vocabulary was another complication in this MJOI. The Queensland OzFoodNet team reported that many cases they had interviewed were unfamiliar with the term “spring onion”, and instead referred to this vegetable as “shallot”. However, for many other interviewees across Australia, “shallot” referred to another vegetable. Anecdotal experience shared at meetings by OzFoodNet interviewers indicated that there was also confusion between spring onions, chives and leeks. Although the MJOI-specific versions of the HGQ sought to pre-empt any misunderstandings around this item by alerting interviewers and providing them with visual guidance (Appendix 5), this dialectal variation may have led to misclassification of cases who had consumed spring onion.

Another anecdotal finding from case interviews may have resulted in information bias. It was noted, in NSW OzFoodNet team discussions, that because the contamination in the spring onion product was known prior to the commencement of the MJOI, many case interviewers gave this exposure more attention than they did for other items. More details were collected around purchase and consumption of spring onion, including entries about possible exposures that may have fallen within the exposure period. This may have biased the information gathered. On occasions, the focus on spring onions led to the interviewee suspecting this exposure as the cause of their illness, which may have led to over-reporting their exposure.

An additional challenge in this investigation was the variety of packaged commercial salad items that cases reported. For certain supermarket chain branded items, the producer varied across jurisdictions, and used different ingredients depending on location. Considerable effort was made to source the state-specific ingredient list for each product. However, misclassification of exposures may still have occurred where ingredients were not listed.

Several OzFoodNet teams also felt that the time taken to obtain serovar typing and WGS results from jurisdictional reference laboratories delayed conducting environmental investigations of potentially transient sources of contamination (Appendix 3). It was also felt to impact data quality, with many cases being unable to recall exact details of food exposures when eventually interviewed. The delay in jurisdictions being able to submit new sequences to QHPHML meant that there were delays in the process of comparing new sequences to the outbreak sequence for case classification, which limited data analysis.

It must also be recognised that this outbreak occurred within the context of the COVID-19 pandemic. Although COVID-19 cases were relatively low at the time, and social restrictions were relatively relaxed, subsequent pandemic developments during the investigative period of the MJOI caused disruptions to usual processes. Examples included various jurisdictions having reduced human resources to interview some of their MJOI cases, leading to delays in data collection.

Conclusion

This *S.* Saintpaul MJOI has shown that it is not sufficient only to demonstrate genomic links between cases and food items in the investigation of a foodborne outbreak. Despite WGS evidence indicating plausible causal association with spring onion and Supermarket Chain A-branded coleslaw, the recall of the coleslaw did not lead to a reduction in new cases. Details relating to the process of bacterial contamination are also important to uncover in an investigation, and are essential for informing public health actions to prevent recurrence through the same mechanism.

Additionally, to advocate for regulatory measures to be initiated, the strength of association needs to be convincing(15). Establishing definitive proof of association with a satisfactory strength of association has been difficult in many of the recent fresh produce outbreaks, including the *Salmonella* Typhimurium MJOI used as a comparator in this *S.* Saintpaul investigation. Reasons for this may include the involvement of “stealth items”, or the variety of fresh produce items which are often combined into a wide range commercially prepared salad products.

In this MJOI, further advice was sought from an expert panel review, regarding strategies to improve the strength of association. A case-control study may have added to the statistical evidence supporting spring onions as the most likely source of the outbreak, but to improve the strength of association already established, an unfeasibly large sample size may be required. Additional strategies to increase the strength of association, such as cluster investigations, extensive environmental sampling and examination of retail loyalty card data, did not add any weight to the evidence. Despite being unable to achieve this objective, the outbreak concluded without further public health interventions.

This *Salmonella* Saintpaul MJOI was example of a fresh produce outbreak where a food item was implicated with strong laboratory evidence, but without additional supporting information, including details around how this contamination occurred. This demonstrated some further challenges beyond the identification of the most likely food exposure. With ongoing discussions and reviews of regulatory strategies involving the food industry, and the limitations of recent public health outbreak investigations, there is still much to learn about the most effective methods to gather useable information relating to the safety of fresh produce.

Appendix 1: Food exposure clusters

During the MJOI, the following seven food exposure clusters were referred to jurisdictional food authorities for further investigation (Appendix Table 1). Environmental sampling was undertaken for two of these clusters, with no additional information uncovered.

Appendix Table 1 – Possible exposure clusters investigated in S. Saintpaul MJOI

Exposure	Jurisdiction	Number of cases	Exposure date range	Symptom onset date range	Investigation outcome
Venue #1	Qld	2 + 1 possible case	16/12/2020	17/12/2020 – 20/12/2020	Interviews revealed that there were spring onions in the dishes consumed by the cases. The venue did not have any samples remaining for testing. Traceback investigations revealed that Farm A was a potential source of the restaurant spring onions, via a Queensland distributor. However, there could have also been another possible farm source. Environmental sampling at the distributor was negative for *Salmonella.*
Venue #2	Qld	3	21/12/2020	23/12/2020 – 24/12/2020	Investigated by jurisdictional food authorities in Queensland, with no definitive links found to any sources
Venue #3	NSW	2	05/01/2021 – 07/01/2021	07/01/2021 and 12/01/2021	Initial review of cluster revealed that one case had limited recall of food exposures. The other case did not consume any uncooked food items thought to be at higher risk of contamination, and was subsequently excluded from the MJOI based on WGS results. No further investigation was pursued.
Food delivery service	NSW, Qld, Vic	10	28/12/2020 – 06/01/2021 (Exact date unknown for 6 cases)	26/12/2020 – 18/01/2021	Traceback investigations for NSW cases undertaken by NSWFA, with a focus on dishes that may have contained raw spring onion. No additional sources for environmental sampling could be identified.

Exposure	Jurisdiction	Number of cases	Exposure date range	Symptom onset date range	Investigation outcome
Supermarket salad item	NSW, Qld (location of exposure was NSW)	2	26/12/2020	26/12/2020 and 27/12/2020	Cases were unable to recall this exposure clearly, with inconsistencies between the two histories. Therefore, there was not enough information for further investigation.
Fast food chain #1	ACT, NSW, Qld, SA, Tas, Vic	36	24/12/2020 – 26/01/2021 (Exact date unknown for 16 cases)	24/12/2020 – 26/01/2021	Menu items reported by cases were investigated. Most items were found not to contain raw items considered to be likely sources of infection. Most cases also reported consuming foods containing spring onion from other venues.
Fast food chain #2	ACT, NSW, Qld, SA, Vic	21	28/12/2020 – 03/02/2021 (Exact date unknown for 3 cases)	01/01/2021 – 08/02/2021	Raw spring onions found to be part of several menu items reported to have been consumed by cases. This was traced to Processor B, and in turn to Farm A. However, no definitive epidemiological link could be made between confirmed cases and exposure this fast food chain. Samples were taken at Processor B of spring onions received from Farm A, with all 32 samples negative for *Salmonella* species.

Appendix 2: Retail loyalty card investigation

Background and method

The increasing prevalence of retail loyalty card programs has meant that several jurisdictions worldwide have recognised the potential usefulness of data from this source for the investigation of foodborne outbreaks(18, 19). The NSW OzFoodNet team had previously explored the use of food purchase records linked to retailer loyalty card programs, in collaboration with NSWFA. The HGQ for the *S.* Saintpaul MJOI was amended on 22 January 2021 to include questions to request store loyalty card numbers for any retailers where the case had made any purchases during their exposure period.

Mechanisms were in place prior to this MJOI for NSWFA to obtain product purchase details linked to Supermarket Chain A loyalty cards for NSW. NSWFA was able to negotiate this arrangement with Supermarket Chain A due to previous collaboration in state-level outbreak investigations. For this MJOI, this arrangement was extended to include Supermarket Chain A stores and customers in all jurisdictions. However, there were no existing equivalent arrangements to obtain purchase data linked to the Supermarket Chain B loyalty program between the relevant state food authority and Supermarket Chain B. It was not possible to establish this process during the course of this MJOI.

The loyalty card data from Supermarket Chain A were supplied in a de-identified format, and restricted to include purchases within ten days of symptom onset of items classified by Supermarket Chain A as fresh produce only. This classification included pre-packaged salad items. Each item purchased was line-listed with information on the date and place of purchase, specific product details and the loyalty card number of the buyer, which the NSW OzFoodNet team used to link to individuals in the MJOI. These data were stored on spreadsheets maintained by the NSW OzFoodNet team, and were mainly used to corroborate information gathered in case interviews. It was thought that with delays between illness and interview, there were uncertainties in recall that could be checked against purchase data.

Results

Of the 270 interviewed confirmed cases who were asked about retail loyalty cards, 161 reported using at least one in the exposure period. A total of 156 store loyalty card numbers were collected from 127 confirmed cases (Appendix table 2). Most of these card details were from loyalty programs at two of the major supermarket chains, Supermarket Chain A and Supermarket Chain B.

Supermarket Chain A was able to provide record of purchases within the specified time period for 71 confirmed cases (16% of all interviewed confirmed cases) and seven non-outbreak cases interviewed prior to 19 February 2021. These records included 591 purchases of fresh produce items during visits to 77 supermarket stores. The exact stores indicated by the loyalty card data corroborated closely with information gathered during case interviews.

The purchase data were reviewed for three items (banana, blueberry, carrot) nominated by the lead MJOI epidemiologist as relatively common supermarket purchases in the general population. Two items (salad leaves, spring onion) relevant to the outbreak were also identified for review. This approach was taken so that the common items may be used as a rough comparison for data quality and general purchase patterns.

Among the three more commonly purchased items, retail loyalty card data revealed two to five additional purchases for each item that were not elicited from case interviews (Appendix table 3). In addition, all three cases who were unsure in their interviews about whether they had consumed carrots during their exposure periods were identified to have purchased carrots.

Reviewing discrepancies between interview and purchase data for outbreak items showed that for salad leaves, loyalty card data identified three additional purchases in cases who had denied consumption. Among the people who had purchased spring onion at Supermarket A, there were two cases who denied consumption of spring onion, and an additional two cases who were unsure about consumption.

Appendix table 2 – Loyalty card information obtained from confirmed cases

Loyalty card program	Card numbers obtained: NSW (% of confirmed cases asked for loyalty card details; N = 155)	Card numbers obtained: Other jurisdictions (% of confirmed cases asked for loyalty card details; N = 115)	Total card numbers obtained (% of confirmed cases asked for loyalty card details; N = 270)	Number of confirmed cases for whom card purchase data were available (% of card numbers obtained)
Supermarket chain A	59 (38)	37 (32)	96 (36)	71 (74)
Supermarket chain B	31 (20)	27 (23)	58 (21)	N/A
Other*	2 (1)	0	2	N/A

*Other included loyalty programs at local independent supermarkets.

Appendix table 3 – Loyalty card purchase analyses for selected items

Food item*	Number of confirmed cases denying consumption of item, but had purchased item at Supermarket A	Number of confirmed cases who were unsure about consumption of item, but had purchased item at Supermarket A
Banana	2	0
Blueberry	5	0
Carrot	4	3
Salad leaves	3	0
Spring onion	2	2

*Either item on its own, or in a combination product containing the item.

Discussion

The use of loyalty card data was novel in an OzFoodNet MJOI. This presented challenges in terms of both the collection of useful data, and the analysis of the data that were available.

More than half the loyalty card numbers obtained were from NSW. It was reported by jurisdictional representatives that many of the staff performing interviews were unsure about how these data would be used by the NSW OzFoodNet team, and could not answer questions from interview respondents about how their purchase data would be sourced and stored. This may have led to the loyalty card questions being omitted during interviews. When they were asked, the uncertainty of the interviewer may have raised concerns about data privacy, and led to a reluctance to share this information.

Consequently, the purchase data obtained represented only a small proportion of all cases in the MJOI. It was also biased in terms of including data from only one large supermarket chain, and geographically biased towards NSW for both shoppers and stores.

Even in the ideal scenario of having a complete set of food purchase data for each case in the investigation, it is clear that purchase data linked to shopper loyalty programs have inherent limitations(18). For example, proof of purchase of an item does not necessarily equate to proof of consumption. Equally, food items consumed by a case may have been purchased by another person, or may have been purchased at a time when the loyalty card was not used. These data also do not account for food purchased at restaurants and other outlets without loyalty schemes that link purchases to individual buyers. The Christmas and New Year period may have increased the discrepancy between purchase and consumption, in that there may have been more functions where food was prepared by other people. All these limitations were considered by the OzFoodNet epidemiologists when adding the questions about loyalty cards to the MJOI HGQ. The intention behind incorporating these data into the MJOI analyses was to supplement, but not replace, information gathered from detailed case interviews.

After reviewing the loyalty card purchase data that were obtained, it was thought that the small numbers of purchases in addition to consumption reported by cases would be unlikely to change analytical outcomes significantly. Therefore, no additional analyses were performed on this dataset.

Conclusion

In this MJOI, in itself, the retail loyalty card information did not generate any additional insights. This may be partly due to the fact that data were only available for a small percentage of interviewed confirmed cases, and only a small number of food items purchased was analysed. It also appears that a recall of consuming an item was a sensitive indicator for having purchased the item, even for a "stealth item" such as spring onion, which may not necessarily be the main ingredient in a pre-packaged salad. The case interview data collected during this investigation appeared to have been an adequate source of exposure information.

Appendix 3: Additional laboratory findings

Genomic clusters identified through WGS

Apart from the outbreak WGS cluster, 210112-02, other genomic clusters were monitored throughout the MJOI, as it was possible for the outbreak to involve more than one sequence of *S.* Saintpaul.

As discussed, QHPHML detected 41 additional clusters detected through WGS. These clusters contained one to 17 cases. One of these clusters, designated as 200610-02, attracted further attention and analysis. It was the second largest genomic cluster at the time of this analysis, and involved 11 individuals. It initially appeared in one case in Queensland, with a specimen collection date of 28 December 2020. Subsequently, it reappeared in Queensland and ACT in specimens collected from 18 February to 16 March 2021. Nine of these cases were interviewed, and one case reported having consumed uncooked spring onions within three days of symptom onset. These findings were discussed among MJOI participants, and it was determined that this sequence was unlikely to be related to the outbreak being investigated through the MJOI.

Laboratory turnaround times

It was noted that in the context of the COVID-19 pandemic, many jurisdictional reference laboratories were facing competing demands for resources, leading to delays in WGS being performed on MJOI samples, which in turn delayed the process of case confirmation. In response, both QHPHML and the NSW OzFoodNet team quantified the time taken for different stages of this laboratory process for each jurisdiction.

The NSW OzFoodNet team determined the median time in days between symptom onset and specimen collection through extracting this information from the case interview and notification data. In the pre-laboratory stage, for all cases interviewed up to 24 February 2021, the median time between symptom onset and specimen collection for each jurisdiction ranged from two to six days. Victoria had the widest range, from zero days to 41 days (median of four days).

QHPHML requested jurisdictional reference laboratories to report the median time intervals in each step between receipt of specimen and dispatching the specimen to QHPHML. This evolved into a broader investigation into the timing of processes at public health laboratories, and was later presented to OzFoodNet as a separate investigation.

Appendix 4: Literature reviews

To inform the ongoing development of the MJOI HGQ, targeted literature reviews were performed to identify food exposures that had been implicated in *Salmonella* outbreaks globally.

Salmonella (any serovar) and spring onion

The initial literature review performed by the NSW OzFoodNet team focused on whether there were other documented outbreaks globally attributable to spring onion being contaminated with any serovar of *Salmonella*. In particular, the team was interested in whether the spring onions were an ingredient in a specific product.

Only two reports were identified, neither of which were from an academic source. One outbreak was listed on the US CDC National Outbreak Reporting System Dashboard dating from 2009, involving nine people diagnosed with *Salmonella* Javiana in seven states of the US(20). The exact source was not specified. The second outbreak was from a non-government Canadian database that referenced a newspaper article describing an outbreak of *Salmonella* Oranienburg in 2010 that affected 25 people who had purchased fresh spring onions from a single supermarket in Ontario(21). Neither of these reports contributed to hypothesis generation in the *S.* Saintpaul MJOI.

Salmonella Saintpaul and any fresh produce items

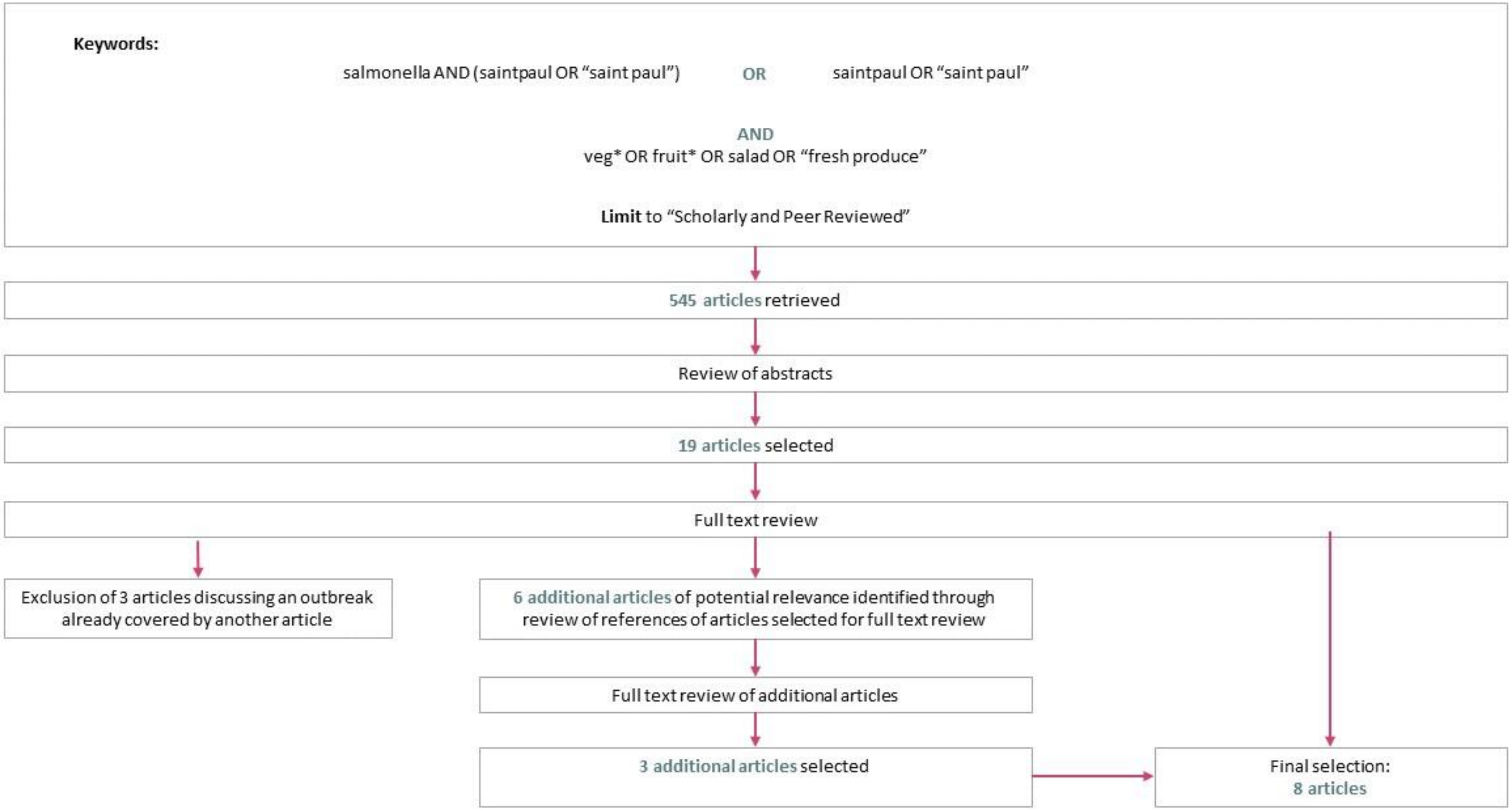
To inform my own understanding for this project, and to provide feedback for the shortened version of the HGQ (HGQ version 5), I performed an additional literature search to examine the range of fresh produce items that had previously been implicated in *S.* Saintpaul outbreaks.

The search was performed using the Australian National University (ANU) Library SuperSearch tool, which incorporates both PubMed and Scopus. Appendix Fig 1 describes the search process. No date range limits were applied, with the search being carried out on 4 February 2021. No language limits were applied, but articles were limited to “scholarly and peer reviewed”.

An initial review of the abstracts of articles retrieved from the search was performed. This review excluded articles that were unlikely to contain descriptions of specific outbreaks of *Salmonella* Saintpaul with a fresh produce source. Examples of articles belonging in this category included descriptions of *Salmonella* Saintpaul isolated through environmental sampling at farms, but without linked human cases. The 19 articles that remained after the initial abstract review underwent a full text review.

In the full text review, articles were included in the final selection if *Salmonella* Saintpaul was documented to be the causative organism of an outbreak with a fresh produce source, with “fresh produce” defined as vegetables, fruit and any other items listed in the “vegetables” and “fruits” sections of the MJOI HGQ versions 1 to 4, including pre-packaged salads, fruit juices and smoothies, and fresh herbs. Where more than one article described the same outbreak, the article giving the greatest level of descriptive epidemiological detail in terms of time, place, person and most likely exposure, was selected. An additional six articles of potential interest were identified from the reference lists of articles that underwent full text review. These additional articles were retrieved and also underwent full text review with the same criteria to assess for inclusion.

Appendix Fig 1 – Literature search process for S. Saintpaul *and fresh produce items*



The eight final articles selected are summarised in Appendix Table 4.

Appendix Table 4 – Summary of final selection of articles from literature review, by year of publication

Author and year (Ref)	Outbreak details: month and year, location	Number of cases	Source of exposure	Additional notes
O'Mahony, Cowden, Smyth, Lynch, Hall, Rowe et al 1990 (22)	February to May 1988, multiple regions across England	143	Bean sprouts	Case-control study undertaken; *S.* Saintpaul isolated from retail samples and from producer; resulted in the closure of producer premises
Beatty, LaPorte, Phan, Van Duyne, Braden 2004 (23)	February to March 2001, 7 states of the US	26	Mango likely imported from Peru	Case-control study undertaken; inadequate purchase histories to undertake more definitive traceback investigations
Munnoch, Ward, Sheridan, Fitzsimmons, Shadbolt, Piispanen et al 2008 (3)	October 2006, mainly NSW, Vic and ACT, Australia	115	Cantaloupe	Case-control study undertaken; *S.* Saintpaul isolated from the skin of two cantaloupes at an implicated retailer
Jain, Bidol, Austin, Berl, Elson, LeMaile-Williams et al 2009 (24)	May to July 2005, 23 states of the US	152	Unpasteurised orange juice from one company	Exact route of contamination unknown; case-control study performed during investigation
Safranek, Leschinsky, Keyser, O'Keefe, Timmons, Holmes et al 2009 (25)	February to April 2009, 13 states of the US	228	Alfalfa sprouts	Case-control study undertaken; cases linked to a single seed grower
Barton Behravesh, Mody, Jungk, Gaul, Redd, Chen et al 2011 (17)	April to August 2008, 43 states of the US and additional cases in Canada	1500	Raw tomatoes (multiple varieties), jalapeño peppers, serrano peppers	Three case-control studies were undertaken, and nine cluster analyses of restaurant outbreaks; statistically significant exposures include consumption of raw tomato, eating at a Mexican-style restaurant, and consumption of pico de gallo salsa; environmental sampling detected the outbreak strain on a sample of jalapeño peppers and another sample of serrano peppers at a farm
Bennett, Sodha, Ayers, Lynch, Gould, Tauxe 2018 (26)	Any reported *S.* Saintpaul outbreak in the US, years 1998-2013 inclusive	Not stated	2 outbreaks involving fruit as the exposure, 6 outbreaks involving vine vegetables (including tomatoes), 3 outbreaks involving sprouts	A review of fresh produce foodborne outbreaks in the US from 1998-2013; no specific details of each outbreak given; 11 outbreaks in broad fruit and vegetable categories listed, presumably with some of these outbreaks overlapping with the US-based outbreaks already described

Author and year (Ref)	Outbreak details: month and year, location	Number of cases	Source of exposure	Additional notes
Dyda, Nguyen, Chughtai, MacIntyre 2020 (27)	January to April 2013, US	84	Cucumbers	Discussed in a journal article summarising several *Salmonella* outbreaks involving cucumbers, with information originally from a grey literature source

The literature review did not contribute any additional insights into the *S.* Saintpaul MJOI HGQ. All food items implicated in the articles reviewed were already included in the HGQ, and were retained in the shortened version. An exception was pico de gallo salsa, which did not appear in any version of the HGQ, as it was a far less common exposure in the Australian setting, and possibly not able to be identified by name by a large proportion of the general public.

In terms of general guidance for the *S.* Saintpaul MJOI, these articles demonstrated the difficulty in pinpointing the exact source and mechanism of contamination for many fresh produce items. Many of the outbreaks described by these articles were large, in both the number and the geographical spread of cases. This demonstrates the additional investigative challenges that stem from a well-connected food distribution network, particularly if the source of contamination is closer to where the item is grown.

Appendix 5: Pictorial guide to spring onions from *Salmonella* Saintpaul MJOI HGQ

The following pictorial guides were inserted into each version of the S. Saintpaul MJOI HGQ to ensure that case interviewers were able to give consistent guidance where there was confusion with the names for specific vegetables.

Appendix Fig 2 – Excerpt from S. Saintpaul *MJOI HGQ showing pictorial guidance to case interviewers regarding spring onions*

VEGETABLES / SALAD (Cont.)	Eaten in 7 days prior to illness	Type / brand / description specify if eaten (RAW)	Where purchased or eaten
Green onions / shallots / spring onions (long green strands with a white tip, a singular white bulb may or may not be present) 	☐Y ☐N ☐DK	☐Cooked ☐ Raw	
Eschalots (small brown or purple bulb like an onion)  	☐Y ☐N ☐DK	☐Cooked ☐ Raw	
Leeks	☐Y ☐N ☐DK		

Note: Pictures obtained by another member of the NSW OzFoodNet Team – exact source unknown

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Learning to Count

5

Counting Stakeholders

The NSW COVID-19 Surveillance System: An evaluation of the first months

Surveillance Evaluation: List of Abbreviations

AHPPC	Australian Health Protection Principal Committee
APDC	Admitted Patient Data Collection
AUD	Australian Dollar
CAH	Centre for Aboriginal Health
CALD	Culturally and Linguistically Diverse
CCAS	COVID-19 Case Assessment System
CCTT	Close Contact Tracing Team
CDB	Communicable Diseases Branch
CDC	Centers for Disease Control and Prevention
CDNA	Communicable Diseases Network Australia
CHeReL	Centre for Health Record Linkage
CHO	Chief Health Officer
DET	Department of Education and Training
DoH	Department of Health
ED	Emergency Department
EHB	Environmental Health Branch
ELR	Electronic Laboratory Reporting
eMR	Electronic Medical Records
HETI	Health Education and Training Institute
HPLT	Health Protection Leadership Team
HPNSW	Health Protection New South Wales
ICD-10	International Classification of Diseases, 10th Revision
ICPMR	Institute of Clinical Pathology and Medical Research
ICU	Intensive Care Unit
ILI	Influenza-Like Illness
LHD	Local Health District
MAE	Master of Philosophy in Applied Epidemiology
MERS	Middle Eastern Respiratory Syndrome
MoH	Ministry of Health
NCIMS	Notifiable Conditions Information Management System
NCIRS	National Centre for Immunisation Research and Surveillance

NIR	National Incident Room
NNDSS	National Notifiable Diseases Surveillance System
NSC	National Surveillance Committee
NSW	New South Wales
OHP	Office of Health Protection
PCR	Polymerase Chain Reaction
PHEIC	Public Health Emergency of International Concern
PHEOC	Public Health Emergency Operations Centre
PHREDSS	Public Health Rapid Emergency, Disease and Syndromic Surveillance
PHRB	Public Health Response Branch
PHU	Public Health Unit
POC	Police Operations Centre
POCLO	Police Operations Centre Liaison Officer
QML	Queensland Medical Laboratory
QR	Quick Response
RNA	Ribonucleic Acid
SEALS	South Eastern Area Laboratory Services
SEOC	State Emergency Operations Centre
SHA	Special Health Accommodation
SHEOC	State Health Emergency Operations Centre
SMS	Short Message Service
SoNG	Series of National Guidelines
URL	Uniform Resource Locator
VPN	Virtual Private Network
WGS	Whole Genome Sequencing
WHO	World Health Organization

Surveillance Evaluation Project: Prologue

My role

I had just been given my first regular special project assignment in the Epidemiology Team of the COVID-19 response when Jeremy, my Field Supervisor, came to my desk for a chat one day. I told him that I would be doing a weekly surveillance report on new COVID-19 diagnoses among healthcare workers.

Jeremy told me that I could also get a surveillance project out of this. I responded that sure, continuing to set up the surveillance of healthcare workers with COVID-19 infections seemed like a reasonable project.

"No. I want you to evaluate the entire thing. The whole COVID-19 surveillance system in NSW."

My heart sank more than five floors, right into the basement of the building. "Oh. I don't think I can. It's too complex." By then, I had already managed a COVID-19 situation involving people across multiple states threatening to litigate. "And too political."

What followed, in terms of my role, was a lot of learning. I had to start almost from scratch, learning how all the parts of the system worked so that I could describe them. I had to learn how to carry out my role as an evaluator who was simultaneously working within the system. These were some of the other aspects of my role in the project:

- Planned and designed the surveillance system evaluation, using the CDC Updated Guidelines for Evaluating Public Health Surveillance Systems as a general framework
- Reviewed documents to understand the goals, structures and processes within the surveillance system, and its inputs and outputs
- Examined the NSW Notifiable Conditions Information Management System (NCIMS) to understand and describe its role in the NSW COVID-19 surveillance system. This occurred through:
  - Daily use of NCIMS as a Surveillance Officer in the COVID-19 surveillance system
  - Interviewing several staff members responsible for the maintenance and development of NCIMS
  - Assisting with the ongoing development of the electronic data entry fields in NCIMS
  - Assisting with NCIMS training activities for PHU staff and new staff in the PHRB, including a new member of the PHRB executive
- Created interview guides to reflect the CDC surveillance system attributes selected for evaluation
- Interviewed a range of stakeholders using these interview guides, both to understand their role and to obtain their feedback about the system
- Synthesised qualitative findings from stakeholder interviews and identified main points of feedback for each attribute
- Synthesised findings from quantitative data for attributes such as timeliness and data quality
- Drafted a list of recommendations based on evaluation findings to present to stakeholders
- Presented surveillance evaluation findings and recommendations to principal stakeholders
- Facilitated stakeholder discussions around recommendations and evaluation findings, and refined evaluation recommendations based on these discussions

Outside of this surveillance system evaluation, I was involved in the NSW COVID-19 response in several other capacities. An overview of these roles can be found in Chapter Six.

Lessons learned

Not to sound like I am blowing my own trumpet, but my learning process in this surveillance evaluation project was like starting to understand quantum physics. And I mean it more literally than one might imagine. I came into this project thinking about the system as a complex web of structures. After more than 18 months working on this evaluation, and being able to interrogate some insightful public health minds, I have changed how I see the fundamental nature of the system. It is actually made up of interlinked processes. Instead of tangible matter, concrete particles, the system is movement itself. Made up of waves in perpetual motion. Without a form or shape, other than the constraints that contain it at a given time. It could even be poetic, if it didn't involve dealing with respiratory secretions, nor were it under the direction of somebody with a title reminiscent of Thomas the Tank Engine (Incident Controller).

Despite learning so much about counting as a Surveillance Officer in the pandemic response, I am still unable to count the lessons I have learned through undertaking this project. There is something intangible about moments of epiphany that cannot be described in lists and numbers. It is with a sense of embarrassment that I admit that after more than 18 months since starting as a Surveillance Officer, I finally understood why we did many of the surveillance tasks that I performed obediently every day.

I have also learned my first lessons in how to undertake the evaluation of a surveillance system. If I had to do it again, I would have approached the task differently. I would have had a different perspective. I would have asked the stakeholders different interview questions. I would have been more structured and coherent in my descriptions of the system. To Jeremy, and to some of my friends, I tried to explain things like this: I felt like an early explorer who had just seen an elephant for the very first time. Unable to make sense of what I was seeing, and without any prior mental template, I proceeded to describe all aspects of this unknown creature in fine detail, hoping that later on, I would be able to refine my observations and assessment of the situation, guided by greater understanding. Looking back, I have indeed gained greater understanding, but to use this to reshape the project would require skills in time travel.

I learned from many of the discussions during stakeholder interviews. Many of their comments allowed me to continue to reflect on the management of relationships in these central-versus-peripheral structures of PHUs and the PHRB, and states and the Commonwealth. My Aboriginal colleagues raised many concerns about the collection and reporting of Indigenous data I had not noticed or considered. I walked away from many interviews with senior colleagues utterly awed by the amount of surveillance system planning and preparation that had taken place years before the pandemic. I learned about all the less visible actors that contribute to the system.

I learned more about managing large projects. This was the very first standalone project I had embarked on that lasted for more than a year. Sure, I had been involved in five-year research studies in the past, but my own part of the whole project had been self-contained, bite-sized chunks. It was made worse by the fact that I entered the fray without knowing what to expect from a surveillance evaluation. I thought that I would need six months at most. When reality turned out to be quite different from these expectations, I grew despondent and lost confidence. I thought that it meant that I was not capable enough to be entrusted with this task. There were also no interim outputs in this surveillance evaluation. It took a chorus of reassurance from MAE alumni friends for me to trust that at the end, I would end up with something that can be shown to the world. It felt lonely without a team to collaborate with. I had to look for motivation frequently, either from within myself, or from support networks. Along with the large project was the large writing task. It bored me. I wanted to keep interviewing people instead. I have come to accept that perhaps from this point onwards, this project will be my personal baseline of an unpolished report.

I will be honest in admitting that I learned that Jeremy was right about presenting. I continued to avoid it, thinking that it was one of those activities that he found to be enjoyable, and I did not. There was extra work involved in preparing a presentation. He was insistent, though, that the recommendations of the evaluation could not be final without the input of stakeholders. To me, that felt like deliberately placing myself under unwanted spotlight. After I took the plunge, I finally understood. The actual exercise, only an hour long, opened my eyes to what I did not know that I did not know, both in terms of how to present and discuss recommendations, and how to move from an academic exercise to action and change within an organisation like the NSW Ministry of Health. It saved my evaluation from being relegated to the recesses of a digital repository somewhere, never to be considered again.

The process of drafting recommendations was completely new to me at the time. I was extremely fortunate in having the political know-how of my academic supervisor, Stephanie Williams. She was also an invaluable resource in her advice about how to manage new stakeholder situations that I had not encountered before. I realised the depth of her wisdom and experience when I found myself parroting her suggestions in a workshop for an external project later in the month.

Public health impact

The NSW COVID-19 surveillance system evolved at a breathtaking speed. My evaluation took significantly longer than I had anticipated. After months of cajoling from Jeremy, I presented my findings to principal stakeholders on October 29, 2021, almost a year after my data collection cut-off date of November 14, 2020. This also coincided with an external consultancy firm concluding its investigation into aspects of HPNSW that overlapped with parts of my evaluation. I was convinced that my work no longer had any public health impact. I was reluctant to attend my own presentation, certain of the fact that I had just wasted a year of the valuable time of everybody kind enough to help me.

As it turned out, the discussion during the presentation was how the usefulness of the evaluation became more apparent. I was able to take everyone back to the beginning, when the NSW COVID-19 surveillance system was first being built. We discussed how early decisions influenced subsequent developments, including many of the processes that still underpin the system currently. What were some of the fundamental assumptions of the system? In hindsight, what could have been done differently, and what have we learned? It should have been less surprising to me how much preparation was already taking place for the next phase of the surveillance systems in NSW, for COVID-19 and for all other notifiable conditions. I was informed that my work would feed into this planning process. I'd like to think that another small but positive impact was the effect of my presentation on general morale. We could see how the basic surveillance processes at the beginning developed over a few short months, and became a more refined and streamlined system that was well regarded by most stakeholders.

MAE core activity requirements

- Establish or evaluate a surveillance or other health information system

Acknowledgements

As with every project in this thesis, I need to acknowledge my field and academic supervisors, Jeremy McAnulty and Stephanie Williams. However, with this project, I have made them both suffer even more than usual. The length of time that the project took, and my own complete inexperience at evaluating a surveillance system meant that hours of advice had to be imparted before I even started to understand what I was doing. The additional complexity was that during this project, I was admitted to hospital for 3.5 months, and had to continue working on the evaluation remotely, from the ward. Steph phoned me weekly, and bore the brunt of the emotional rollercoaster, including multiple occasions where I told her I was just going to quit. Jeremy, from the thick of the COVID-19 response, had to respond to panicked emails from me believing that I had done everything wrong.

Specifically, within the NSW Ministry of Health, I would like to thank Paula Spokes and Meeyin Lam. With Jeremy facing the relentless demands of being the Incident Controller of the NSW pandemic response, he entrusted me to their capable and knowledgeable minds for project guidance. Both of them were leaders in the Epidemiology and Surveillance team, and their schedules were beyond hectic. Yet they always found time to meet with me and answer my questions. They are also both people I admire greatly, and maybe one day, we will finally get a chance for me to ask them so many questions about all their past lives.

I would like to thank so many of my other colleagues at the Ministry of Health, and at PHUs, specifically "my" team of unfailingly patient surveillance "Boss Girls", Suhasini Sumithra, Jana Sisnowski and Kwendy Cavanagh. I am not exaggerating when I say that they were the ones who taught me all about the surveillance system in the first place, and provided so much useful feedback as I was collecting information for the project. I would also like to thank all the colleagues who allowed me to interview them for this project. Every one of them was more generous with their time and thoughtful responses than I had dared to imagine.

I would like to thank all the nurses who cared for me during my hospital stay for encouraging me to continue my work and studies, and for allowing me to access spare meeting rooms on the ward so that I could interview my stakeholders undisturbed.

I would also like to thank the broader MAE network, including everyone from program staff to classmates and friends from other cohorts. I was convinced that as soon as everyone found out what was happening in my life, they would try to convince me to take a leave of absence from the program. Instead, they rallied around me and believed in me. They advocated for me regarding administration and deadlines, and reassured me on multiple occasions that yes, surveillance projects are difficult beasts.

I did not believe that I would ever complete this project. Thank you everyone, especially Jeremy and Steph, for challenging me and proving me wrong.

Executive Summary

Introduction

In the latter half of 2020, an internal evaluation of the NSW surveillance system for the NSW COVID-19 public health response to date was undertaken as part of an MPhil in Applied Epidemiology (MAE) surveillance project. This report presents the results of this evaluation, and provides recommendations for improving the surveillance system in the ongoing NSW response to COVID-19.

Background

The public health response to an epidemic depends on timely and accurate information on cases and transmission. This information is often gathered through a range of sources and activities, which form the inputs of a surveillance system. A critical component of the NSW response to the COVID-19 pandemic to date was the NSW COVID-19 surveillance system.

The NSW public health response to the COVID-19 pandemic was activated on January 21, 2020. NSW Health, the State organisation for public sector health services in NSW, was responsible for this response, with support and input from other State and private sector agencies. This response included both central Statewide coordination, through the Public Health Response Branch (PHRB), and localised action through Public Health Units (PHUs). It was governed by the NSW *Public Health Act 2010*. The role of the surveillance system in the NSW COVID-19 response was outlined in the *Enhanced surveillance plan for COVID-19 in NSW*.

The information system for recording surveillance data on individuals and diagnostic test results was the Notifiable Conditions Information Management System (NCIMS). NCIMS was an information system built specifically for the public health surveillance of notifiable communicable diseases in NSW. It was used by NSW Health staff in public health prior to the COVID-19 pandemic. However, many new features were introduced to NCIMS specifically for the COVID-19 response to extend its application to case and close contact management.

As well as NCIMS, the surveillance system collected and stored data in other formats and locations, such as spreadsheets in shared network drives. Examples of these spreadsheets included line lists of close contacts, attendees of venues, or international arrivals in hotel quarantine. Sewage surveillance results and some whole genome sequencing results were also stored outside of NCIMS.

Methods

The general framework chosen for this evaluation of the NSW COVID-19 surveillance system was the Centers for Disease Control and Prevention (CDC) Updated Guidelines for Evaluating Public Health Surveillance Systems. These guidelines recommend assessing the surveillance system using a number of pre-defined attributes.

The planning for this evaluation commenced in May 2020. Data collection for the evaluation commenced in June 2020, with a cut-off date for new data to be considered in the evaluation of 14 November, 2020. Both quantitative and qualitative data were used to inform the evaluation. Quantitative data included statistics collected routinely by the PHRB Epidemiology Team on a variety of surveillance indicators. Qualitative data collection involved conducting interviews with twenty stakeholders who held a range of roles related to the surveillance system, and reviewing documentation describing different aspects of the system.

The focus of this surveillance system evaluation was on NCIMS and the processes to collect, manage and use the data in NCIMS. However, additional components of the COVID-19 surveillance system, such as spreadsheet data outside of NCIMS, were also examined.

Findings

The evaluation identified a range of strengths of the surveillance system. The most positive attributes were flexibility, timeliness, usefulness and acceptability. Simplicity and confidentiality were attributes identified to require improvement by more stakeholders. Table E1 presents a summary of the main findings for each attribute evaluated.

Table E1 - Main surveillance system evaluation findings by attribute

Attribute	Findings from surveillance system evaluation
Simplicity	• The NSW COVID-19 surveillance system was rapidly evolving and perceived to be complex • The decision to use NCIMS for recording close contacts and transmission clusters added to the complexity of the system • Dedicated training was required for new staff to use NCIMS • The processes for recording surveillance data outside of NCIMS (such as venue information or WGS results) were less straightforward than expected
Flexibility	• Overall, the system was highly flexible to the continual developments of the pandemic response • Improvements could be made in the timeliness and user-friendliness of communications about changes to system processes • Integration with external systems was identified as an area that can be improved
Timeliness	• The system was timely at each stage of the pathway for the notification and initial public health actions for positive cases • Implementing ELR procedures for more diagnostic laboratories would lead to additional improvements to the timeliness of the system
Data quality	• High levels of completeness in the data fields considered to be critical for cases captured by the NSW COVID-19 surveillance system • Data fields with the lowest levels of completeness were related to subgroup information, such as ethnicity and occupation • Data quality improved over time, assisted by data linkage, retrospective data entry, the introduction of the Data Quality Team, and data completeness reports
Acceptability	• High levels of acceptability from surveillance staff

	• NCIMS had limitations, but fulfilled basic surveillance requirements and was familiar to many staff members
Sensitivity	• Presumed to be highly sensitive, as determined through a range of indirect indicators
Stability	• NCIMS was a reliable information management system • There was adequate planning for unexpected failures of NCIMS • The staffing surge required by the surveillance system was a substantial undertaking and was largely successful, with some specific shortcomings identified • There were ongoing challenges with sustaining the workforce
Usefulness	• Outputs from the system had been useful for informing public health response strategies, policies and communications
Data security	• The NSW COVID-19 surveillance system was generally secure to external threats • There were several internal sources of security threats that required further attention to mitigate
Confidentiality	• A comprehensive range of processes was in place in the system for maintaining confidentiality • Individual staff member adherence to processes for confidentiality was variable • Additional measures to ensure confidentiality in smaller communities would be a useful development

Conclusion

The evaluation found a functional and useful system, with a high level of satisfaction among a broad range of stakeholders. Many stakeholders attributed the strengths of the surveillance system to the preparatory activities that were undertaken in the years prior to the pandemic, and to pre-existing relationships and structures within communicable diseases surveillance in NSW. Ten main strengths of the system were identified through the evaluation (Box E1, further details in Section D).

A recurring theme during stakeholder evaluations was the necessity of the system to change swiftly, to keep pace with the rapid developments during the course of a pandemic with a novel causative agent. This occurred in the context of a steep surge of surveillance staff, resulting in a critical need for effective communication and training to ensure the effective and efficient operation of the surveillance system.

The need to ensure that the surveillance system remains straightforward for users was often perceived to be at cross-purposes with the parallel need to collect detailed data to assist with detailed reporting and analysis. These outputs of the surveillance system were viewed as being crucial for a diverse audience to monitor and understand the latest COVID-19 developments in NSW. This balance between simplicity and detail was raised by multiple stakeholders as one of the main challenges of the surveillance system. There were stakeholders who also identified the rapid changes in reporting demands and in staffing as potential threats to the security and confidentiality of the system.

The evaluation sought recommendations from stakeholders for improvements to the NSW COVID-19 surveillance system. These were combined with recommendations identified from reviewing information from a range of other sources as part of this evaluation. The initial recommendations were presented to and discussed with principal stakeholders on October 29, 2021. As a dynamic and responsive system, at the time of presentation, many of the recommendations outlined had already been addressed. A final list of recommendations can be found in the Recommendations Table of this report.

Box E1 - Main strengths of the NSW COVID-19 surveillance system

Main strengths of the NSW COVID-19 surveillance system

1. Proactive and collaborative communication between all pandemic response teams
2. Adaptability of the surveillance system to change
3. Timely performance of the surveillance system at each stage of the pathway for notification of positive COVID-19 cases
4. Implementation of strategies to improve data completeness and quality
5. Familiarity of NCIMS to many staff members, especially following recent training activities for using NCIMS in an emergency response
6. Highly sensitive system, with monitoring and reporting of indicators of surveillance system sensitivity
7. A stable information management system in NCIMS
8. Adaptability of the system to human resource needs, such as the ability to surge staff numbers rapidly, and the ability to accommodate remote work
9. Comprehensive and responsive analysis and reporting that has been useful to decision-makers
10. Security of data to external threats

Recommendations from the evaluation of the NSW COVID-19 surveillance system

In order of priority, as at November 14, 2020, with additional feedback from discussion with principal stakeholders on October 29, 2021

Recommendation	Actions required	Addresses attributes	Human resources required	Suggested timeframe for completion	Feedback from stakeholder discussion
1. Training and maintenance of skilled workforce	a. Creation of NCIMS training checklist for all new surveillance system staff b. Continued development of surveillance system training material for pandemic response staff c. Development of a central repository of surveillance system user resources	Simplicity, flexibility	• PHRB Epidemiology Team • PHUs • MoH NCIMS Team	Two months	• Useful to continue to consider staff training needs • New training packages for components of the current surveillance system have been developed by the NSW Health Education and Training Institute (HETI)
2. Continued improvement of processes for transferring laboratory data	a. Continued collaboration with non-ELR diagnostic laboratories to establish ELR processes b. Continued collaboration with diagnostic laboratories to	Flexibility, data security	• PHRB Epidemiology Team • PHRB Laboratory Liaison Team • MoH NCIMS Team	Six months	• The establishment of ELR processes from non-ELR laboratories is now considered to be complete • The improvement of information security is an ongoing process that will continue

	improve security of identifiable information sent to the PHRB				
3. Continued development of user-friendly processes to capture close contact and transmission cluster information	a. Continued collaboration between pandemic response teams to improve the way that clusters and close contacts are recorded and linked in the surveillance system	Simplicity	• PHRB Epidemiology Team • PHRB Operations Team • CCTT • PHUs • MoH NCIMS Team	Two months	• This is an ongoing challenge that is difficult to achieve in a way that meets the need of every team. Multiple ways of recording this data may need to be used simultaneously. New processes have been developed since November 2020, and continue to be refined.
4. Improve surveillance for venues of exposure	a. Continued development of user-friendly processes to document and share information regarding venues of exposure among pandemic response teams	Simplicity	• PHRB Epidemiology Team • PHRB Operations Team • CCTT • MoH Communications Team • PHUs	Six months	• The new venue tracker platform, implemented in 2021, has definitely improved how venues of exposure are recorded and monitored. This tool will continue to be refined with ongoing use.
5. Improvement of ethnicity and occupation data	a. Development of process to improve both retrospective and prospective completion of data in NCIMS fields related to ethnicity and occupation	Data quality	• PHRB Epidemiology Team • PHRB Data Quality Team	Six months	• It continues to be difficult to capture a complete set of data for these fields. However, there is improvement in data completeness for individuals with higher risk occupations

Section A: Introduction

COVID-19 is the disease caused by SARS-CoV-2, a newly described beta coronavirus(1). It was declared to be a Public Health Emergency of International Concern (PHEIC) by the World Health Organization (WHO) on January 30, 2020(2). It first entered the International Classification of Diseases (ICD-10) on January 31, 2020, under the former name 2019-nCoV acute respiratory disease(3).

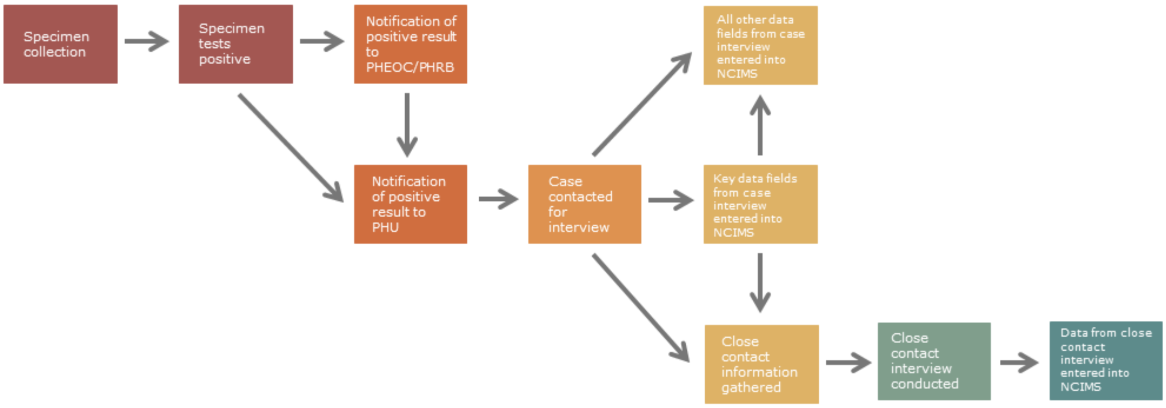
In Australia, “human coronavirus with pandemic potential” was added to the *Biosecurity (Listed Human Diseases) Determination 2016*, an instrument under the *Biosecurity Act 2015*, by the Chief Medical Officer on January 21, 2020(4). This triggered a number of public health actions, including daily meetings of the Australian Health Protection Principal Committee (AHPPC), and activation of the National Incident Room (NIR). Reporting to the AHPPC, the Communicable Diseases Network Australia (CDNA) is a committee that provides leadership and oversight of communicable disease surveillance at a national level(5). It is responsible for developing nationally agreed case definitions, which have continued to change throughout the course of the pandemic. The daily operations of national communicable disease surveillance are usually carried out through the National Notifiable Diseases Surveillance System (NNDSS), under the oversight of CDNA, within the Office of Health Protection (OHP) in the Commonwealth Department of Health (DoH). In the case of COVID-19, much of the disease-specific surveillance activity is delegated to the NIR, which also provides general operational outbreak support at a national level, and liaises with other international COVID-19 surveillance bodies(6).

In New South Wales (NSW), the Minister for Health issued a Public Health Amendment Order to the *Public Health Act 2010* on January 21, 2020 to add COVID-19 to the list of notifiable diseases, under the former name of “Novel Coronavirus 2019”(7). This particular Amendment Order stipulated that all confirmed cases of COVID-19 must be reported to the Secretary of the NSW Ministry of Health by both medical practitioners and diagnostic laboratories. In addition, for COVID-19, a request was made by the Chief Health Officer (CHO) of NSW to diagnostic laboratories within the State to report the outcome of all COVID-19 tests, regardless of whether a positive result was detected (Personal communication: PHRB Laboratory Liaison Team). This was considered to be a novel feature of outbreak surveillance in NSW, as the notification of negative results at an individual level had only previously been carried out for a few specific outbreaks that had been significantly smaller in size and shorter in duration. To date, all laboratories performing COVID-19 testing have complied with this request.

State-wide surveillance of notifiable conditions in NSW was undertaken centrally by the Ministry of Health (MoH) through Health Protection NSW (HPNSW)(8). Data for cases notified to HPNSW were received by and stored digitally in the Notifiable Conditions Information Management System (NCIMS). This electronic system was adapted from a commercial product, and was maintained and updated by a dedicated in-house team within the MoH (Personal communication: MoH NCIMS Team). NCIMS was accessible to MoH staff and public health staff at the local Public Health Units (PHUs). There were 12 geographically based PHUs in NSW(9). PHUs had relationships with many of the other healthcare services in their Local Health Districts (LHDs), such that results of notifiable conditions could be notified to the PHU directly from diagnostic laboratories in the LHD. New cases of many notifiable conditions were followed up individually, usually by the PHU, or in some cases, centrally by HPNSW.

Following the Ministerial Amendment Order issued on January 21, 2020, the NSW Public Health Emergency Operations Centre (PHEOC) was activated to coordinate the state-wide public health response to COVID-19 (Ref: Internal document). Responsibility for the surveillance activities for COVID-19 were designated to the PHEOC, with support from HPNSW staff. Staff in the PHEOC were made aware of all newly confirmed COVID-19 cases, and ensured that PHUs were informed, as well as other teams that may be required to carry out initial public health actions (Fig A1). NCIMS continued to be used within the PHEOC as the information management system.

Figure A1: Notification pathway – positive COVID-19 result



The PHEOC was restructured on June 10, 2020, to become the Public Health Response Branch for COVID-19 (PHRB), one of the branches of HPNSW (Ref: Internal document). This occurred in preparation for facilitating public health activities over the longer term, after more than 4 months of the initial pandemic response. The team mainly responsible for COVID-19 surveillance within the PHRB was the Epidemiology Team. This team was composed of staff in data analysis and reporting roles, staff members on the duty Surveillance Officer roster, and sub-groups responsible for data quality and importing laboratory results. The Team Leader of this Epidemiology Team was also the NSW representative to the National Surveillance Committee (NSC), a subcommittee of the CDNA. In addition to the PHEOC/PHRB, the Epidemiology Team provided surveillance data to other groups within NSW Health, other State Government actors, national infectious diseases surveillance bodies and the general public. Outside of the Epidemiology Team, the PHEOC/PHRB had other teams that played roles in COVID-19 surveillance, such as the Laboratory Team and the Operations Team.

The NSW COVID-19 Surveillance System Evaluation

The executive staff within the PHRB identified the need for this COVID-19 surveillance system evaluation early in the pandemic. It was envisaged that findings and recommendations from this evaluation would inform ongoing changes and improvements to the NSW COVID-19 surveillance system both for the subsequent stages of the pandemic response, and for future outbreaks of a similar scale.

The general framework chosen for this evaluation of the COVID-19 surveillance system was the Centers for Disease Control and Prevention (CDC) Updated Guidelines for Evaluating Public Health Surveillance Systems(10). This framework appraises the surveillance system through several pre-defined attributes.

Planning for this evaluation commenced in May 2020. The initial process involved discussions with principal stakeholders about the scope and structure of the evaluation. This allowed the determination of the stakeholder groups to involve, the data collection strategy and the surveillance system attributes to be examined. These principal stakeholders provided ongoing guidance and advice throughout the evaluation process.

This surveillance system evaluation was carried out within the Ministry of Health and falls under the *NSW Public Health Act 2010*. Therefore, additional ethics approval was not required.

Qualitative data

Semi-structured interviews were used to collect qualitative data for this surveillance system evaluation. Potential interview participants were identified by listing important stakeholder groups in the surveillance system, and then selecting representatives from each group. The aim of this selection was to capture a broad range of experiences, while minimising overlap of roles. The list of interviewees was finalised based on personal acquaintance with individuals within each stakeholder group, and on recommendations from colleagues (Appendix 4).

An individualised interview guide was drafted for three of the principal stakeholders, with a mixture of closed and open-ended questions aiming to obtain responses specific to their roles in the NSW COVID-19 surveillance system. An additional 17 interviews were carried out with representative members of stakeholder groups. The initial interview guide was piloted on one of the Surveillance Officers in the PHRB in August 2020, and refined after this initial pilot. The same interview guide was used for all these additional interviews, carried out between September and November 2020. The responses from the pilot interview were included as part of the 17 additional stakeholder interviews, and considered as a source of input into this evaluation.

Interview responses were analysed according to the CDC attributes. Quotes that were considered to be informative to the evaluation were transcribed. The interview guides requested respondents to provide ratings on a scale of 1 to 4 for a range of questions. These ratings were analysed as a qualitative guide to the general perception of respondents, and not quantitatively as a score that could be compared across surveillance system attributes.

Quantitative data

Quantitative data was obtained from a range of sources within the NSW MoH. This included:

- Direct access to NCIMS
- Weekly NSW COVID-19 surveillance reports
- Internal NCIMS data completeness reports
- Internal figures, reports and general information generated by the PHRB Epidemiology Team and the MoH NCIMS Team
- NCIMS Data Entry Guides
- Internal daily COVID-19 situation reports
- PHEOC and PHRB rosters
- Internal presentations: on human resources and team structures

These data informed the description of the surveillance system, and the evaluation of the attributes of simplicity, flexibility, timeliness, data quality and stability. Only descriptive analyses were undertaken, using a combination of Microsoft Excel and R/RStudio.

Development of recommendations

An initial series of five draft recommendations were developed from the findings of this evaluation. The findings of the evaluation and the draft recommendations were presented to principal PHRB stakeholders. This presentation incorporated an opportunity to discuss the draft recommendations specifically, and to refine these recommendations collaboratively. A final list of recommendations was then developed, incorporating feedback from this discussion.

Section B: Description of the NSW COVID-19 Surveillance System

The public health importance of the health-related event under surveillance

In Australia, from January 21, 2020 until November 14, 2020, there were 27,711 confirmed COVID-19 cases, and 907 deaths attributable to the disease(11). In NSW, in the same timeframe, there were 4,486 cases and 53 deaths(12).

In addition to morbidity and mortality, COVID-19 posed a significant socioeconomic burden, with infection control measures resulting in restrictions in everyday activities, business practices and international travel. In the quarter of March to June 2020, the Australian national Gross Domestic Product fell by a historic 7%(13). There were ongoing impacts on health resources, including restrictions on elective surgery, a reduction in cancer screening activities and increased demands on mental health services(14). Therefore, achieving adequate control over COVID-19 was deemed to be an urgent priority at local, State and Federal levels.

The purpose and operation of the COVID-19 surveillance system

Background

The *NSW Public Health Act 2010* (the Public Health Act) required doctors, hospitals and laboratories to notify the Secretary of NSW Health of any new cases of a pre-designated list of medical conditions(15). The function of receiving notifications and conducting surveillance on notifiable conditions was delegated to Health Protection NSW (HPNSW). HPNSW was also responsible for liaising and coordinating with local Public Health Units to undertake public health actions in response to notifiable conditions. This structure formed the basis of communicable disease surveillance in NSW.

On January 21, 2020, COVID-19, under its former name of "Novel Coronavirus 2019", was added to the list of notifiable conditions in NSW(7). This designation of COVID-19 as a notifiable condition mirrored the activation of the NSW public health response and the NSW state emergency response to COVID-19.

The *Enhanced surveillance plan for COVID-19 in NSW* (referred to as the NSW Surveillance Plan in this report) governed the NSW COVID-19 surveillance system(16). This was a document originally produced by the PHEOC executives and Surveillance Team. The PHRB Epidemiology Team was responsible for maintaining and updating this document. The Surveillance Plan emphasised partnerships between NSW Health and external health sector stakeholders.

Goals

According to the NSW Surveillance Plan as at November 2020, the stated goals of the COVID-19 surveillance system were(16):

- *"Provide daily updates on the characteristics and time-trends of COVID-19 cases, to support planning and evaluation of the public health response*

- *Provide daily updates on the characteristics and time-trends of deaths due to COVID-19 to support planning and evaluation of the public health response, and monitor overall population level mortality*
- *Provide daily updates on tests performed to detect SARS-CoV-2 infection and calculations of test positivity rates to assess the accessibility and equity of access to diagnostic testing*
- *Report on specimen collection and laboratory services to support rapid case finding and contact tracing and the overall public health response*
- *Report on the performance of contact tracing to support planning and evaluation of the public health response*
- *Report on clusters, outbreaks and other community trends in COVID-19 related illness, and other respiratory and viral illnesses, to assess the extent of community transmission and effectiveness of public health measures.*
- *Describe the clinical severity of COVID-19 to allow prediction of resource use and characterise risk factors for serious infection to inform the public health response*
- *Monitor impacts on the tertiary health care system to contribute to forecasts of demand, and to inform surge planning and redirect resources as required*
- *Conduct serosurveys to determine prevalence of SARS-CoV-2 infection over time, age, population group and geographic location to inform the public health response*
- *Undertake strategically targeted asymptomatic screening in high risk settings or vulnerable populations, particularly in association with a case exposure in these settings"*

Each goal was linked to specific indicators and activities. These are discussed in greater detail elsewhere in this report and in Appendix 1.

Legal and organisational context

As discussed, surveillance activities for notifiable conditions in NSW were governed by the *NSW Public Health Act 2010*. The Public Health Act set out the powers of the Minister for Health, the Secretary of NSW Health and the Chief Health Officer in terms of directing activities and delegating their functions(15). It also detailed the responsibilities of diagnostic laboratories and medical practitioners to notify the Secretary of NSW Health in the notification of designated conditions.

Notification information for most notifiable conditions in NSW was stored electronically in the Notifiable Conditions Information Management System (NCIMS; see "Information management system" section and Appendix 3).

NSW Health was the name given to the collection of public health services, including Local Health Districts (LHDs), statewide services such as Health Protection NSW, NSW Health Pathology, eHealth NSW and NSW Ambulance, and advisory agencies such as the Clinical Excellence Commission(8). HPNSW was overseen by the Chief Health Officer (CHO), and was the department responsible for monitoring and responding to outbreaks, notifiable medical conditions and environmental health risks. This remit meant that it was the primary department coordinating the NSW COVID-19 pandemic response. Prior to the activation of the COVID-19 response, there were two main branches within HPNSW, the Communicable Diseases Branch (CDB) and the Environmental Health Branch (EHB). Other divisions and teams within NSW Health that were crucial to the COVID-19 surveillance system included the NCIMS Team, the Media Team, the Centre for Health Record Linkage (CHeReL) and the Centre for Aboriginal Health (CAH). Colloquially, the statewide services of NSW Health were often termed "the Ministry of Health". However, the Ministry of Health encompassed all activities within the oversight of the NSW Minister for Health, including NSW Health.

In NSW, there were 15 LHDs, which were responsible for public hospitals and health services within their local areas(17). Corresponding to the LHDs, there were 12 local Public Health Units (PHUs), with some PHUs covering the geographical areas of more than one LHD. PHUs reported to LHDs administratively and in some operational functions, but worked closely with HPNSW to carry out public health actions(9). The senior staff of each PHU formed a network known as the Health Protection Leadership Team (HPLT). PHU staff working in communicable diseases formed the NSW Infectious Diseases Network. Prior to the activation of the COVID-19 pandemic response, both of these network structures facilitated the coordination and communication of public health responses to communicable diseases throughout NSW.

The NSW Public Health Emergency Operations Centre (PHEOC), as one of the activities of HPNSW, was activated for COVID-19 on January 21, 2020 (Ref: Internal document). The initial internal structure of the PHEOC followed the traditional Incident Command System structure, with Operations, Logistics and Planning Teams, under the leadership of an Incident Controller and Deputy Controllers. The Incident Controller of the PHEOC was the Executive Director of HPNSW, and reported to the NSW CHO. The Deputy Controllers were senior members of staff within HPNSW initially. Additional Deputy Controllers were subsequently recruited from senior public health personnel throughout NSW.

On June 10, 2020, the PHEOC transitioned into the Public Health Response Branch (PHRB) of HPNSW (Ref: Internal document). This meant that the PHRB became one of the divisions of HPNSW, of equal status as CDB and EHB (Fig B5). The internal structure of the PHRB was also adapted to reflect the changing needs of the pandemic response. This included the creation of a separate Epidemiology Team, where previously, the epidemiology and surveillance functions of the PHEOC had been carried out by a surveillance sub-team within the Operations Team. The Incident Controller role was renamed, to become the Executive Director of the PHRB, with Deputies and Medical Advisors also at the executive level.

On November 11, 2020, the PHRB underwent a further change to its internal structure (Ref: Internal document). However, this did not have a significant bearing on COVID-19 surveillance activities.

Within the broader government of NSW, additional response mechanisms were activated, such as the State Emergency Operations Centre (SEOC), under the direction of the State Pandemic Emergency Management Committee. The PHRB worked closely with the SEOC to coordinate the response across NSW. This included supplying information from the NSW COVID-19 surveillance system to the SEOC. Any changes to the NSW Surveillance Plan were presented to the State Pandemic Emergency Management Committee.

Nationally, NSW was represented at the CDNA by senior staff members from HPNSW. Throughout the COVID-19 pandemic, the CDNA issued continually updated Series of National Guidelines (SoNGs) for COVID-19, as well as the *Australian National Disease Surveillance Plan for COVID-19(18)*. Additionally, the NSW CHO was a member of the AHPPC. The AHPPC released the *Coronavirus (COVID-19) in Australia – Pandemic Health Intelligence Plan(19)*. These national documents informed the ongoing development of the NSW Surveillance Plan.

Notable new features of the NSW COVID-19 surveillance system

Decisions were made to implement several new features in the NSW COVID-19 surveillance system that had not previously been part of notifiable diseases surveillance in NSW. The most notable of these features included:

- Notification of all COVID-19 diagnostic results to HPNSW, not only the positive results. This followed from the request from the Chief Health Officer for laboratories to report all COVID-19 results.
- Tracking of all individuals in hotel quarantine in terms of COVID-19 screening test results. This followed the Commonwealth requirement for incoming international travellers to Australia to undertake 14 days of hotel quarantine from March 28, 2020.
- Collection and recording of individual demographic, exposure and symptom-related information for people deemed to be contacts of confirmed cases. This included carrying out daily symptom checks either via phone call or mobile application. The outcomes of these symptom checks were recorded in NCIMS. This information facilitated the management of contacts, which was a function of the NSW public health response to COVID-19 outside of the surveillance system.

Surveillance activities and strategies

A wide range of interlinked surveillance activities were undertaken to fulfil the stated goals of the NSW COVID-19 surveillance system (Table B1; see Appendix 1 for additional detail)(16).

Table B1 – Surveillance activities corresponding to the goals of the NSW COVID-19 surveillance system

Goal	Case-based notification	Test-based surveillance	Active surveillance of higher risk settings	Serosurveillance	Virological / molecular epidemiological surveillance	Syndromic surveillance / surveillance of respiratory illness	Health facility impact monitoring	Priority groups surveillance	International border surveillance	Environmental surveillance	Venue surveillance
1. Provide daily updates on the characteristics and time-trends of COVID-19 cases	✓							✓			
2. Provide daily updates on the characteristics and time-trends of deaths due to COVID-19			✓					✓			

3. Provide daily updates on tests performed to detect SARS-CoV-2 infection		✓						✓	✓		
4. Report on the performance of contact tracing			✓								✓
5. Report on clusters, outbreaks and other community trends in COVID-19 related illness	✓	✓	✓		✓	✓		✓	✓	✓	✓
6. Describe the clinical severity of COVID-19			✓				✓	✓			
7. Monitor impacts on the tertiary healthcare system						✓	✓	✓			
8. Conduct serosurveys to determine prevalence of SARS-CoV-2 infection				✓				✓			
9. Undertake strategically targeted asymptomatic screening			✓								

Components of the NSW COVID-19 case-based surveillance system

Population under surveillance

The population of interest for the NSW COVID-19 surveillance system was all individuals within NSW.

According to the agreements of the NSC, cases tested in NSW diagnostic or reference laboratories, but were physically located interstate and not managed by NSW public health staff, were not counted in NSW case numbers (Personal communication: PHRB Surveillance Team). However, despite not formally being included as NSW cases, these test results still entered the NSW surveillance system and were processed. Therefore, all individuals who were tested for COVID-19 through a NSW laboratory, but who were not physically located in NSW, were indirectly part of the population under surveillance.

Information flow through the surveillance system

Fig B1 – Main inputs of the NSW COVID-19 surveillance system

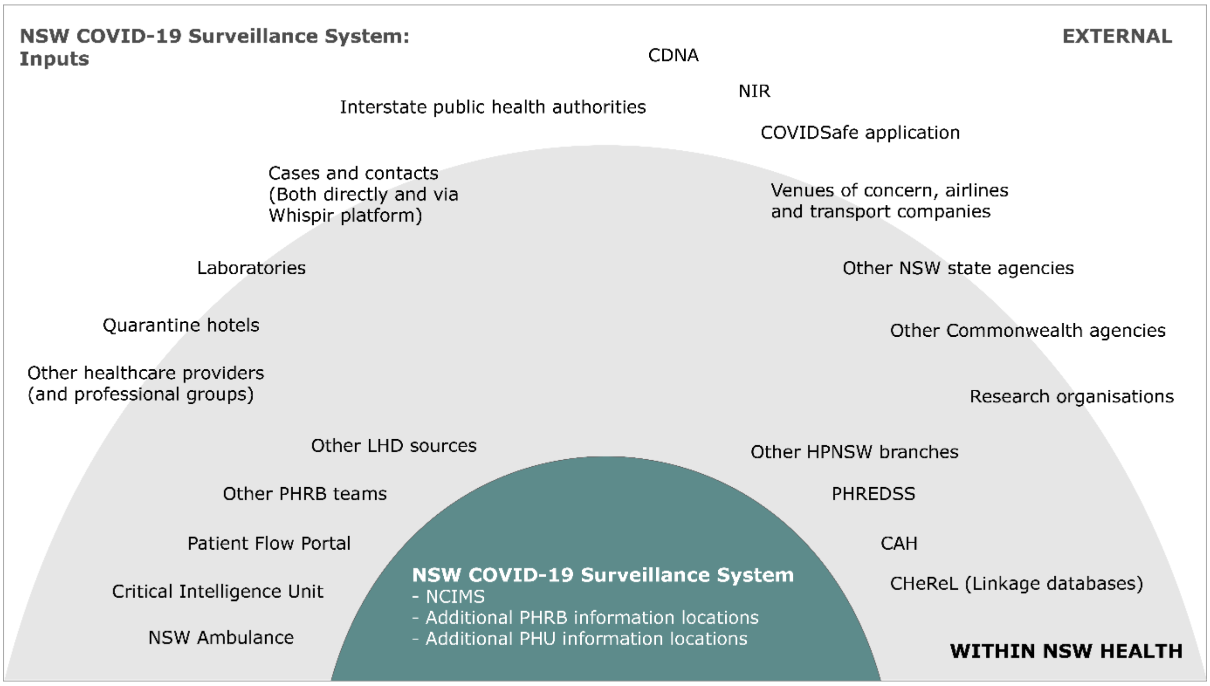
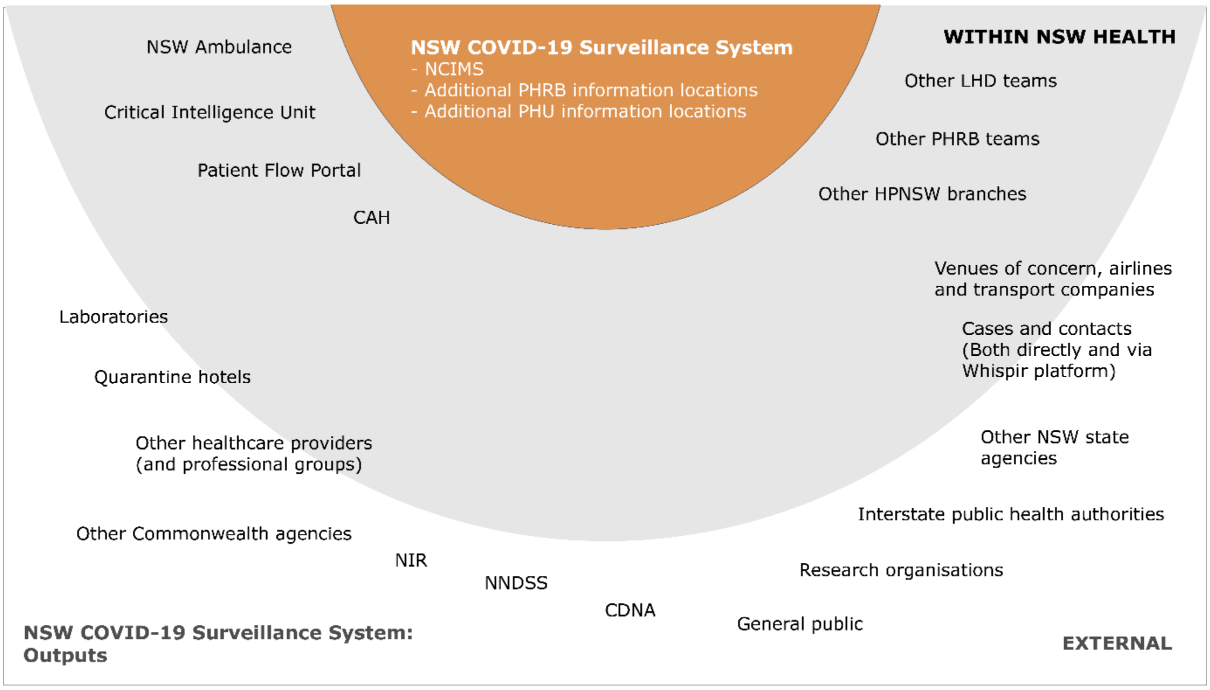


Fig B2 – Main outputs of the NSW COVID-19 surveillance system



The general flow of information through the NSW COVID-19 surveillance system are summarised in Figures B1 and B2. Data in multiple formats were collected from a wide range of sources and stored centrally at the PHEOC/PHRB. Most of the digital information in the surveillance system was stored in NCIMS. However, there were additional digital and physical locations for the storage of surveillance data. The outputs from the surveillance system also took a variety formats, and were shared with a diverse audience. The following sections describe the information management system, inputs and outputs in greater detail.

Information management system

The main information management system for the NSW COVID-19 surveillance system was NCIMS. The decision to use NCIMS in a pandemic was made prior to the activation of the COVID-19 response, on the basis that at a time when urgent action was required, it would be more efficient to adapt an existing system than to create a new system. Many staff members involved in the COVID-19 response were already familiar with NCIMS due to their experiences working within the notifiable diseases surveillance system in NSW.

NCIMS was developed specifically for NSW Health, on the foundation of Maven, a commercial core product (Personal communication: MoH NCIMS Team). NCIMS was first launched as the information management system for the NSW notifiable conditions surveillance system in 2010. The MoH NCIMS Team were responsible for the everyday operation of the information system, and for coordinating modifications and updates when required.

The users of NCIMS included approved staff members in HPNSW (including PHEOC/PHRB), the MoH NCIMS Team, and PHUs. Each user had an individual, password-protected account. Different levels of access were granted depending on staff roles (additional information in Appendix 2). Prior to the COVID-19 response, completion of NCIMS training was required for all new users. Additional training sessions were organised whenever required in response to major changes to the system.

In 2017, a planning exercise, the NCIMS Pandemic Exercise (PaNCIMS), took place to evaluate NCIMS as the information management system in a future epidemic (Ref: Internal document). This exercise involved staff from HPNSW, the MoH NCIMS Team and PHUs, in a scenario modelled on an outbreak of Middle Eastern Respiratory Syndrome (MERS). As planned, feedback from this exercise was incorporated into the ongoing development of NCIMS at the time, prior to its eventual use for COVID-19.

NCIMS was accessible for surveillance staff through a uniform resource locator (URL) link within an internet browser. Within NCIMS, notifications and records were organised by condition. As an example, this meant that each individual with any COVID-19-related information would have a COVID-19 "person event" record, identifiable by a unique nine-digit event identifier number. This event could be created either automatically, in response to a new electronic laboratory result, or manually by a staff member (additional details in Appendix 2).

NCIMS had the capacity to be customised for each notifiable condition, in terms of the type of information that could be recorded. New fields could be created for specific conditions, to collect data that were particular to that condition. The decision about the fields to be included was made by HPNSW and PHU staff, with national guidance through CDNA SoNGs and meetings within the NSC.

In addition to "person events", "outbreak events" could be created manually in NCIMS. This allowed information relating to an entire outbreak or a cluster within an outbreak to be recorded in one place. It also allowed public health staff to monitor the development of an outbreak overall.

Separate but related person events and outbreak events could be linked to each other in NCIMS. This may occur for cases and their contacts, to facilitate the follow up of contacts. This may also occur for clusters or outbreaks, in that person events could be included in an outbreak event.

Searching for an event within NCIMS could be carried out through two main methods, described in Appendix 2. Workflows were features within NCIMS that could be considered as advanced data searches with a set of pre-defined criteria. Opening a workflow prompted NCIMS to return all events that fit these criteria. For example, all new person events on a particular calendar day would appear in the “Open cases and contacts created today” workflow. The responsibility for checking through events in each specific workflow was assigned, by prior agreement, to either PHUs or an HPNSW team.

Reporting functions were available within NCIMS. For each notifiable condition, a range of reports could be generated, and filtered by fields such as dates of notification, or geographical area. A range of additional custom reporting functions could be created by the NCIMS Team.

Multiple components formed the non-user-facing “back end” of NCIMS. These components included, but were not limited to, the codes that executed NCIMS functions, the interfaces with external systems, and the data tables (also known as denormalised tables) where the data in NCIMS were stored (additional details in Appendix 3).

Adaptations of NCIMS for COVID-19

A new user account type in NCIMS was introduced for surge staff, restricting browsing and editing access to COVID-19 data only (see Appendix 3 for details).

New individual data entry fields were created specifically for COVID-19. Some of these fields were included in the new data entry wizards for COVID-19 events, for both cases and contacts. These wizards were designed to align with the paper-based COVID-19 Case Questionnaire and Close Contact Questionnaire. A range of COVID-19-specific workflows were also created (see Appendix 3 for details).

Apart from the user interfaces in the front end of NCIMS, many adaptations were made to the structures and processes in the back end of NCIMS specifically for COVID-19. The capacities of NCIMS to accommodate usage volumes, and to receive, process and store data were scaled up substantially during the NSW COVID-19 response (see the “Material resources” section). To manage this volume of COVID-19 data, and to facilitate more efficient data retrieval for reporting and analysis, it was determined that the denormalised tables holding the data in NCIMS needed to be re-developed with a new structure. This was carried out by the MoH NCIMS Team in July and August 2020, during the pandemic response, without compromising the functions in the front end of the system. To extract data from the denormalised tables, staff members in the PHRB Epidemiology Team developed bespoke programs for COVID-19 data analysis and reporting, using statistical software such as R and STATA (see “System outputs and dissemination”).

New interfaces between NCIMS and external systems were created for the NSW COVID-19 response. As an example, several laboratories started to notify results to HPNSW through electronic laboratory reporting (ELR) processes for the first time during the COVID-19 response. Modifications to the back end of NCIMS were made to read and process the new electronic data feeds from these laboratories.

NCIMS was also used to support the management of cases and contacts, including communications through automated text messaging to mobile phones. Initially, this occurred directly through NCIMS, with daily welfare check surveys being sent to cases and close contacts, and responses to surveys being received and recorded automatically (additional details in Appendix 3). This generated a high load of automated tasks to be processed by NCIMS, and a large volumes of data movement. With increasing numbers of cases and contacts, the strain of the short message service (SMS) functionality on NCIMS had negative impacts on other critical surveillance functions of the information system, and was disabled in late March 2020. A solution was found in July 2020 through the Whispir platform, an external tool that facilitated the follow up of close contacts through SMS messaging. This platform exchanged information automatically with NCIMS through a custom interface, and sent links to an electronic survey form to cases and close contacts. Individual responses to surveys were imported into NCIMS through the electronic interface, while reports on metrics such as the response rate and time spent on completing surveys are generated by Whispir and sent directly to the NCIMS team.

System inputs and sources

The mandatory inputs into the NSW COVID-19 surveillance system were laboratory results and basic demographic information for new confirmed cases, required as part of case notification. However, many other inputs were used by the surveillance system to gather data on a range of indicators, to guide the state pandemic response.

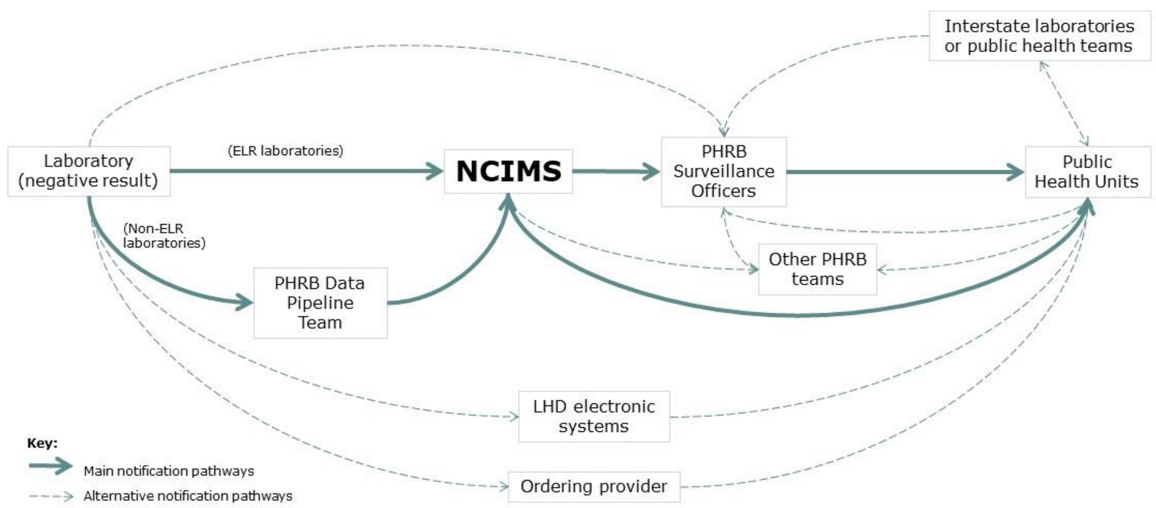
Diagnostic test result notification

Information requested for initial case notifications for COVID-19 in NSW included individual identification and contact details, laboratory testing details and requesting doctor details. Notifiers were encouraged to provide additional information such as whether the person tested belonged to any high risk groups or special populations under surveillance, and the cycle threshold (C(t) value, an indicator of the viral load) of any polymerase chain reaction (PCR) testing.

Notifications of new cases may reach the surveillance system through several different routes, from a number of sources. These routes are illustrated in Figures B3 and B4, with some salient differences between the processes for positive and negative results.

Negative diagnostic test result notification

Figure B3 - Notification of negative results in the NSW COVID-19 Surveillance System



The notification of negative and other (such as indeterminate, technical error, cancelled request) PCR test results for SARS-CoV-2 RNA was a novel feature of the NSW notifiable conditions surveillance system. The majority of these results originated from NSW laboratories. As at October 31, 2020 (the date of the final NSW Weekly COVID-19 Surveillance Report publishing this statistic), less than 5% of diagnostic SARS-CoV-2 RNA PCR tests for NSW residents, both positive and negative, were performed by interstate laboratories(20).

When a negative SARS-CoV-2 RNA PCR result was confirmed by an NSW diagnostic laboratory, it reached the COVID-19 surveillance system through several different routes, depending on the laboratory. The main notification pathways, on which the surveillance system depends for normal operation, are in bold in Figure B3.

Results from the laboratories listed below (referred to as "ELR laboratories" by PHRB surveillance staff; list was current in November 2020) entered NCIMS through an electronic laboratory reporting (ELR) process, where every hour, any new COVID-19 results from the laboratory were sent as secure HL7 format messages to an NCIMS interface designed to receive these feeds. The interface then read these messages and uploaded them into NCIMS. As at November 2020, test results from ELR laboratories accounted for 79.5% of all COVID-19 results in NCIMS.

- Australian Clinical Labs
- Capital Pathology
- Douglass Hanly Moir
- ICPMR/Pathology West
- Laverty
- QML Pathology
- SEALS
- Southern IML Pathology
- Sullivan Nicolaides Pathology

As at November 2020, the PHRB Epidemiology and Laboratory Liaison Teams and the NSW Health NCIMS Team were working with the following laboratories to establish ELR processes for COVID-19 results:

- Medlab Pathology
- Other Health Pathology NSW (public) laboratories not in list above

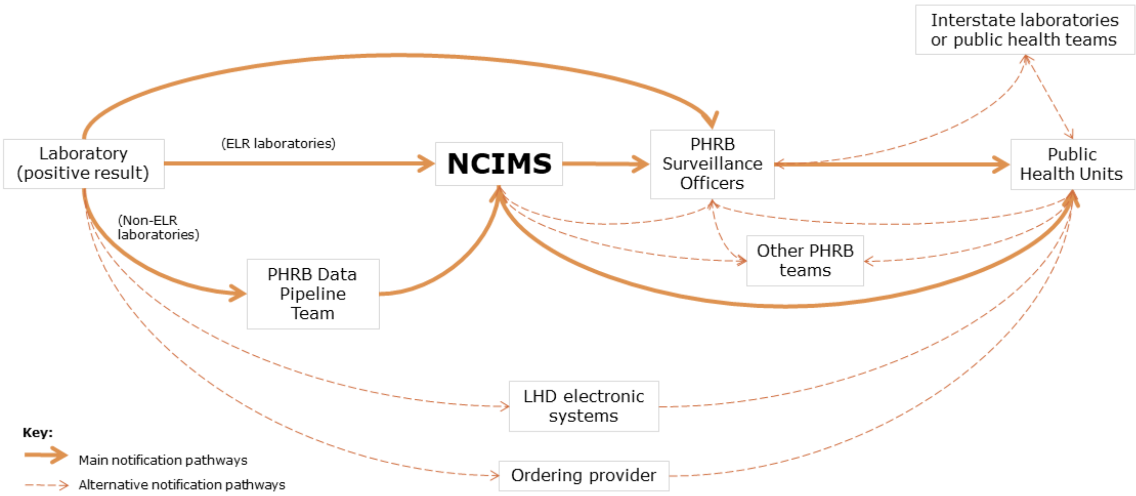
A manual batch import process was required for laboratories without an ELR process. This involved the laboratory emailing a line list in spreadsheet format of all COVID-19 test results to the PHRB Data Pipeline Team. The interval at which this occurred varied with the laboratory, with smaller laboratories batching negative results over two or three days. The Data Pipeline Team checked and reformatted this line list to enable these results to be imported in bulk into NCIMS. This process of manual processing by the Data Pipeline Team could take up to twelve hours for a large list.

In addition, all NSW diagnostic laboratories emailed line lists of all tests performed to the PHRB Laboratory Team and the PHRB Surveillance Officer. This allowed cross-verification of results in NCIMS.

Outside of the PHRB, the diagnostic laboratory would notify the medical practitioner requesting the test. Public laboratories (NSW Health Pathology laboratories) also uploaded test results into LHD electronic information systems, where it could be viewed by PHU staff, often prior to the arrival of these results in NCIMS. For urgent diagnostic tests, the PHU may learn of the result through LHD systems, and then inform the PHRB Operations and Surveillance Teams with this information.

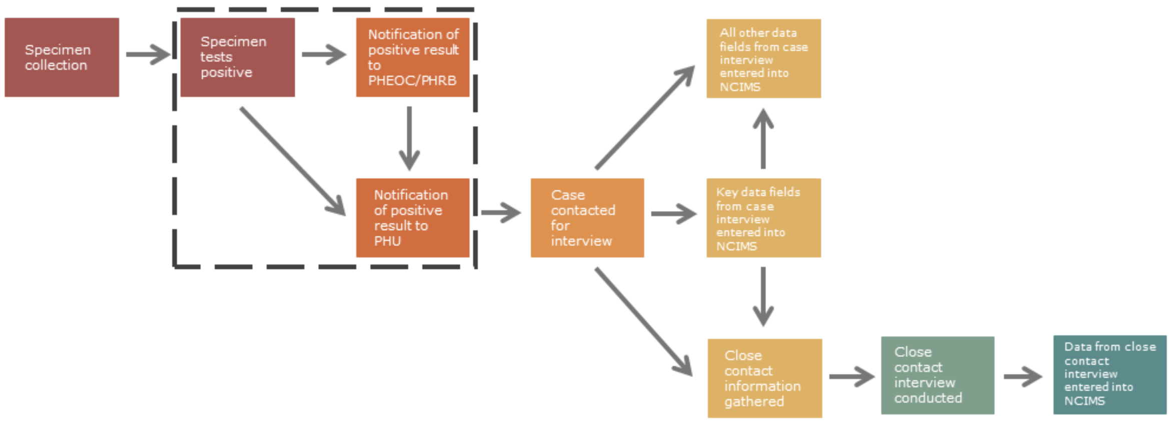
Positive diagnostic test result notification

Figure B4 - Notification of positive results in the NSW COVID-19 Surveillance System



The same actors were involved in the notification of a positive SARS-CoV-2 RNA PCR result to the NSW COVID-19 surveillance system. However, additional processes were in place to ensure that this notification was sufficiently timely and reached the relevant people responsible for carrying out public health actions (Fig B4). In the full pathway of the notification and public health actions for a positive COVID-19 result, Fig B4 corresponds to the steps within the dashed lines in Fig B5.

Fig B5 - Public health action pathway for a positive COVID-19 result, with the notification part of the pathway highlighted



As at November 2020, both ELR and non-ELR laboratories were instructed to notify the PHRB Surveillance Officer by telephone as soon as possible after each confirmation of a positive COVID-19 result. At this phone call, the laboratory also relayed any additional clinical information that accompanied the test request. Overnight between 22:00 and 08:00, this notification was made by the diagnostic laboratory to the senior HPNSW staff member rostered to respond to the on-call telephone. If the case was not yet in NCIMS, the Surveillance Officer entered the information received via telephone notification into NCIMS manually, to facilitate prompt action. The Surveillance Officer would then notify both the Operations Team and the relevant PHU. In addition, laboratories also notified the doctor who ordered the test by telephone. Several PHUs had requested doctors in their catchment area to telephone the PHU after they received laboratory notification of a positive case, as an additional safeguard to ensure that public health actions were undertaken as soon as possible for all new cases.

In addition to telephone notifications, electronic notifications via NCIMS occurred for positive results. The same processes, in terms of ELR and manual batch importing, took place as they did for negative results. New positive COVID-19 results uploaded into NCIMS appeared automatically in the “High Priority Events” workflow (see the “Information management system” section for further details on workflows). PHRB Surveillance Officers and PHU staff reviewed this workflow regularly throughout the day, to ensure that they had accounted for all new positive cases. As well as this, the Surveillance Officer cross-checked the emailed line lists of all COVID-19 tests performed for any new cases. This was followed by any manual data entry if necessary, and notifications to the PHRB Operations Team and PHU.

As with negative results, positive results from public diagnostic laboratories could also appear in the electronic information systems of the LHD, which was another source of notification for some PHUs. When PHU staff saw a new positive case through this channel, they entered this case manually into NCIMS and then informed the PHEOC/PHRB Surveillance Officer and Operations Team.

In urgent situations, the PHRB Operations Team could also telephone the testing laboratory directly for the result before it was made available electronically. If this result was positive, the Operations Team then notified the PHEOC/PHRB Surveillance Officer and the relevant PHU. The Surveillance Officer then manually entered this information into NCIMS.

In addition to the usual notification processes, individuals in hotel quarantine who tested positive were included in a list compiled by the diagnostic laboratory, sent to the PHRB Laboratory Liaison Team on a regular basis via email. The Laboratory Liaison Team then cross-verified this list against confirmed cases on NCIMS. The hotel quarantine locations of these cases were then relayed to the PHRB Surveillance Officer, Operations Team, relevant PHU (based on the usual residential address of the hotel quarantine case) and the relevant staff coordinating the quarantine hotels. The medical staff managing hotel quarantine were responsible for informing the new confirmed case of their diagnosis.

COVID-19 test results for individuals living interstate, but tested through an NSW diagnostic laboratory, were notified to the PHEOC/PHRB and entered NCIMS in the same manner as those for NSW residents. Once in NCIMS, the absence of an associated NSW residential address triggered this case to appear in the relevant workflows to be brought to the attention of the Surveillance Officer. The Surveillance Officer initially confirmed the physical location of this case through a range of channels available. If this location was outside of NSW, it was the task of the PHRB Surveillance Officer to inform the relevant interstate public health authorities. This was carried out electronically, using secure file transfer software for relevant documents, including laboratory results. When this process was completed, the Surveillance Officer excluded this case from the NSW case numbers. Negative results were not routinely notified to interstate agencies.

Conversely, interstate laboratories notified the NSW COVID-19 surveillance system about any new positive results belonging to individuals that they had tested, but were physically located in NSW. As at November 2020, this occurred through a number of different channels, depending on the state, the PHUs involved, and the laboratory. Capital Pathology, the public laboratory in the Australian Capital Territory, notified the PHEOC/PHRB directly, initially through secure electronic faxing, and then through ELR. PHUs located near state borders often had pre-existing relationships with interstate laboratories, with mechanisms for positive result notifications. The PHU would then notify the PHEOC/PHRB of this new case. In addition, the laboratories notified their own state public health authorities of any new confirmed cases. These authorities would then notify the PHRB Surveillance Officer via email, at a minimum.

Case and contact information

Various additional information about cases and contacts was collected by the surveillance system. This originated from a wide range of sources.

All new confirmed COVID-19 cases physically located in NSW were interviewed. Most cases were interviewed by the PHU with a jurisdiction corresponding with the residential address of the case. This was conducted over the telephone, and covered questions regarding demographics, clinical details and information regarding potential settings of exposure, onward transmission and broader community risk. The PHU was responsible for collecting this information using the Initial Case Interview Questionnaire form, and for entering the data from this form into the relevant fields in NCIMS. These electronic fields could be updated as needed during the public health management of each case. If the PHU did not have sufficient capacity to carry out initial case interviews in a timely manner, they could request assistance from the PHRB. At the PHRB, initial case interviews may be carried out by members of the Operations Team or the Close Contact Tracing Team (CCTT), with data entry by the Operations Team or the Epidemiology Team (most commonly the Data Quality Team within the Epidemiology Team).

In the event of a newly confirmed case having a residential address outside of NSW (for example, an interstate resident physically located in NSW hotel quarantine), the initial case interview was conducted by the PHRB CCTT. This information was collected using the NSW COVID-19 Initial Case Interview Questionnaire form, which was then passed onto the Data Quality Team for entry into the corresponding digital fields in NCIMS.

Close household contacts were identified at the initial case interview. This information would be entered at the same time as the rest of the initial case interview information. The PHU would then carry out the initial telephone interviews of close household contacts, entering this information into the relevant fields in NCIMS, as well as scanning the Close Contact Interview Questionnaire form into NCIMS. For close contacts from schools, workplaces or other venues, the PHU liaised with an appropriate contact person at the venue to obtain a list of people who met the close contact criteria for that exposure. When this list was compiled, it was emailed to the PHRB CCTT, who conducted close contact interviews for these groups. From the information on the Close Contact Interview Questionnaire form, the PHRB Data Quality Team (DQT) completed the relevant electronic fields in NCIMS.

Additional information obtained in the management of a case or a contact can also be entered into NCIMS as free text, in the “notes” section found in every COVID-19 event. Depending on the individual case, there could be a range of sources of information for this additional information. These sources included:

- Other PHRB Teams, such as the Exemptions Team: Provided information on whether an individual was exempted from hotel quarantine or other restrictions.
- Healthcare providers, including hospital staff, general practitioners (and other primary health staff), health staff at quarantine hotels, specialists, NSW Ambulance: Provided additional clinical information, as required. PHUs may access hospital information either digitally, through electronic medical records systems, or verbally, through telephoning the relevant treating team. For timely notification of major clinical developments, such as deaths, PHUs often relied on proactive communication from staff providing clinical care.

- Patient Flow Portal (PFP): This was an internal website managed by the Health System Information and Performance Reporting Team in NSW Health. It was accessible to the Surveillance Officers in the PHRB Epidemiology Team, who used it to determine the location (general ward versus intensive care) of admitted COVID-19 cases in public hospitals in NSW. In some instances, new hospital deaths in COVID-19 patients may also be displayed for a short time on this website.
- Other State agencies, such as NSW Police, the NSW Department of Education and Training (DET) or the NSW Department of Transport: NSW Police provided information such as whether an individual was in a police-managed quarantine hotel or in police custody. The NSW DET provided details on any school or child-care related details for children and education staff, including class lists. The Department of Transport provided information on public transport services taken by cases.
- Airlines and other transport companies: Passenger manifests may be provided.
- Australian Border Force: Provided information on cases or close contacts who posed specific concerns regarding international travel.
- Australian Defence Force: Provided information on cases or close contacts who were members of the Australian Defence Force.
- Public venues, including (but not limited to) restaurants, performance venues, gyms: These venues provided customer or attendance data to facilitate contact tracing.
- Workplaces: Provided lists of work locations and workplace close contacts of confirmed cases.
- NIR and interstate public health authorities: Provided information on any interstate or international exposures or close contacts, and any venues of concern in other jurisdictions.
- The COVIDSafe mobile application: For some cases who had this application installed on their mobiles, and who consented to their COVIDSafe data being accessed, this was an additional source of information(21). It provided a list of mobile numbers belonging to other individuals who also had this application on their mobiles, and who were in the vicinity of the case for more than a designated length of time. This information was accessed through a specific web-based portal by the PHRB Team or PHUs, and each potential contact on this list needed to be checked manually.

The Whispir platform was another source of information systematically used for many of the cases and known close contacts (Ref: Internal document). This was a tool for sending and receiving automated SMS messages to conduct symptom checking (further details in the "Information Management System section").

Additional laboratory results

A number of other, non-diagnostic COVID-19 laboratory results were also stored within the NSW COVID-19 surveillance system. These included results from non-diagnostic SARS-CoV-2 PCR testing ordered to monitor known cases, SARS-CoV-2 serology, viral culture or whole genome sequencing (WGS).

Additional, non-diagnostic PCR testing and serology results for an individual would enter NCIMS following the same processes as for diagnostic PCR results. Positive results would trigger the same automated notification processes in NCIMS, which would prompt a staff member to view this result and make a decision on whether this was a subsequent notification for a known case. The CDNA provided guidance in the COVID-19 SoNG about case classifications for individuals whose previous COVID-19 infection was only detected through serology.

SARS-CoV-2 viral culture was requested on some occasions during the NSW COVID-19 response. However, this was not undertaken for surveillance purposes, and was not considered as part of this evaluation.

Whole genome sequencing for SARS-CoV-2 was performed more routinely during the NSW COVID-19 response. This information was sent from ICPMR to the PHRB Epidemiology, Operations and Laboratory Liaison Teams in the form of a weekly WGS Situation Report. This weekly report contained a summary of the WGS carried out in the past week, and described new findings from the perspectives of individual cases, clusters and viral genomic evolution. These findings were also discussed in a weekly WGS teleconference attended by PHRB and ICPMR staff. Any relevant outcomes from the report and teleconference, from a case and cluster management viewpoint, were usually entered into NCIMS by PHRB Operations or Epidemiology Team members, or staff from the relevant PHU, often in inconsistent locations and formats. To improve data quality, a line list of COVID-19 WGS sample details and results was sent to the PHRB Laboratory Liaison Team and Data Quality Team (DQT) on a regular basis. The DQT staff checked each sample on the line list against the relevant NCIMS event. They then entered the WGS result in the “Labs” section of the corresponding NCIMS event, following a set of standard guidelines about the format and location for this information. The DQT had not always been given the task of data entry for WGS results, and extensive retrospective data entry and cleaning were needed when the team was first assigned to this role.

Population level information

Other inputs into the surveillance system included population level information generated from surveillance activities outlined (see “Surveillance activities and strategies” section and Appendix 1). This information included syndromic surveillance data from the NSW Public Health Rapid Emergency Disease and Syndromic Surveillance (PHREDSS) system, hospital bed occupancy monitoring by the Health System Information and Performance Reporting Team, influenza-like illness monitoring from the HPNSW CDB, influenza sentinel laboratory testing data collected by HPNSW CDB, and sewage sampling results from the HPNSW EHB. HealthStats NSW, another team in NSW Health, also provided some advice on denominator statistics for specific population groups.

Additional aggregated data, although not at a broader population level, originated from sources that carried out international border surveillance activities. This included information on international passenger and vessel arrivals, both by air and by sea, supplied by the Australian Border Force and the Australian Department of Agriculture and Water Resource. The health screening teams at ports of international entry into NSW provided daily updates on the number of passengers who underwent symptom screening, or were transferred to healthcare facilities on arrival (see Appendix 1 for more information). Staff from the Sydney and South Eastern Sydney LHDs emailed updates on the number of individuals in quarantine hotels, and the number of COVID-19 tests performed at quarantine hotels each day.

Data linkage

The NSW COVID-19 surveillance system interfaced with some of the other databases within NSW Health through data linkage activities. The main linkage was with the Admitted Patient Data Collection (APDC) that was maintained by the Centre for Health Record Linkage (CHeReL)(22). The APDC contained demographic data on all patients admitted to both public and private hospitals within NSW up to June 2019, and only public hospitals from June 2019 onwards. Demographic information was recorded for each patient in the APDC, as well as hospital admission details including diagnosis and procedure codes, length of stay and discharge destination. Hospitals transmitted this data to the CHeReL at regular intervals. However, due to the steps involved in this process, there was on average a three-week delay between the hospital sending the data, and the appearance of this information in the APDC.

Data linkage between the NSW COVID-19 surveillance system and the APDC commenced in March 2020. It was carried out by members of the PHEOC/PHRB Epidemiology Team. Linkage occurred weekly until May 2020. Given the decrease in new cases at that point, and given that the process of data linkage was resource-intensive, it was decided to decrease the frequency of linkage with the APDC to every three weeks. As part of this data linkage process, all COVID-19 person events in NCIMS were matched to any corresponding individuals in the APDC. Statistical analyses for COVID-19 reporting were then performed on this combined dataset, on variables relating to demographic sub-groups, geographical locations, hospital admissions, level of care required. This database linkage activity was particularly useful for obtaining denominator data for COVID-19 diagnostic testing among Aboriginal and Torres Strait Islander people, in order to answer questions such as testing rates among Indigenous groups.

The Emergency Department Data Collection and the NSW Ambulance dataset, also from the CHeReL, supplemented the APDC in providing additional information about individuals captured by the COVID-19 surveillance system. A linkage between these datasets and NCIMS, involving all individuals in NCIMS with a COVID-19 event, was also performed every three weeks.

Another database that the COVID-19 surveillance system links to is the Stafflink Database, maintained by eHealth NSW. This was a database of all employees within NSW Health, including the public hospital system, public community services, and Ambulance NSW. It did not include private facilities. Each employee was assigned a unique Stafflink identification number. This database contained information on the role(s) and work location(s) for each employee and their pay grade.

Linkage between the NCIMS and Stafflink database occurred once in June 2020. This process was carried out by the PHRB Epidemiology Team, who matched the COVID-19 dataset in NCIMS against the Stafflink database. Analyses were then carried out with this combined dataset. These analyses obtained statistics such as testing rates among healthcare workers, and also allowed many of the errors in the data entry of healthcare worker cases to be identified and rectified manually.

As at November 14, 2020, there had not been any further data linkage exercises between the NCIMS and Stafflink databases. It was felt that the changes in the data entry processes in NCIMS would lead to better completion of the high risk occupation fields. As well as this, the publication of weekly healthcare worker reports by the PHRB was thought to have raised awareness at the PHU level about improving data entry for healthcare worker cases in NCIMS.

Data storage and management

Most of the data in the NSW COVID-19 surveillance system were stored in NCIMS (see “Information management system” section). Additional locations containing surveillance information included:

- NSW Health network directories (digital, password-protected): This was where most of the digital files of the PHEOC/PHRB were stored, outside of NCIMS. In particular, population-level information was stored here, as NCIMS was designed to capture individual or cluster events.
- Content Manager (digital, password-protected): This was an application available on the NSW Health network. Content Manager was the designated filing location for important NSW Health digital documents, with specific processes for creating new folders and filing locations.
- Email inboxes (digital, password-protected): All staff members in NSW Health were given personal NSW Health email accounts, created as part of the recruitment processes. There

were also shared email inboxes among various teams in the PHEOC/PHRB. Both team and personal email inboxes often contained surveillance information that had not yet been downloaded and filed into the relevant network drive or Content Manager folders.

- Microsoft Teams/SharePoint and Microsoft Azure (digital, password-protected): These were online platforms where information relevant for the operation and maintenance of the NSW COVID-19 surveillance system, including software coding, was stored. There was no identifiable information related to cases or contacts in these locations.
- PHEOC/PHRB whiteboards (physical): Cluster diagrams and transmission trees were often sketched physically on whiteboards at the PHEOC/PHRB.
- PHU locations (digital and physical): This varied by PHU, and depended on local processes.

The PHEOC/PHRB Epidemiology Team was responsible for the management of the surveillance data in NCIMS. This included managing the deduplication workflows to remove duplicate records, and other data cleaning tasks. Initially in the COVID-19 response, assistance in terms of human resources was required from the HPNSW Communicable Diseases Branch. This led to the creation of the Data Quality Team within the Epidemiology Team in June 2020.

Initial basic analyses of the data for confirmed cases were carried out by members of the PHRB Epidemiology Team. This usually involved an assessment of the quality of the clinical and exposure venue location for each new case, to facilitate accurate daily reporting of NSW cases.

System outputs and dissemination

Outputs for internal use: for NSW COVID-19 surveillance staff only

Certain outputs of the NSW COVID-19 surveillance system were only shared among staff members who were part of the surveillance system. This included direct access to the information within the COVID-19 part of NCIMS.

In the initial months of the pandemic, NCIMS had the functionality to generate a range of line list reports for COVID-19. However, as the number of cases increased, the technological resources required to perform these procedures were excessive, preventing other network users of NCIMS from carrying out tasks in a timely manner simultaneously. Subsequently, much of this functionality was disabled in NCIMS in April 2020, such that only a reduced range of specific COVID-19 reports could be run from NCIMS directly. To allow other reporting activities, the PHRB Epidemiology Team generated a reporting dataset on a daily basis, from the data tables in the back end of NCIMS. This reporting dataset was sent to PHUs to facilitate their data analysis and reporting. The reporting activities of PHUs varied depending on local needs. The data completeness snapshot (also known as the data completeness report) was also generated periodically by the PHRB Epidemiology Team from August 2020 onwards. This was a line list of confirmed cases with incomplete data fields, sent to PHUs to assist PHUs with identifying data management priorities.

To extract the surveillance system data for these outputs, the PHEOC/PHRB Epidemiology Team staff wrote programs, using statistical analysis software such as R and STATA, that linked directly to the data tables in the back end of NCIMS. Many internal analyses were performed on the surveillance data by the Epidemiology Team. This included monitoring a range of data indicators to detect unexpected events in both COVID-19 transmission activities and surveillance system processes. Analyses performed for the weekly NSW COVID-19 Surveillance Reports were also reviewed internally among the Epidemiology Team before publication. Other internal reviews, usually involving both the Epidemiology and Operations Teams, included discussions about clusters and sources of infection acquisition, the classification and management of contacts, and the findings of whole genome sequencing. Where relevant, PHUs and other teams in the surveillance system also participated in these discussions.

Outputs for internal use: for broader NSW Health audience

A number of outputs from the NSW COVID-19 surveillance system were shared with other teams within NSW Health, but outside of the surveillance system. This included other teams in the PHEOC/PHRB that did not have surveillance roles.

The Epidemiology Team provided information to the whole of PHEOC/PHRB on several occasions every day. Initially in the COVID-19 response, PHEOC briefings took place three times daily. In June 2020, it was decided to replace the evening briefing with an internal review meeting attended by a reduced audience. The PHRB morning and afternoon briefings took place over teleconference. They were attended by PHRB staff, and were open to attendance by State Health Emergency Operations Centre (SHEOC) staff. PHU staff were invited to morning briefings. The purpose of these briefings was to discuss new cases and to update all relevant teams about any cluster investigations and PHRB activities that had taken place. Staff from the Epidemiology Team usually provided an update on the latest cases notified to the surveillance system. This information, in a de-identified format, was also displayed on the internal briefing dashboard created by the Epidemiology Team.

The evening review meetings occurred at 18:30, after the automated NCIMS reporting cut-off time. They were attended by the Incident Controller and Deputy Incident Controller on duty, the Manager of the Operations Team, members of the Epidemiology Team on duty, and representatives of the Media Team. The purpose of these meetings was to review the total number of new and reclassified cases reported to the surveillance system in the 24 hours prior, verifying that the nightly reporting of case numbers and transmission settings were consistent between teams. This also ensured that the PHRB executive were aware of all significant issues that had arisen during the day. In addition, these meetings facilitate discussion about the most appropriate strategies for public communication about the latest cases and local developments. The outcomes of this review meeting were used as one of the information sources for the daily Situation Report produced by the PHEOC Planning Team / PHRB Operational Policy Team, and circulated to a set distribution list of stakeholders within NSW Health.

Information from the surveillance system was also shared daily with Ambulance NSW, and weekly with the NSW Health COVID-19 Critical Intelligence Unit. Ambulance NSW received a daily line list of new confirmed COVID-19 cases from the surveillance system. The Critical Intelligence Unit received a set of weekly COVID-19 statistics to contribute to the NSW Health Risk Monitoring Dashboard. There was also a daily automated NCIMS feed of all confirmed COVID-19 cases that was sent to the Health System Information and Performance Reporting Team, in order to allow cross-verification of the data in the Patient Flow Portal (PFP).

Data from the surveillance system were distributed on an as-needed basis to medical experts in NSW Health when expert panels were convened by staff in the NSW COVID-19 response. Population information in the surveillance system, such as syndromic surveillance or sewage surveillance data, was also shared and discussed initially with specific teams in NSW Health prior to any decisions for external release.

Outputs for external distribution

Daily outputs:

The PHRB Epidemiology Team provided daily updates to audiences external to NSW Health, on new case numbers and a range of summary statistics. This information was reported to the NSW State Premier via PHRB executive staff between once daily and three times daily, depending on the requirements of the response. It was sent once daily to the Communications and Media Teams for release to the public. These once daily case and testing numbers were based on the outcomes of discussions at the PHRB evening review meetings. This information was used for the creation of media and social media content, including the nightly NSW Health website COVID-19 statistics update at 20:00, and other online information for general public perusal. These data also informed daily video briefings to the public by PHRB executive staff.

In addition, the Epidemiology Team emailed a daily summary of relevant case, testing and public health action statistics to the NIR, as part of the national COVID-19 surveillance system. This was completed manually by the Surveillance Officers, using a reporting template supplied by the NIR. The NIR stipulated the definitions of most of the metrics in this template. However, the definition of the "active cases" and "recovered cases" fields were completed according to the definitions of each State or Territory public health authority. The numbers reported by each State were incorporated into national counts and online displays, including the dashboard found on the Australian Government Department of Health COVID-19 website. This was supplemented by an automated, deidentified and encrypted extract of new cases of all notifiable conditions sent nightly from NCIMS to the NNDSS. This line list was a pre-existing component of the notifiable conditions surveillance system in NSW.

Other daily external outputs from the surveillance system included a line list of all confirmed cases currently required to undergo isolation, supplied to NSW Police through approved channels, and by prior agreement in terms of the scope of use of this document. A list of new confirmed cases for the day was also sent to a designated email account at NCIRS, to facilitate research activities. The NSW Data Analytics Centre, a state government department external to NSW Health, used the data received from the surveillance system each weekday as one of the sources to update the publicly available COVID-19 cases, tests and case locations datasets.

Weekly outputs:

The Epidemiology Team published a weekly surveillance report for public release(12). The report contained statistics on multiple topics related to COVID-19, including cases, transmission clusters, testing statistics, sewage surveillance results, and data from syndromic monitoring for influenza-like illness. It also included analyses performed on these data by the PHRB Epidemiology Team. Interpretations in plain English were supplied, to facilitate public understanding of the information presented. The reports were initially circulated internally for feedback among PHRB and PHU staff and the Chief Health Officer, before they were uploaded to a public website.

The PHRB Epidemiology Team also had weekly reporting obligations to the NIR, in terms of updates on transmission clusters and on new healthcare worker infections.

Outputs without regular time intervals:

The PHRB Epidemiology Team responded to media and other external enquiries about COVID-19 data whenever they arose. When venues of concern for disease transmission were identified, this was discussed at the evening review meetings, and any relevant surveillance information was then sent by the Epidemiology or Operations Teams to the Communications and Media Teams for public release, through a range of media and social media channels. A similar process was followed after each COVID-19 detection through sewage surveillance that was deemed to be of concern.

Whenever new cases with interstate or international concerns arose, relevant information was distributed to the relevant interstate public health authority, or to the NIR.

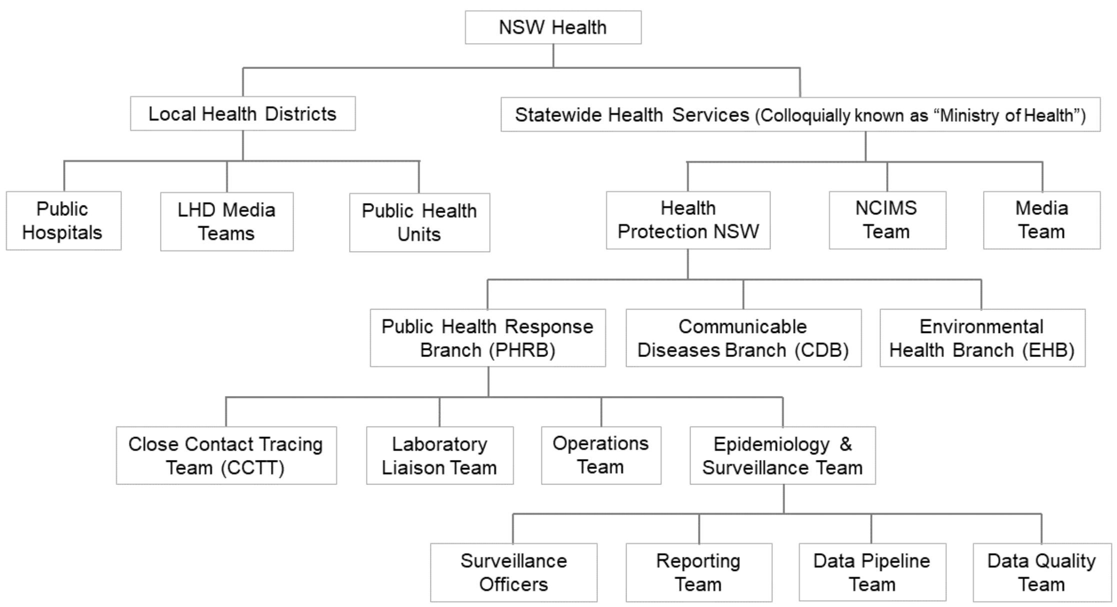
In addition, some of the weekly surveillance reports were accompanied by supplements of special analyses. These analyses ranged from transmission and infections in specific populations of interest, such as pregnant women or Aboriginal and Torres Strait Islander people, to specific statistical approaches, such as survival analyses based on recovery data.

External research organisations could submit data requests to access NSW COVID-19 surveillance data for academic purposes. This was supplied on a case-by-case basis. Both external organisations and other departments within NSW Health could also apply to the PHRB Epidemiology Team to access the NCIMS COVID-19 linkage dataset, available through the NSW Centre for Health Record Linkage (CHeReL). As at November 2020, there were various academic works published by external researchers that use data collected by the NSW COVID-19 surveillance system.

Resources used to operate the surveillance system

Human resources

Figure B6 - Organisational chart of the NSW COVID-19 surveillance system



The human resources within the NSW COVID-19 surveillance system could be divided into staff members within the PHEOC/PHRB, staff members in other statewide services of NSW Health, and staff members in LHDs (Fig B6).

There had been significant changes in the composition of COVID-19 response staff in NSW during the time period examined by this report (Ref: Internal document). In the week of 3-9 February 2020, there were a total of 60 staff members across all PHEOC teams, with 96% of these staff members recruited from other teams within the statewide services. Recruitment from outside the statewide services took place over the following months, with new staff entering the PHEOC Surveillance Team and subsequently the PHRB Epidemiology Team. In the week of 23-29 May 2020, prior to the transition from PHEOC to PHRB, 59% of the 229 PHEOC staff members were from within the statewide services. In the week of 21-27 September 2020, 29% of the 464 staff members working across all the PHRB teams had originally been staff in the statewide services. Data were not available for the composition of specific PHRB teams.

PHRB Epidemiology Team

The PHRB Epidemiology Team was the primary team responsible for updating, cleaning and maintaining the data within the NSW COVID-19 surveillance system, with a focus on, but not limited to, NCIMS. In addition, team members performed a range of epidemiological analyses on these data, disseminating the results of the analyses through various channels. This team began as part of the PHEOC Operations Team in January 2020. One staff member was rostered as the Surveillance Officer within the Operations Team each shift. With the expansion and reorganisation of the duties performed by the Surveillance Officer, a separate PHEOC Surveillance Team was formed in March 2020. At the time of the changeover of the COVID-19 pandemic response structure from the PHEOC to the PHRB in June 2020, the Surveillance Team was renamed the Epidemiology Team, to reflect the new priorities of the team. Also at this time, the structure and roles within the team were defined more clearly.

As at November 2020, the Epidemiology Team was overseen by one full-time Manager and four Deputy Leads. The Manager of the PHRB Epidemiology Team was also the NSW representative to the NSC. Within the Epidemiology Team, staff members were divided into subgroups: Surveillance, Reporting, Data Pipeline and Data Quality. One or two Team Leaders were appointed for each of these subgroups. Members of the Epidemiology Team carried out the majority of their COVID-19 tasks from the Ministry of Health building. However, the option of working from home was available for team members, with the exception of the Surveillance Officer role.

The PHEOC Surveillance Officer role was originally filled by a pool of nine staff members, drawn from HPNSW. As at November 2020, the Surveillance Team consisted of ten full-time and part-time staff members, with most of these staff members recruited from outside of HPNSW specifically for this role. Members of this team filled the PHRB Surveillance Officer role following a rotating roster system, with two shifts per day staffed by one Surveillance Officer each. This meant that there was a Surveillance Officer on duty seven days per week from 8am to 10pm.

The primary role of the Surveillance Officer was to be the designated first point of contact for all new case notifications. At this point, the Surveillance Officer took note of any demographic and risk group details of each new case, including their physical location (such as hotel quarantine, aged care facility, hospital intensive care unit), age (such as school aged children or elderly), and race or ethnicity (such as Aboriginal and Torres Strait Islander or CALD groups). There was an initial investigation using the surveillance data into any potential sources of infection, including whether the case was already linked to another known case or outbreak cluster, or whether an airport swab was collected. The Surveillance Officer ensured that this new case was recorded accurately in NCIMS, and that all relevant teams were informed, including public health authorities in other States and Territories where applicable.

Additional roles of the Surveillance Officer included cross-checking a range of data sources several times per shift to ensure that all new cases detected by the laboratories had been alerted to the surveillance system. These data sources included automated workflows on NCIMS, line lists from laboratories, and email correspondence from Public Health Units, other PHRB teams and interstate public health bodies. The Surveillance Officer was responsible for monitoring the PHU follow-up actions for the COVIDSafe mobile application, tracking known COVID-19 cases in intensive care units (ICUs), and entering venues of concern and daily Sydney Airport screening details into the appropriate shared Epidemiology Team spreadsheets. He or she was also involved in reporting, by presenting at PHRB briefings, assisting with daily NSW COVID-19 Situation Reports, submitting the daily NSW response statistics to the NIR, and sending daily line lists to stakeholders such as Ambulance NSW and the Police Operations Centre Liaison Officer (POCLO) at the SHEOC. The Surveillance Officer assisted with some of the larger reporting tasks of the Epidemiology Team, such as the weekly Surveillance Reports. The Surveillance Officer also had a liaison role between the PHUs and the rest of the Epidemiology Team.

In order to carry out these tasks, the Surveillance Officer needed to be a confident NCIMS user. In addition, the Surveillance Officer needed to be able to use external information systems such as the Patient Flow Portal and the web portal of the COVIDSafe mobile phone application. The initial group of Surveillance Officers came from HPNSW, and were already proficient in using NCIMS through their work with other notifiable conditions. New Surveillance Officers were trained through shadowing existing Surveillance Officers for several shifts, and through being provided with NCIMS data entry guides and the Surveillance Officer Standard Operating Procedures for reference.

The roles of the Reporting Team were to synthesise COVID-19 data for routine reporting tasks (see "System outputs and dissemination"). This team also supported the PHRB by providing data on request, such as written responses to media queries, or line lists of cases and contacts within outbreak clusters. These tasks were initially performed by the PHEOC Surveillance Officer from January to March 2020. From March 2020 onwards, the increase in the volume of data and the complexity of reporting led to the need for reporting using programs written within statistical packages external to NCIMS. To facilitate this process, the Reporting Team was established. As at November 2020, there were eight staff members in the Reporting Team, rostered for shifts seven days per week. All members of this team had proficiency in using statistical software.

The Data Pipeline Team was responsible for importing laboratory results into NCIMS. For results received from non-ELR laboratories, this entailed reorganising line list data into a format that could be uploaded into NCIMS in batches. The Data Pipeline Team consisted of six staff members, as at November 2020. Team members were rostered from 8am to 4pm, seven days per week, with an additional staff member on call from home from 7pm until 9pm, five days per week. Members of this team had all received additional training in the back end operations of NCIMS.

The Data Quality Team (DQT) initially commenced as two separate subgroups within the Epidemiology Team in March 2020: the Workflow Management Team and the Data Entry Team. Over time, the tasks and responsibilities of these teams became better defined, and a decision was made in June 2020 to combine the teams. The primary role of the DQT was to ensure that the relevant data fields in NCIMS were as complete and accurate as possible. As part of this, one of the main tasks was working through the data quality workflows automatically generated by NCIMS. These workflows included COVID-19 events that were determined by NCIMS algorithms to have potential inconsistencies. Each of these events were reviewed individually by the DQT, and any errors were corrected manually. Another of the principal tasks of the Data Quality Team was to enter close contact data gathered by the CCTT into NCIMS. Additional tasks included assisting with general data entry in NCIMS, and managing line list spreadsheets of diagnostic testing data from the hotel quarantine system. As at November 2020, there was one Team Leader, and 14 other members in the team. The team was staffed seven days per week.

Other PHRB teams

Within the PHEOC and the PHRB, several other teams also contributed to COVID-19 surveillance activities. Of these, the most pertinent to pandemic surveillance were the Laboratory Liaison Team and the Operations Team.

The Laboratory Liaison Team was responsible for linking between the PHRB and both public and private diagnostic laboratories. The team was the first point of contact for PHRB teams when there were queries about the interpretation of laboratory results. Team members liaised with ICPMR, the reference laboratory, when there were indeterminate samples that required re-testing or additional testing. In the initial months of the pandemic response, the team also assisted with establishing the process for referring samples for whole genome sequencing (WGS) at ICPMR. When particular geographical areas were identified for increased testing, the Laboratory Liaison Team collaborated with NSW Health Pathology to organise additional temporary testing sites. In addition, the team coordinated testing and specimen transport for people in hotel quarantine, or in special situations such aged care facility outbreaks. Another important role of the Laboratory Liaison Team was to assist new diagnostic laboratories with establishing processes to notify the PHEOC/PHRB of SARS-CoV-2 test results. As well as this, the team also assisted existing non-ELR laboratories to implement ELR processes. The Laboratory Liaison Team had eight staff members as at November 2020. Most of this team worked between 8am to 4pm Monday to Friday, with one person rostered as the evening cover, working 2pm to 10pm. Each day on weekends, there was one person rostered for a daytime shift, and one person rostered for an evening shift.

The Operations Team was responsible for coordinating and carrying out investigations and public health actions in response to the notification of new cases. It supported PHUs in conducting initial case interviews and collecting close contact information, and following up cases and contacts in isolation and quarantine. The team conducted investigations both into individual cases, in terms of likely exposures, and into clusters of cases, in order to describe chains of transmission. The Operation Team ensured that relevant cross-jurisdictional information about cases and clusters were communicated to other PHUs in NSW and to interstate public health authorities. The team also communicated with external stakeholders, such as the NSW Department of Education and Training (DET) for actions involving schools. In the event that there were uncertainties about public health actions to be undertaken, or about the classification of indeterminate cases, the Operations Team was responsible for convening expert panel meetings to reach a verdict. As at November 2020, the Operations Team was staffed by one Manager, one Deputy Manager, one Administration Officer, a pool of nine experienced staff members who were rostered for Team Leader shifts, and a pool of 25 other staff members who were rostered for general operations shifts. There were two shifts per day, 8am to 4pm and 2pm to 10pm, seven days per week.

The PHEOC/PHRB executive staff, consisting of the Incident Controller, Deputy Incident Controllers and Medical Advisors, provided directions and support to the COVID-19 surveillance staff, but did not participate in surveillance tasks. Therefore, in this report they are not considered to be surveillance system staff. This was also true of other teams in the PHEOC/PHRB not already mentioned.

NCIMS Team

The NCIMS Team was a pre-existing group within the MoH before the activation of the PHEOC. The team was responsible for carrying out ongoing updates and maintenance of NCIMS. Additionally, the team supported other MoH teams in using NCIMS by providing training resources, answering queries and troubleshooting. In collaboration with other MoH teams, and with assistance as required from the Maven vendors, the NCIMS Team made changes and built new functionalities in NCIMS according to organisational need. The NCIMS Team also took on a coordinating role in PaNCIMS in 2017, a simulation exercise described in the "Information management system" section.

At the commencement of the NSW COVID-19 pandemic response, the NCIMS Team collaborated with PHEOC staff to enable the entry, storage and retrieval of COVID-19 data in NCIMS. Since the initial creation of COVID-19 as a notifiable condition in NCIMS, the NCIMS Team had made significant ongoing changes and refinements in the COVID-19 capacities within the information system. This included continued adaptations to the architecture and processes in the back end of NCIMS to accommodate the increase in the volume of COVID-19 data.

The NCIMS Team was physically located within the central MoH building. However, team members were able to work remotely. Initially, prior to the commencement of the COVID-19 response, there were two full time staff members in the NCIMS Team, who worked five days per week, between the hours of 9am and 5pm. From late March 2020, the team expanded to include five staff members, working 8am to 10pm across two shifts, seven days per week. As at November 2020, team members were rostered to work seven days per week, from 8am to 10pm across two shifts on weekdays, and for four hours each day of the weekend. Team members all have proficiency in software programming languages. Training to new staff members on performing specific tasks in the back end of NCIMS was given by existing team members.

Media Team

The NSW MoH Media Team was also pre-existing prior to the COVID-19 response. Its functions were to address and coordinate media enquiries and interviews for the whole of the MoH. In addition, the team was responsible for media conferences and releases in relation to the activities of MoH and events of public health significance.

Specific members of the MoH Media Team were allocated to the COVID-19 response. As at November 2020, there were five members of this team dedicated to COVID-19 full-time. In addition, two of the Directors of the Media Team were involved in the activities of the PHRB.

In addition to the MoH Media Team, LHDs also had their own Media Teams that could contribute to the surveillance system in terms of disseminating the relevant outputs of the surveillance system to the local population.

Public Health Units

Public Health Units were primarily responsible for the management of individual COVID-19 cases and household close contacts. Cases were assigned to PHUs based on their residential address. The geographical area for which each PHU had jurisdiction was pre-determined prior to COVID-19, and was the same for other diseases within the NSW notifiable conditions surveillance system. Some PHUs held additional responsibilities in the statewide COVID-19 surveillance system. For example, the Randwick PHU had leading roles in airport and cruise ship surveillance, while the Camperdown PHU had significant involvement the special health accommodation (SHA) process.

In terms of human resources, each PHU had its own organisational structure, and was responsible for ensuring that there was enough surge staff available in the event of a major outbreak. Most PHUs had staff members with training in epidemiology, who could perform analyses on data specific to their geographical jurisdiction. As at November 2020, there had not been a formal count of the exact number of additional COVID-19 surge staff employed across all PHUs.

Other HPNSW Teams

Teams within the two other branches of HPNSW also contributed human resources towards the NSW COVID-19 surveillance system. The Communicable Diseases Branch (CDB) monitored for influenza-like illnesses, especially in aged care facilities, and often liaised with the PHRB to ensure that appropriate testing for both COVID-19 and other respiratory viruses had been undertaken in institutional respiratory outbreaks. At times of high workload, CDB staff members provided data management support in terms of addressing NCIMS data quality workflows and deduplications, and telephone interviewing assistance for close contact and recovery interviews. The Immunisation Unit within the CDB had been central to planning for surveillance related to COVID-19 vaccines.

The Environmental Health Branch (EHB) was also involved in the NSW COVID-19 surveillance activities through its Water Unit, which had a lead role in the Sewage Sampling Research Program. As well as this, senior staff members in the EHB assisted the PHRB through reviewing Public Health Orders, or staffing overnight public health on-call shifts.

Non-human resources

A range of non-human resources were also required by the NSW COVID-19 surveillance system. These resources can be categorised roughly into financial and material.

Financial resources

The NSW COVID-19 surveillance system was mainly funded through the budget of the NSW Ministry of Health (Ref: Personal communication with PHRB executives). It is not possible for this report to derive exact figures for the financial resources required for the NSW COVID-19 surveillance system for a number of reasons. Firstly, the NSW COVID-19 response is still ongoing, and continuing to adapt to the rapidly evolving course of the pandemic. This means that any estimates of the financial outlay of the system would be incomplete, and have a significant margin of error.

Secondly, it is not possible to demarcate definitively the financial resources required for the COVID-19 surveillance system, and those required for other COVID-19 response activities outside of surveillance. In addition, many of the pre-existing financial investments into the routine notifiable diseases surveillance activities in NSW contributed to the establishment and maintenance of the COVID-19 surveillance system. An example of this was the initial cost of creating NCIMS. Also, from a staffing point of view, there were a significant number of pandemic response staff members who worked in a combination of COVID-19 and non-COVID-19 roles. While there was some separation in the remuneration of staff members between their pandemic response and their other roles, it is less straightforward to account for the financial requirements for maintaining this workforce, especially given that a number of staff from HPNSW were already highly skilled in many of the information systems, and did not require additional training resources.

There was also a wide complement of diverse activities and actors in the NSW COVID-19 surveillance system. For the purposes of this evaluation, it would be difficult to account for all of them from a financial perspective.

Material resources

Similar to the financial resources in the NSW COVID-19 surveillance system, the material resources in the surveillance system were a combination of pre-existing elements already in the NSW public health structures, and new assets specific to the COVID-19 response. The technological resources in the surveillance system made up a significant part of the resources in both of these categories. In addition, there were resources that were used for the broader NSW COVID-19 response, and could not be attributed the surveillance system alone. Examples of these included the telecommunications resources used by the surveillance system, and the physical office spaces in which surveillance activities took place. Given these challenges, this evaluation does not attempt to enumerate all of the material resources required by the surveillance system.

However, an internal report from the NCIMS Team allowed insight into some of the technological resources required by NCIMS alone. As at November 2020, at the time where data collection for this evaluation was completed, there were seven active servers and three database servers used for

NCIMS. The database servers had each been scaled up since the activation of the COVID-19 response, in terms of processing capacity and memory.

Ethical considerations concerning the NSW COVID-19 surveillance system

Data and system security

The Notifiable Conditions Data Security and Confidentiality Policy Directive (2012) from NSW Health covered the security of all paper and electronic notification records in NSW, including NCIMS(23). Additionally, for NCIMS, the policies of Cyber Security NSW served as the overarching framework for the security measures in place. The most relevant policies were the NSW Cyber Security Policy and the NSW Cyber Incident Response Plan(24). Cyber Security NSW was the department of the NSW Government responsible for the security of digital information stored and used throughout State agencies and Ministries, including the Ministry of Health. NSW Health is also covered under the NSW Cyber Security Incident Emergency Sub Plan, endorsed by the NSW State Emergency Management Committee(25).

A formal NCIMS security assessment was undertaken in May to July 2018. This was initiated jointly by NSW Health and eHealth NSW, with the engagement of PricewaterhouseCoopers Consulting as external consultants (Ref: Internal document). This assessment resulted in 30 findings, which were reviewed and addressed by NSW Health and eHealth NSW.

The NCIMS Team was responsible for granting COVID-only access to NCIMS for new surge users in the COVID-19 response. This would always occur with the knowledge of a PHRB Deputy Controller or a PHU Director. This level of access would only allow the user to view and edit COVID-19 events. The list of existing NCIMS users was reviewed on a six-monthly basis by the NCIMS team, who liaised with team managers to identify any users no longer requiring NCIMS access. In addition to NSW Health staff, limited access to NCIMS was given to a team of researchers at the National Centre for Immunisation Research and Surveillance (NCIRS), to facilitate access to data for research.

The security of the interfaces between NCIMS and external data systems was considered to be of crucial importance to the NCIMS Team, and was analysed during the initial establishment of each interface. This was then monitored regularly and frequently for any breaches or potential breaches.

In addition to the security measures in place for NCIMS, other safeguards were in place to maximise the security of the data within the broader surveillance system. Staff at the PHRB carried out their work using MoH laptop or desktop computers. To use and access the files stored on these computers, a password login process was required. Authorised users were only able to access files on a number of shared network directories when connected the MoH internet network, including the MoH virtual private network (VPN). This authorisation for a staff member to access the shared directories was granted by network administrators within the MoH, after a formal request was received from the relevant team manager. Access was only given to the specific shared directories that were required for the tasks of the individual staff member. For example, the PHRB Operations Team members, with the exception of the Managers, did not have access to the Epidemiology Team shared directory. The team responsible for overseeing the security of MoH network directories was eHealth NSW.

At PHUs, access to the local LHD internet network was provided. Access to LHD network drives was possible remotely, through VPN. Staff who only worked in PHUs did not have access to the MoH network drives, nor to network drives outside of the LHD(s) where they worked.

NSW Health email accounts were accessible through both NSW Health internet networks and private networks. However, extra security measures were in place when signing into an NSW Health email account from an external network. In order to send identifiable information via email, secure file transfer was available using Accellion software.

Identifiable data were also sent to the PHRB by diagnostic laboratories, in the form of line lists of test results. Public diagnostic laboratories all belonged to NSW Health Pathology, and test result line lists were sent as spreadsheet attachments from email addresses within NSW Health. Some of these spreadsheets were password-protected, with the password sent in a separate email. Private diagnostic laboratories varied in their practices. All private laboratories emailed line lists of diagnostic testing results as spreadsheet attachments. However, not all private laboratories used password protection for these test result line lists. In addition to line lists, some private laboratories emailed scanned copies of pathology request forms and result printouts for positive results. These scanned documents were attached to the email as image files, and contained full name and contact details.

In terms of additional digital information storage locations, Content Manager was accessible to all users on the NSW Health network or VPN. All users could view all files on Content Manager, but only certain users had permissions to delete existing files, or to create specific types of file structures. The security of the coding and programming data on Microsoft Teams and Microsoft Azure was also important, because unauthorised alteration of these software codes and commands could have significant impact on the functioning of the system. Access to the relevant areas in each platform was managed by Team Leaders within the PHRB Epidemiology Team.

In terms of physical security measures, there was restricted access to the MoH building through an individual access card system. However, this did not prevent staff members in other branches of the MoH from entering the PHRB area of the building and viewing written documents or information on whiteboards and screens, or overhearing conversations or meeting discussions.

The verbal information shared in PHRB meetings and briefings was secured by sending teleconference invitations and access codes to NSW Health email addresses only. However, this did not prevent invitations from being sent in error to staff members in other areas of NSW Health. An additional security measure involved the PHRB Pandemic Response Coordination Team (formerly the PHEOC Logistics Team) verifying the identity of participants who had dialled into briefing teleconferences.

Privacy and confidentiality

As was the case for data security, the confidentiality of the NSW COVID-19 surveillance system was covered by the NSW Health Notifiable Conditions Data Security and Confidentiality Policy Directive (2012)(23). Additional guidance was provided by the NSW Health Privacy Manual for Health Information (2015)(26).

All NSW Health staff were required to complete an online training module on privacy and confidentiality. This training module covered accessing and working with sensitive or identifiable health data, and also provided guidance on the disclosure of identifiable information to external parties. In addition, as discussed, a signed Notifiable Conditions Data Security and Confidentiality Agreement was required for new staff to be granted NCIMS access.

Internal communications between staff within the NSW COVID-19 surveillance system were understood to be confidential information shared only with other staff members who required this information to carry out public health actions. There were frequent reminders from PHRB executive staff to this effect. Specific training was given for conducting external telephone calls, for example to cases and contacts, where callers were instructed specifically not to disclose information regarding other people during the conversation. Staff in the PHEOC/PHRB were instructed to remove all identifying information from documents prior to uploading to Content Manager. References to specific individuals were made using their NCIMS person event identification number.

Identifiable information was exchanged between the NSW COVID-19 surveillance system and other NSW Health departments, such as NSW Ambulance, NSW Health Pathology and LHD staff outside of PHUs. In addition, through prior agreement for the purposes of essential public health actions, identifiable information was shared with groups external to NSW Health, including the State Emergency Operations Centre (SEOC), the Police Operations Centre (POC), the National Centre for Immunisation Research and Surveillance (NCIRS) and other Australian State and Territory public health authorities. Staff in the NSW COVID-19 surveillance system were required to perform these tasks using predetermined protocols. For some external organisations, these protocols involved relaying information through approved liaison officers, such as the Police Operations Centre Liaison Officer (POCLO).

Information to be released from the NSW COVID-19 surveillance system through reporting activities or through the media required approval by the PHRB Controller or a delegate. This information was reviewed for several reasons, such as ensuring confidentiality. Cases and contacts were reported in a way that did not allow their identities to be inferred. Venues of possible transmission of infection were only named if this was deemed to be necessary for contact tracing. Where contact tracing was required for flights and other venues with assigned seating, the procedure was to identify people seated in the same row, and in the rows in front of and behind the index case, for the confidentiality of the index case.

De-identified information may have also needed to be shared with the NIR, for the purposes of international contact tracing. This was only undertaken if there was a clear indication to do so, and carried out centrally at the PHRB, with the knowledge of the Team Leader of the PHRB Operations Team. Otherwise, NSW jurisdictional data were sent to the NIR without identifying information. The automated nightly feed from NCIMS to the NNDSS was also de-identified.

Section C: Results

Introduction

The CDC guidelines focus on a number of parameters that are generally considered to be important for surveillance systems(10). These parameters were considered in the context of the NSW COVID-19 surveillance system, and discussed with some of the key stakeholders in the system. Those that were considered to be the most relevant were chosen for evaluation. The CDC attributes selected were: simplicity, flexibility, timeliness, data quality, acceptability, sensitivity and stability.

In addition, usefulness was examined as an independent, separate attribute. This was thought to be a more effective structure for organising the evaluation findings. In a pandemic response, determining the usefulness of the surveillance system would give important evidence about whether significant changes are needed to be made promptly.

In the planning process for the evaluation, it was felt that data security and confidentiality were additional important aspects of the system to consider. Therefore, questions covering these properties of the surveillance system were included in the stakeholder interview question guide.

Where stakeholders are quoted in this report, they are classified as either a PHRB or a PHU respondent. The small number of respondents from other state-wide MoH teams were classified as PHRB, so that they are less readily identifiable.

Simplicity

In the NSW COVID-19 surveillance system, simplicity relates to whether a range of everyday activities in the system are operating in a straightforward, user-friendly manner. For example, how easy it is for different teams to work together to carry out surveillance tasks and public health actions, and how easy it is for new notifications to reach the surveillance system and be followed up appropriately. In this evaluation, this is assessed through examining the simplicity of inputs into the system, the ease of communication between actors in the system, and the user-friendliness of NCIMS, the main information management system of the surveillance system. Responses were collected from interview respondents on their subjective experiences of the simplicity of some of these aspects of the NSW COVID-19 surveillance system.

Findings

Amount and types of data collected

In addition to case-based and test-based data recorded in NCIMS, data collected by the NSW COVID-19 surveillance system included a wide range of other inputs from a variety of sources. Not all these inputs have been stored in NCIMS.

Given the diversity of these COVID-19 data, and that some of these data were held by groups outside of the PHRB, it was not possible to quantify the data in the NSW COVID-19 surveillance system for this evaluation report.

Training provided for surveillance system staff

Many of the staff members in the NSW COVID-19 surveillance system had worked in communicable disease surveillance in NSW prior to the pandemic. Through these roles, they had received training in using NCIMS, and in responding to urgent public health events.

Pandemic preparation training took place regularly in the years prior to 2020. This involved teaching presentations within HPNSW, and to new public health trainees. PaNCIMS was a pandemic simulation exercise that took place in June 2017, involving both PHU and HPNSW staff. It was designed with the main purpose of trialling the use of NCIMS in a pandemic response setting, but also allowed staff from PHUs and HPNSW to experience and evaluate a range of other pandemic response processes.

Training during the pandemic response was provided to PHRB and PHU staff through a number of structured and unstructured channels. At the PHRB, in the initial months of the NSW COVID-19 response, new staff members were given training by their own teams. The first central orientation webinar for new PHRB staff took place on October 22, 2020, and subsequent orientation webinars were organised depending on the intake of new staff. PHRB staff members also organised PHRB-wide education sessions on topics related to COVID-19, delivered in a webinar format. Between the activation of the NSW COVID-19 response and November 14, 2020, there were six sessions of “Bunker Education”, later renamed “Lunchtime Labs Learning”, and subsequently “Lunch and Learn”.

PHUs were varied in the local level COVID-19 surveillance training that they provided to their staff members. Additionally, PHU staff were included in information sessions organised by the PHRB Epidemiology Team in response to major changes in case and close contact interview questionnaires and wizards.

Communication within the system

Communication between different teams working in the NSW COVID-19 surveillance system took place through a multitude of channels. In this evaluation, interview respondents were asked to provide their assessment of the effectiveness of general communication within the system.

Interview question: “How well do the different parts of the surveillance system communicate with each other (for example, between the PHRB and PHUs, between PHUs, between different teams in the PHRB)? Please give your answer as a rating from 1 representing ‘very poorly’ to 4 representing ‘very well’.”

Rating	Number of respondents (%) *N=20*
No rating given	3 (15)
4	4 (20)
3.5	4 (20)
3	4 (20)
2.5	2 (10)
2	2 (10)
1	1 (5)

The respondents giving ratings of 3.5 to 4 generally felt that there was a willingness from all teams to communicate with each other, and that there was effective use of technology to assist with communication.

"The SHEOC (State Health Emergency Operations Centre) people are participating in the PHRB briefings now, so they can see what's coming through in terms of new cases, which is good. In the past they've had to wait for the public release of numbers. But now in public communications, they can also frame things pre-emptively. We can brace people about what is coming." – PHRB respondent

"The people from the other PHUs and from the Ministry are all very willing to communicate and to share any useful information with each other. And when we meet, we use web conferencing technology whenever it's needed. For example, when we talk about a large cluster, it's shown on screen. That's been done well." – PHU respondent

"Because NCIMS is a web-based portal, everybody has access to the same information. It's one of the key strengths in our surveillance system, I think." – PHRB respondent

A range of concerns were raised by other respondents, with a focus on communication between different teams at the PHRB.

"In each team, there are only a select few people who understand the roles and functions of the other teams, and will know to involve certain people or certain teams in a particular task or response. So a lot of things happen without the right people being involved early on. They're often asked very late in the process. The whole task could have been easily solved if the right people had been engaged early on. I can think of many examples of not involving the right people in the upstream process, which has led to many delays." – PHRB respondent

The respondent who gave a rating of 1 was concerned about the risks in the current communication channels.

"All the key knowledge is held between several key people across the PHRB, like maybe just one or two people in each team. So if a few of these key people are away or not able to be contacted immediately, the consequences are pretty bad. The knowledge needs to be better dispersed within each team." – PHRB respondent

User-friendliness of NCIMS in general

The simplicity of NCIMS is assessed in this evaluation through examining specific processes within NCIMS, and through interviewing stakeholders. Stakeholder respondents were asked about the user-friendliness of NCIMS as a whole, and of specific functions in NCIMS. These functions included data entry, searching the system, and extracting information from NCIMS.

Interview question: "What is your general impression of the user-friendliness of NCIMS as a whole during COVID-19? Please give your response as a rating from 1 representing 'very difficult to use' to 4 representing 'very easy to use'."

Rating	Number of respondents (%) *N=20*
No rating given	3 (15)
4	5 (25)

3	6 (30)
2.5	3 (15)
2	3 (15)

Three of the respondents stated that they could not give a rating, because they did not use NCIMS at all in their roles. Out of the respondents who gave a rating of 4, three had used NCIMS to carry out public health surveillance tasks prior to the COVID-19 response, and felt that their ratings were likely to have been biased by their familiarity with the system. However, another one of these respondents was a member of the surge staff at a local PHU, and had never used NCIMS prior to her recruitment in the COVID-19 response.

"I read the NCIMS manual, and then the first time I was using it, a more experienced staff member sat with me just to enter the first part of the data. I do frequently ask other more experienced staff if I'm not sure of what I'm supposed to do in NCIMS. I get lots of help if I ask for it. And it helps that I only have access to COVID-19 so I don't have as many things to deal with. And I only do a small number of different things in the COVID response, so it can be quite repetitive and then you get used to those things." – PHU respondent

A range of concerns were raised by the nine respondents who gave the user-friendliness of NCIMS ratings of 2.5 to 3.

"Our main difficulty has been in the reporting. Because we're not supposed to generate line lists ourselves anymore, we've kind of had to give the reporting dataset to one of our local epidemiologists to look at with statistical programs. But he … doesn't have NCIMS access, so whenever he has questions he has to contact us. And sometimes all we want to do is something simple like to count the number of cases." – PHU respondent

"I think the main challenge with NCIMS is keeping up with the changes, especially when things get moved around and you don't know where they are anymore. Other than that though, it's not an extremely difficult system to use." – PHU respondent

The remaining three respondents gave the user-friendliness of NCIMS an overall rating of 2.

"When I first arrived, there was no real training or introduction. There was a lot of assumed knowledge because a lot of the colleagues around me had used NCIMS before, in their careers at the Ministry … Well, many of us who were brought in, we initially didn't know what the expectations were for some of the fields. And so we weren't using those variables and then later we had to go back and enter that data in retrospectively." – PHRB respondent

"It's quite a complicated system, and definitely needs more training than what's been provided. There are lots of traps for new users, for example around things like duplicate records and how to deduplicate them." – PHRB respondent

"The system is easy only if you understand data." – PHRB respondent

Data entry in NCIMS

The Initial Case Interview data entry wizard in NCIMS evolved over time to meet the changing data requirements of the pandemic response. Data entry guidance documents were drafted to assist staff members with understanding the requirements for each field, and to ensure that data coding was uniform across users. The first guidance document for the Initial Case Interview wizard, starting from March 18, 2020, was sent to PHUs by the PHEOC Surveillance Team, and was focused only on 2 mandatory fields and 6 optional fields where clarification was thought to be required (Ref: Internal document). The guidance documents were updated on a regular basis by the PHEOC Surveillance Team, as the format and the questions included in the Initial Case Interview wizard changed over time. Major updates occurred in April, May and June 2020 (Refs: Internal documents).

In late August 2020, Version 1.0 of the formal COVID-19 NCIMS Initial Case Interview Data Entry Guide was drafted, containing instructions and explanations for all fields in the Initial Case Interview wizard (Ref: Internal document). It was disseminated among PHUs and the PHRB Epidemiology Team in early September 2020. Version 2.0 of the COVID-19 NCIMS Initial Case Interview Data Entry Guide was dated October 1, 2020, and was still the most current version as at November 14, 2020, the end date of information collection for this evaluation (Ref: Internal document). The guide detailed the procedure for completing 16 data fields that were considered to be mandatory for all cases, 4 additional mandatory fields that for all locally acquired cases, and 18 additional optional fields in the Initial Case Interview wizard.

There were additional data fields in NCIMS for case information that were not included in the Initial Case Interview wizard, as they were thought to be less important to state-level analysis, reporting and operations. However, PHUs could choose to use these fields for their local COVID-19 response.

The Initial Close Contact Interview Wizard was a dedicated data entry wizard in NCIMS for close contact information. A data entry guide for this wizard was drafted by the PHRB Epidemiology Team in September 2020. This guide outlined the data entry requirements for each data field in the wizard. This included 1 automatically completed field, 15 mandatory fields for all close contacts, 4 fields that are only mandatory for close contacts who were not classified as household close contacts, 7 additional optional fields and 1 field that was to be completed by PHRB staff only.

Interview question: "How easy is it to enter COVID-19 data into NCIMS? Data entry could include completing the case or close contact wizard, uploading scanned questionnaires, manually entering laboratory results or writing progress notes in each event. Please give your response as a rating from 1 representing 'very difficult' to 4 representing 'very easy'."

Rating	Number of respondents (%) *N=20*
No rating given	5 (25)
4	6 (30)
3.5	2 (10)
3	4 (20)
2	3 (15)

Five respondents declined to give a rating for this process, stating that they were not involved in NCIMS data entry for COVID-19. Eight respondents gave ratings of 3.5 to 4, with three of them being new to NCIMS when they started work in the COVID-19 response.

"It's not difficult at all if you follow the data entry guide. I've personally never felt that it was a difficult task." – PHRB respondent

"We've tried to make the user interface as simple as possible. And so we use tools like the case wizards … That's evolved over time … I think given what's been expected of the surveillance data, I think we've probably got as best a balance as we can in having a simple user interface, but requiring a lot of very complex information for a lot of different purposes." – PHRB respondent

The seven respondents who gave ratings of 2 or 3 for the ease of COVID-19 data entry into NCIMS highlighted a number of perceived shortfalls in this process.

"A lot of variables and fields don't necessarily make sense to a novice user … and also which fields we're supposed to be focusing on and where to put things. We're not consistent with some of the fields sometimes, how different people are filling them out." – PHU respondent

"It's fiddly, particularly for a few of the fields. But overall there's also a lack of flexibility about how data can be entered." – PHRB respondent

"Sometimes linking everything together can be a bit tricky … especially retrospectively, when you realise that something is connected and you're going back to make changes." – PHU respondent

Two of these respondents stated that there was unnecessary redundancy in having to complete both paper-based questionnaires and electronic fields on NCIMS.

Search functions within NCIMS

Interview question: "How easy is it to search for COVID-19 information in NCIMS? Please give your response as a rating from 1 representing 'very difficult' to 4 representing 'very easy'."

Rating	Number of respondents (%) *N=20*
No rating given	5 (25)
4	6 (30)
3.5	1 (5)
3	7 (35)
1	1 (5)

Five respondents declined to give a rating, as they did not perform searches in NCIMS on a regular basis in their roles. Ratings given by the remaining respondents varied widely.

The six respondents who gave the user-friendliness of NCIMS search functions a rating of 4 stated that overall, it was straightforward to find records and information in NCIMS.

"It's very easy, and when somebody has multiple events in there, this is quite obvious." – PHU respondent

"I do like how there are two search areas so that you can search in a couple of different ways." – PHU respondent

Eight respondents gave a rating of 3 or 3.5. They felt that there was a lack of flexibility in the search input required by the system.

"People who only use Google for searching struggle to get the hang of it. You have to put in the correct text string." – PHRB respondent

"It's not very good at handling smart queries, which is what you can get out of a modern search engine in your web browser. It's also not good at accommodating spelling errors and phonics … so I mean different variants of spelling for the same name or word." – PHRB respondent

The respondent who gave a rating of 1 felt that it was particularly difficult to use the search functions within NCIMS for outbreak clusters.

"The spelling has to be exactly correct … And then searching cases within a cluster … can be frustrating … just pulling out some basic information about the cluster, like how many cases are primary cases, or secondary or tertiary cases, and how many close and casual contacts that we have." – PHRB respondent

Extracting information from NCIMS

The COVID-19 information that could be extracted from NCIMS evolved over the course of the pandemic response. Basic information extraction could simply involve viewing individual or cluster information in NCIMS and obtaining clinical or laboratory information for the event or outbreak. More detailed data such as line-listed and aggregated information could also be obtained from NCIMS.

Interview question: "How easy is it to extract COVID-19 information from NCIMS? Examples of this could be checking laboratory results, or finding exposure information for a case or contact, or retrieving clinical information. Please give your response as a rating from 1 representing 'very difficult' to 4 representing 'very easy'."

Rating	Number of respondents (%) *N=20*
No rating given	3 (15)
4	5 (25)
3.5	2 (10)
3	8 (40)
2	2 (10)

Three respondents did not give a rating for this question, stating that they did not obtain information directly from NCIMS in their roles. Some of the remaining respondents considered additional, more involved forms of data extraction, such as producing reports.

Three of the respondents who gave a rating of 4 stated that in their roles, they did not require complex information directly from NCIMS.

"I'd usually get very basic information out of NCIMS, so it's quite easy. For additional data and analyses, I'd use the reporting dataset from the Epi Team and plug that into R. I wouldn't use NCIMS for that." – PHRB respondent

One of the respondents with a rating of 3.5 was from the PHRB Epidemiology Team, and felt that for people with the appropriate skills, this process was straightforward.

"For me it's quite easy, but that's because that's the area that I work in. At the back end of NCIMS it's just fundamentally a bunch of data tables with fairly standard interfaces. But I can see that for an average user, it would be a bit more challenging to get anything out of NCIMS beyond basic information." – PHRB respondent

The other respondent who gave this rating felt that sometimes inconsistencies and errors in manual data entry meant that she could not obtain what she had hoped to find.

"NCIMS is pretty good, but sometimes it's the other people in the system. So it can be hard to get information out of NCIMS because people forget to put it there, or put it in the wrong place." – PHU respondent

A total of ten respondents gave ratings of 2 or 3 for the extraction of information from NCIMS. Several of these respondents mentioned that a shortcoming was the reliance on the PHRB Epidemiology Team to continue to generate each updated reporting dataset required for data analysis. Four respondents mentioned that the interpretation of data fields and workflows in NCIMS also posed challenges to extracting information, especially in times of rapid changes to processes.

Additional interview respondent discussions about simplicity

Interview question: "Are there particular structures or processes within the NSW COVID-19 surveillance system that are more complex than required or expected?"

Several respondents indicated that the additional feature of capturing details about contacts and clusters in the surveillance system had not been as useful and usable as desired.

"I don't think anyone expected how messy it would be when we started recording close contacts in NCIMS, and then linking them to clusters and to other people. This should be improved in the future." – PHU respondent

Two respondents also indicated that the management of laboratory data in the surveillance system was more complex than expected, having to manage a range of inputs.

"Managing the whole genome sequencing data can be complicated. And just managing the details of the lab results. We still use a lot of disparate systems to check and keep track of results because that has worked so far, but that has made things more complicated, when everything is in separate places." – PHU respondent

"Different labs are using different systems, and … having to check many different spreadsheets as well, especially for hotel quarantine screening." – PHRB respondent

Additional concerns were raised around using spreadsheets and manual processes for recording venues of exposure.

"… venue risk assessment, and finding out about and then managing the people who were at that venue. I know that at the Ministry they're still using a spreadsheet for that. It's not a part of NCIMS." – PHU respondent

One respondent spoke about the complexity of the surveillance system in general.

"It's a complex system because there are many redundancies to make sure that nothing is missed, which is both good and bad. When things get really busy, those redundancies can weigh us down." – PHRB respondent

Simplicity: In Summary

- The NSW COVID-19 surveillance system was rapidly evolving and complex.
- Staff in the surveillance system have identified clear and timely communication as a priority for the operation of the system.
- Dedicated training was required for new staff to use NCIMS. Challenges identified for using NCIMS span data entry, searching, and data extraction.
- The decision to use NCIMS for recording close contacts and transmission clusters added to the complexity of the system.
- The processes for recording surveillance data outside of NCIMS (such as venue information or WGS results) were also less straightforward than expected.

Flexibility

Flexibility denotes the adaptability of the surveillance system to change and to new requirements. It can also be considered in terms of the ability of the system to integrate with other systems(10). In the context of the NSW COVID-19 surveillance system, flexibility entails being responsive to a variety of potential changes, such as updates to case definitions, testing and procedures. Among the stakeholders interviewed for this surveillance system evaluation, it was generally agreed that it was desirable for the system to respond quickly to pandemic developments, but not change so rapidly that it would be difficult for users to adjust to an ongoing stream of new features.

In this evaluation, the flexibility of the NSW COVID-19 surveillance system was assessed through a timeline review of system changes, and through interviewing stakeholders.

Findings

A timeline of changes in the NSW COVID-19 surveillance system was mapped against relevant developments in the Australian and NSW COVID-19 pandemic response. This can be found in Appendix 2. In the stakeholder interviews for this evaluation, respondents were asked to consider how well changes in the surveillance system had been communicated, and whether it was still straightforward to navigate around NCIMS after each NCIMS change. Respondents were also asked about the integration of the NSW COVID-19 surveillance system with other data systems locally and nationally.

Timeline review

The timeline of relevant COVID-19 developments in 2020 reflects a rapidly evolving national and state pandemic response to a completely novel pathogen. Within the first two months of the activation of the NSW COVID-19 response, there were twenty changes to the CDNA COVID-19 Series of National Guidelines (SoNG)(27). In addition, there have been a number of wide-reaching policy changes external to the NSW MoH, involving the closure of national and state borders(4).

The NSW COVID-19 surveillance system was pre-emptive of many of these changes, as can be seen at a number of points in the timeline. For example, at the commencement of the pandemic response, the case definitions for 2019-nCoV surveillance in NSW were developed prior to national case definitions being published in the first version of the CDNA 2019-nCoV SoNG. Case questionnaire fields were often added prior to the collection of this information being recommended by the SoNG. In particular, fields to enter IgA, IgG and IgM serology results were available in NCIMS from March 10, 2020, while serological criteria were added to COVID-19 case definitions in the SoNG on May 13, 2020(28). Another example of where the NSW COVID-19 surveillance system was pre-emptive of developments at a national level was that “loss of taste/smell” was added to the list of symptoms reportable in the NCIMS case data entry wizard before April 7, 2020. This symptom was added to the CDNA 2019-nCOV SoNG on June 12, 2020(29).

When changes occur in the NSW COVID-19 response, the COVID-19 surveillance system was often responsive. One example was the reporting of testing numbers. On May 26, 2020, NSW began to report the number of tests conducted, rather than the number of individuals who had undertaken COVID-19 tests. This meant that NSW started to use the same definition as the other States and Territories of Australia for reporting the volume of testing carried out. When this decision was made to change the method used for reporting testing numbers, the NSW COVID-19 surveillance system was able to make this adjustment promptly, demonstrating a high degree flexibility.

There were also some examples of the NSW COVID-19 surveillance system being less responsive to change. One instance was a change in the CDNA SoNG on April 17, 2020, to extend the infectious period of COVID-19 to 48 hours prior to symptom onset(30). As at May 10, 2020, there were still new case interviews performed using older versions of the NSW COVID-19 questionnaire, where the contact tracing questions asked for exposures for only 24 hours prior to symptom onset.

Another example of the surveillance system being less flexible was the data entry of whole genome sequencing (WGS) results. WGS was first performed for COVID-19 cases in March 2020. As at the end of the data collection period for this evaluation, on November 14, 2020, WGS was being performed for 27% of confirmed COVID-19 cases in the surveillance system (Ref: Internal report). However, at that time, the most comprehensive records of WGS data in the surveillance system were still in the form of weekly reports from ICPMR. There was no consistent method for entering individual WGS results into NCIMS.

System change communication

Interview question: “In a rapidly evolving pandemic, the surveillance system needs to be adaptable to new changes, but not change so much that it is difficult for users to keep up. In your opinion, how well have new changes been communicated to you? Please give your response as a rating from 1 representing ‘very poorly communicated’ to 4 representing ‘very well communicated’.”

Rating	Number of respondents (%) *N=20*
4	4 (20)
3.5	2 (10)
3	9 (45)
2.5	2 (10)
2	1 (5)
1	2 (10)

One of the respondents who gave a rating of 4 remarked that he observed these changes communicated through a range of channels, such as during briefings and via email. Another respondent with the same rating felt that her PHU had received adequate prior warning when changes were impending, and benefitted from training teleconferences organised by the PHRB Epidemiology Team. However, one respondent felt that changes to surveillance procedures and reporting could have been better communicated to external stakeholders.

All of the respondents who gave ratings of 3 or 3.5 agreed that the communication about changes to the surveillance system had been thorough and useful. However, they identified a number of areas for improvement. Two respondents felt that communication had not occurred in a timely manner.

"It took a long time to get the data entry guide out to PHUs. It was not timely. And before this guide reached them … they had already made some of their own decisions about what to do with some of the fields … which didn't align with what we had intended … the inconsistencies this caused led to poorer data quality." – PHRB respondent

Other respondents felt that at times, changes occurred very frequently, as were communications about these changes. This meant that it was difficult to ensure that changes were not missed, and that staff members remembered these changes.

"It's just the rapidity … of the changes! They're very difficult to keep up with. It's a particular challenge for people working part time. You can … just fall behind with all the emails about the changes, just because you've had a day off." – PHU respondent

"Sometimes it's more of an issue with the managers and higher ups not being across all the changes … When there are changes, everyone needs to know." – PHRB respondent

Some of these respondents suggested that a central repository of change documentation would have been a useful for some of the situations that they had faced.

"It would be nice if there's a central repository to receive updates for any changes … and we can use it to store action plans and policies and guides. Often I find that changes are mentioned at briefings. And if you miss a briefing, you might not have any idea about what has been changed, or that there's even been a change. It's hard to keep up with changes this way." – PHRB respondent

User-friendliness of NCIMS after changes

Interview question: "Now thinking about NCIMS specifically, and thinking about all of the changes that you have perceived to be major: how easy has it been to navigate your way around NCIMS after each of these changes? Please give your response as a rating from 1 representing 'very difficult' to 4 representing 'very easy'."

Rating	Number of respondents (%) *N=20*
No rating given	7 (35)
4	5 (25)
3	5 (25)
2	3 (15)

Five of the respondents declined to provide a rating because they felt that they did not use the front end of NCIMS enough. The other two respondents without ratings stated that they had been too involved in the design and implementation of each new change to be aware of the perception of a more "average" NCIMS user.

One of the five respondents who gave a rating of 4 stated that even with major changes to NCIMS, the user interface and navigation remained consistent. All of the respondents with a rating of 3 felt that after each major change, there was an initial period of adjustment and re-orientation to the relevant section of NCIMS.

Two respondents felt that it was an ongoing challenge to retain control over the change process in NCIMS, and to ensure that users are adapting to the changes.

"We've had to make changes in the middle of a pandemic. There's no time to do a lot of testing … in a test environment … like user acceptance training, and all of those things that we would normally do when we're making significant changes in NCIMS … to the database, the data collection and to the reporting. So that's been really difficult to manage, and it's meant that we've borne a lot of the quality implications of that. We've been able to make changes quickly, but the other work around those changes … that's difficult in a pandemic environment." – PHRB respondent

Integration with other data systems

Interview questions:

"How well has the NSW COVID-19 surveillance system integrated with the information systems in place at PHUs? Please give your answer as a rating from 1 representing 'very poorly' to 4 representing 'very well'."

(This question was repeated for other data systems in NSW, and for national data systems.)

Rating	Integration with PHU systems Number of respondents (%) *N=20*	Integration with NSW systems Number of respondents (%) *N=20*	Integration with national systems Number of respondents (%) *N=20*
No rating given	10 (50)	11 (55)	13 (65)
4	3 (15)	1 (5)	0
3.5	2 (10)	3 (15)	3 (15)
3	2 (10)	2 (10)	1 (5)
2.5	0	1 (5)	0
2	1 (5)	2 (10)	1 (5)
1	2 (10)	0	2 (10)

Four respondents declined to give ratings to any of the three questions, stating that they did not know enough about other systems at each level.

Half of the respondents felt that they knew enough about PHU information systems to provide a rating. The respondents who gave a rating of 4 stated that at their PHUs, they were accustomed to using NCIMS and associated processes for the surveillance of other communicable diseases.

"Well, NCIMS has been dictating pretty much all our communicable diseases work anyway. We organise our work around NCIMS, not the other way around. So adding COVID to it didn't change much. It just fitted into our systems." – PHU respondent

However, other respondents had doubts about whether this level of integration was uniform across all PHUs.

"I think overall the PHU integration works pretty well, but different PHUs have different local systems and people. Some PHUs have people who are very experienced at working with NCIMS. Other PHUs might have a lot of surge staff who might be new to all the systems and have trouble seeing how they all fit together. There the integration might be less smooth." – PHRB respondent

"We've had NCIMS as a shared system for a long time. And there's a long history of the Infectious Diseases Network working with NCIMS and with state and national guidelines. But this has only translated to a certain degree to the network's public health response to COVID. The system is pretty well integrated with PHUs overall, but sometimes each PHU wants to do things differently, or follow their own processes." – PHRB respondent

Three respondents felt that a pre-existing disadvantage of notifiable diseases surveillance systems in NSW was the lack of integration with local hospital systems, and this was exacerbated during the COVID-19 response.

"The electronic medical records system of our LHD is the other main information system that we work with. And there's always been this problem that it's separate from NCIMS … But the swab results from the local hospital COVID clinics are usually in eMR (electronic medical records) before they're in NCIMS, so you need to work with it, especially if you're desperate for a result." – PHU respondent

Slightly more than half of the respondents felt that they were unable to give a rating for the integration between the NSW COVID-19 surveillance system with other data systems in use in NSW. Of the respondents who did provide a rating, the data systems mentioned were laboratory databases and state datasets accessed through linkage projects.

In terms of integration with diagnostic laboratory databases, the consensus among respondents was that although the ELR processes in NCIMS were an advantage of the system, further improvements in information integration with laboratories could be made.

"Since the beginning, we've had many more laboratories brought on board to do ELR. This is a very positive development. Now we just need to get them all to do it so that we don't have to do any manual roster importing at all." – PHRB respondent

Upon further discussion with the PHRB Epidemiology Team staff, it was noted that they felt the data linkage activities should not be considered one of the integrations of the surveillance system, but rather as separate, ongoing projects to improve data quality in the surveillance system. However, stakeholder comments about data linkage were found to be insightful, and included in this section. In general, respondents felt that data linkage activities were valuable.

"We've tried quite hard to get things like ICU data integrated into our system so that we can report on those numbers. There's been linkage with hospital admission data. It's not a native integration, but we've still been able to do it, which is very helpful for our response." – PHRB respondent

"It's especially useful for the Aboriginality status of all the people who get tested for COVID." – PHRB respondent

"Even though it's not instantaneous, the level of integration is really good. And actually, this 3-weekly timeframe for getting linked data is the envy of the world! … Not many other linkages happen as quickly as ours." – PHRB respondent

Most respondents stated that they were not aware of national systems and therefore, they could not give a rating on this level of integration. One respondent was from a PHU in one of the border regions of NSW, and discussed national integration from the point of view of accessing surveillance systems from the other side of this state border.

"Being on the border means that there are more issues with the interstate notifications and results integrating with our surveillance systems. At the PHU here, we don't have access to (other state's) system at all. It's getting a bit better with them keeping the Ops Team in Sydney informed a bit more, but we still really don't have all that much visibility across the border." – PHU respondent

The other respondents who gave a rating for this question discussed the NNDSS database and the NIR. Most of these respondents felt that there was effective integration between NCIMS and the NNDSS database, through the nightly extract of new NSW disease notifications being transmitted. However, two respondents expressed dissatisfaction that the process for the PHRB to update the NIR was manual.

"Our daily numbers are entered manually into the NIR dashboards. It's a bit clunky. There are two manual steps: so first we type the numbers into a daily email to the NIR. And then I'm assuming that

somebody from the NIR reads that email and enters those emailed numbers into their computer system and does some manual checks to make sure that things add up from day to day. It would be great if that could just be automated, like the nightly NNDSS feeds. And then there's that whole headache of timing and embargoing things. Every state has its own timing for reporting their numbers and in NSW we need them to embargo our numbers we report until a certain time the next day ... There's a lot that needs to be done in this process." – PHRB respondent

Flexibility: In Summary

- Overall, the NSW COVID-19 surveillance system, including NCIMS, was highly flexible to the continual developments of the pandemic response.
- Changes to processes within the surveillance system were communicated to stakeholders. However, improvements could be made in the timeliness and user-friendliness of these communications.
- There were many useful interfaces between the NSW COVID-19 surveillance system and external information systems. The integration across some of these interfaces was identified as an area that could be improved.

Timeliness

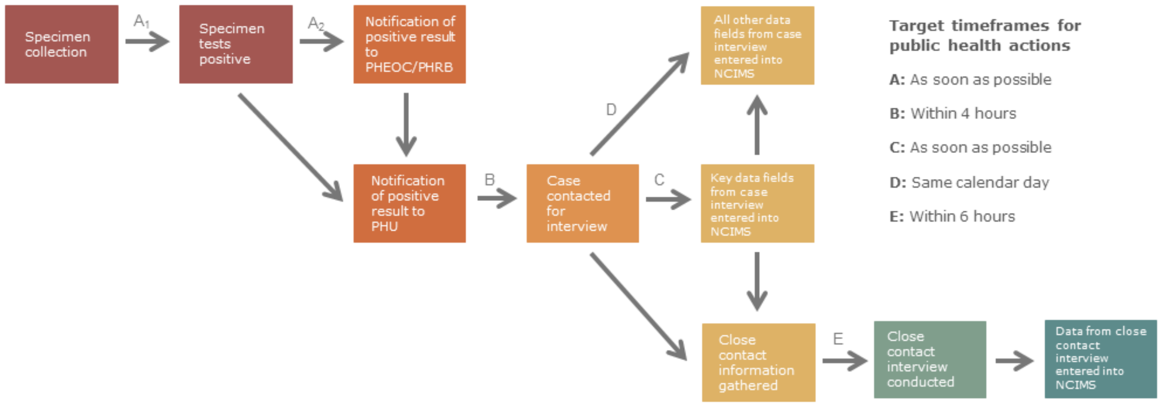
In the NSW COVID-19 surveillance system, guidelines on appropriate timeframes existed in the form of the NSW COVID-19 SoNG Appendix(31). The SoNG Appendix was used in addition to the national CDNA COVID-19 SoNG, to guide specific public health actions in NSW. It was written by the executives and medical advisors in the PHRB, in consultation with executives in NSW Health, representatives from PHUs, and team leaders within the PHRB.

In the August 11, 2020 version of the NSW COVID-19 SoNG Appendix, the timeframes recommended for public health actions were:

- Each new confirmed COVID-19 case was to be contacted by telephone by the PHU within 4 hours of initial notification of the positive result to NSW Health.
- The following fields were to be entered into NCIMS by the PHU as soon as possible after the initial case interview:
    - Likely place of infection (locally acquired, interstate, or overseas)
    - For locally acquired cases, any links to known cases or clusters, and any other information available for the likely location of exposure
- The rest of the core data fields on NCIMS for a new confirmed COVID-19 case were to be completed on the same day of the initial case interview. This was generally interpreted to mean the same calendar day.
- Close contacts of confirmed cases were to be contacted by telephone by either the PHU or the PHRB Close Contact Tracing Team within 6 hours of initial identification as close contacts.

In addition, the NSW *Public Health Act 2010* legislated that diagnostic laboratories must notify the Ministry of Health of a positive COVID-19 result "as soon as practicable", without a specific time limit. The diagram below illustrates these timeframes in the pathway from diagnostic specimen collection to public health action (Fig C1).

Figure C1 – Pathway from diagnostic specimen collection to public health action for a positive result



Diagnostic specimen collection is used as the starting point of this timeframe because this date is recorded for each result notified to the Ministry of Health. In most cases, it is not known when exactly a particular specimen was found to be positive or negative.

The timeliness of the NSW COVID-19 surveillance system is assessed both quantitatively and qualitatively in this evaluation. The quantitative component involves examining the timeliness data generated by the PHRB Epidemiology Team for the weekly COVID-19 Surveillance Reports. The qualitative component involves analysing the responses from interviews with stakeholders within the surveillance system.

Findings

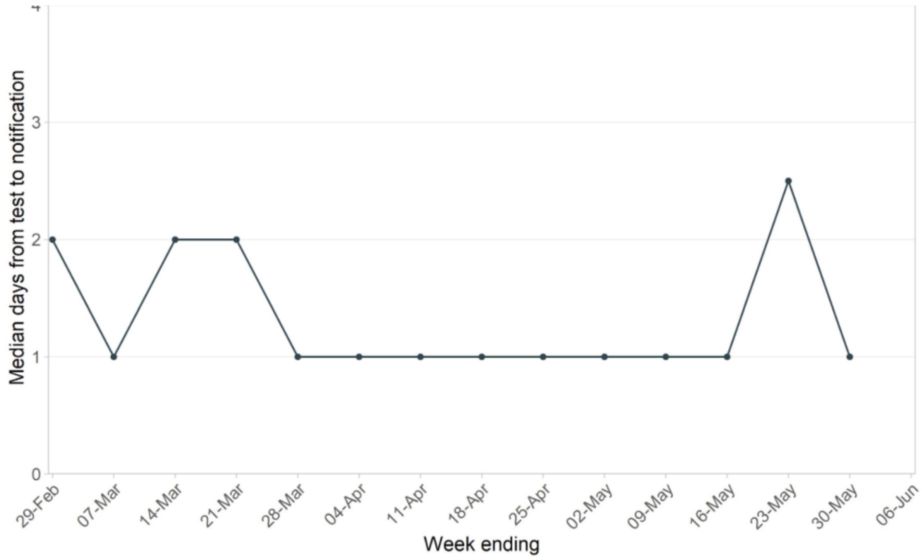
The PHRB Epidemiology Team had included statistics on the timeliness of diagnostic testing for COVID-19 since the first weekly NSW COVID-19 Surveillance Report published for the week ending April 30, 2020(32).

Time interval A: Specimen collection to notification of positive result to MoH

<u>Week ending February 29, 2020 to week ending May 30, 2020:</u> In the initial weekly PHEOC Surveillance Reports (dated from the week ending April 30, 2020 to the week ending June 6, 2020), the statistic reported was the median number of days between a) the collection of a specimen for PCR testing, and b) the notification of a positive result from this specimen, calculated from all of the confirmed locally acquired cases in the previous week (corresponding to time period marked as A in Fig C1). This was compared against the same statistic from each of the preceding weeks, retrospectively starting from the week ending February 29, 2020 (Fig C2)(33).

It was assumed within NSW Health and among stakeholders that ideally, this time interval would be as short as possible. A major limitation of these data is that the system only captured the dates of specimen collection and result notification, without further details about the exact time of day. Therefore, it was not possible to perform analyses of whether notifications occurred within 24-hour or 48-hour timeframes. In analyses, it was the practice of the PHRB Epidemiology Team to round this interval up to the nearest whole day. The number of days between specimen collection and positive result notification was only calculated for locally acquired cases, because it was considered to be more important for directing public health actions. For overseas acquired cases in hotel quarantine, it was assumed there were already isolation measures in place.

Fig C2 - Median time from specimen collection to notification for locally acquired cases Feb 29, 2020 to May 30, 2020. Source: PHEOC COVID-19 Surveillance Report week ending June 6, 2020.



These data showed that the median time between specimen collection and positive result notification ranged between one and two days in the early months of the pandemic response, until the end of March. Between the end of March and the end of May, the median time between specimen collection and notification was consistent at one day, with only one peak in the week ending 23 May of 2.5 days, due to one particular positive result requiring additional confirmation at a reference laboratory (Figure C2).

<u>Week ending May 23, 2020 to week ending July 11, 2020:</u> The next PHEOC/PHRB Surveillance Reports (dated from the week ending June 13, 2020 to the week ending July 11, 2020) presented the time from specimen collection to notification for all locally acquired cases from the preceding four weeks as a tally, grouped by increments of one calendar day. Retrospective results from the week ending May 23, 2020 were reported. There was a total of 39 locally acquired cases in this time period (Table C1).

<u>Week ending July 18, 2020 to week ending November 14, 2020:</u> In subsequent PHRB Surveillance Reports, the format for reporting the time to positive result notification changed once again. The new statistics reported were the proportion of new locally acquired cases of COVID-19 notified to NSW Health within one day (including positive results notified on the same day), two days and three days of specimen collection, and those notified more than three days after collection. From this time point until the end of data collection for this evaluation on November 14, 2020, a total of 624 new locally acquired COVID-19 cases were reported (Table C1).

For four out of the seven cases that were notified to the MoH more than three days after specimen collection, preliminary results were provided to the MoH within one day of collection, so that public health actions could be carried out as soon as possible. For the other three cases notified more than three days after collection, detection of infection occurred through serology rather than diagnostic PCR testing. Therefore, these results were considered to represent evidence of past infection, and public health actions were not required immediately.

Table C1 - Time from specimen collection to notification for locally acquired cases, week ending May 23, 2020 to week ending Nov 14, 2020. Source: PHRB COVID-19 Surveillance Reports week ending June 13, 2020 to week ending November 14, 2020(12).

Time period	Number of notifications (proportion)					Total cases
Interval	Same day	1 day	2 days	3 days	>3 days	
Week ending May 23 – Week ending July 11 ^	5 (25%)	8 (40%)	4 (20%)	2 (10%)	1 (5%)	20
Cumulative*#	5 (25%)	13 (65%)	17 (85%)	19 (95%)	20 (100%)	
Week ending July 18 – Week ending November 14#	Not reported	Not reported	118 (19%)	7 (1%)	7 (1%)	624
Cumulative*^	Not reported	492 (79%)	610 (98%)	617 (99%)	624 (100%)	

* Cumulative denotes the total number of notifications within a certain number of days
^ Directly from numbers reported in the weekly PHRB Surveillance Reports
# Inferred from numbers reported in the weekly PHRB Surveillance Reports

Table C1 illustrates that when these two reporting periods are compared, the timeliness of the notification of new locally acquired cases improved over time, despite a higher volume of cases.

Interview question: "What has your experience been of the timeliness between the laboratory detecting a new positive case and the case being notified to the surveillance system, through any means? Please give your response as a rating from 1 representing 'unacceptably slow or delayed' to 4 representing 'very timely'."

Rating	Number of respondents (%) *N=20*
No rating given	2 (10)
4	14 (70)
3.5	1 (5)
3	1 (5)
2.5	1 (5)
1.5	1 (5)

Given that there was no benchmark against which to assess the timeliness of the surveillance system for this step of the notification pathway, it was decided to ask stakeholders about whether this occurred rapidly enough to meet their needs.

It is worth noting that all but one respondent at the MoH gave a rating of 4. Most of these respondents also mentioned that there have been improvements over the course of the COVID-19 response.

"The timeliness is very good. There are prompt phone calls from the lab. Over time we've become a lot better at prioritising people at higher risk, like school children, and to do it in a more streamlined way." – PHRB respondent

"I think turnaround times may have improved overall since the start because labs … have more capacity to … deal with higher volumes." – PHRB respondent

Despite the overall satisfaction, some concerns were raised by the respondents regarding the timeliness of the notification of positive results.

"The laboratories that don't have electronic reporting … there may be delays. All the labs should ring through positive case detections, but that didn't always happen when we had high volumes of cases. And of course, that's a bit more of an issue with the non-ELR labs if they don't ring. We have to wait until manual batch importing has happened before we find out new cases. Some labs also … contact the PHU with a new positive case rather than the Ministry. And sometimes the PHU doesn't pass that notification on immediately." – PHRB respondent

"It depends more on the lab. I think this is probably the biggest factor. It probably helps if you're in an LHD with a big tertiary hospital. Private labs can be slower." – PHU respondent

As well as this, concerns were raised about results from interstate laboratories, especially for PHUs that border another state.

"It's very timely from the NSW laboratories. But it has been a problem from (state name) laboratories. But I'd say that this has improved greatly … I think now we have better processes in place for interstate notifications … For example, I think the PHRB Operations Team Manager now has permission to view the electronic systems from one of the states." – PHU respondent

Time Interval B: Notification of positive results to case being contacted for interview

From the week ending July 25, 2020 onwards, the PHRB Surveillance Reports published the weekly proportion of new locally acquired cases interviewed within one calendar day of notification to the MoH(34). This report also included this statistic retrospectively, from the week ending July 18, 2020. Every week from this time until the week ending November 14, 2020, the proportion of cases interviewed within one day of notification was 100%(12).

However, the NSW SoNG Appendix recommended this time interval to be no longer than four hours(31). It has not been possible to determine the proportion of cases where this recommendation was met, as the data captured by the surveillance system only included the date of notification to the MoH, and the date that the initial case interview was conducted. Therefore, it is not possible to evaluate the timeliness of the surveillance system quantitatively against the standards set by NSW Health.

Interview question: "What has your experience been of the timeliness between the notification of a new positive case and public health actions being carried out? Please give your response as a rating from 1 representing 'unacceptably slow or delayed' to 4 representing 'very timely'."

Rating	Number of respondents (%) *N=20*
No rating given	4 (20)
4	11 (55)
3.5	5 (25)

All of the respondents who answered this question, representing both PHUs and MoH staff, expressed their general satisfaction with the timeliness of public health action, and gave ratings of 3.5 to 4.

Time Intervals C & D: Entry of initial case interview data into NCIMS

The PHRB Epidemiology Team has not conducted a formal quantitative analysis of the timeliness of the interval between conducting initial case interviews and the entry of this interview data into NCIMS. This is because this information is not captured by the surveillance system in a manner that can be extracted and analysed easily.

Interview question: "What has your experience been of the timeliness of collecting information from case interviews, and for this information to be available to the rest of the surveillance system? Please give your response as a rating from 1 representing 'unacceptably slow or delayed' to 4 representing 'very timely'."

Rating	Number of respondents (%) *N=20*
No rating given	4 (20)
4	7 (35)
3.5	2 (10)
3	6 (30)
2.5	1 (5)

Ratings were varied among the respondents. The majority of the respondents giving a rating of 4 felt that even when the PHUs had high workloads, essential information about each case would be communicated to the PHRB as soon as possible after case interviews. This corresponds to the timely completion of time interval C, but not necessarily time interval D.

The concern raised by most of the respondents giving ratings of 2.5 to 3.5 was that the timeliness of this step was variable between PHUs.

"We're a small PHU, so we're more affected by fluctuations in case numbers compared to big ones. When it gets busy, we need to resort to more efficient procedures, like entering a few lines into the progress notes section of the NCIMS record to say that an interview's been done and that there will be

more details to come. We usually include a few salient points there. When we get a break later in the day, we'd then upload the scanned case interview form and complete the NCIMS wizard." – PHU respondent

Time Interval E: Conducting close contact interviews

The proportion of close contacts contacted by NSW public health staff within 48 hours of case notification to the MoH had been published in the weekly PHRB COVID-19 Surveillance Reports since the week ending August 29, 2020, with retrospective data from the week ending August 22, 2020 also reported(35). There were no reports in the weeks ending September 26, October 3, 2020 and November 14, 2020(12). In every week where this statistic was reported, until the week ending November 14, 2020, the proportion of close contacts contacted within 48 hours of case notification was 100%.

The NSW SoNG Appendix recommended close contact interviews to be conducted within six hours of the close contact being identified(31). However, the statistic reported by the Surveillance Report, as described, corresponded to the combination of time interval B (the time taken to identify and gather close contact information) plus time interval E in Figure C1. As well as this, the timeframe of 48 hours for case notification to close contact interview was not stated in the NSW SoNG appendix, nor any other guidelines used by NSW Health. Therefore, the statistics reported in the Surveillance Reports was not necessarily an accurate assessment of how well the surveillance system met recommendations in terms timeliness of close contact interviews being conducted.

Interview question: "What has your experience been of the timeliness of collecting information from close contact interviews, and for this information to be available to the rest of the surveillance system? Please give your response as a rating from 1 representing 'unacceptably slow or delayed' to 4 representing 'very timely'."

Rating	Number of respondents (%) *N=20*
No rating given	6 (30)
4	4 (20)
3.5	3 (15)[a]
3	6 (30)[b]
2.5	1 (5)[c]

[a] = Total includes 1 response where an average was calculated from a rating of 4 for household close contacts and 3 for venue close contacts

[b] = Total includes 1 response where an average was calculated from a rating of 4 for household close contacts and 2 for venue close contacts

[c] = Total includes 1 response where an average was calculated from a rating of 3.5 for household close contacts and 1.5 for venue close contacts

The interview question asked respondents to rate the timeliness of the combination of time interval E and the time it took for the information gathered during close contact interviews to be made available to the surveillance system. Of note, three of the respondents felt that they could not give an overall rating for this process, arguing that the timeliness was very different for household close contacts followed up by the PHU, and the venue close contacts followed up by the PHRB Close Contact Tracing Team (CCTT). An average rating was calculated from the household close contact and venue close contact ratings, and noted in the results table above.

"It's different for household close contacts and venue close contacts. Household close contacts are managed locally by PHUs, and this is usually very timely. But the venue close contacts … that's done centrally, and there's often a bit more of a delay with those." – PHRB respondent

All of the remaining respondents gave this process a rating of 3 to 4. In general, they were satisfied with the timeliness of the management of close contacts by the surveillance system, with some respondents giving suggestions for areas of additional improvement.

"We have to pass on a lot of close contacts to follow up, because we don't have the capacity locally and some of those lists can be quite large … especially when we had some huge clusters … I feel that here at the PHU, we put together those lists and collected all the information for those lists as quickly as we could, but that wasn't perfect either. But when we send those lists onto the Ministry … I guess just by introducing another step in the process, and another group of people, it automatically slows down already." – PHU respondent

"A major constraint for following up venue close contacts is getting attendance lists from external organisations … Hopefully working with Service NSW with apps will speed this up a little bit." – PHRB respondent

"With venues, sometimes the PHRB executives and expert panels will keep changing their minds in terms of whether to classify something as a close contact venue or a casual contact venue. And then all these people have to wait for this decision to figure out who they need to prioritise to contact, and what advice to tell people over the phone. So that can be a big delay with some venues, sometimes by more than a couple of days!" – PHRB respondent

Timeliness of negative result notification

This evaluation also examined the timeliness of the notification of negative SARS-CoV-2 PCR results to the surveillance system, after this result was confirmed by the diagnostic laboratory. As pointed out by one respondent, the main purpose of having negative results in the surveillance system is to understand population testing rates, rather than to guide urgent public health actions for an individual case. The prompt return of test results to individuals undergoing testing and to community health practitioners, while important for the experience of testing for the individual, was felt by this respondent to be outside the remit of the surveillance system. Therefore, for the purposes of the NSW COVID-19 surveillance system, the notification of negative results does not need to occur as rapidly as that for positive results.

The time interval between specimen collection and the notification of a negative result to the MoH was not published in the weekly NSW COVID-19 Surveillance Reports.

Interview question: "What has your experience been of the timeliness of negative diagnostic COVID-19 results being notified to the surveillance system, through any means? Please give your response as a rating from 1 representing 'unacceptably slow or delayed' to 4 representing 'very timely'."

Rating	Number of respondents (%) *N=20*
No rating given	4 (20)
4	4 (20)
3.5	4 (20)
3	5 (25)
2.5	2 (10)
1	1 (5)

All four of the respondents who gave a rating of 4 were experienced staff members, who had previously been involved in the NSW pandemic influenza response in 2009.

"The negatives … we use that largely to understand testing rates in the population. So we can cope with a bit of delay for that information. In the surveillance system we're not responsible for informing the individual of those results in a timely way, although that is important for the person. But that's not our responsibility. For us, the timeliness of negative results is adequate." – PHRB respondent

However, a respondent from a regional PHU gave a rating of 1 for the timeliness of notification of negative results, commenting that PHUs may use negative results for additional purposes.

"Sometimes the delays are unacceptable … Negative results help us with knowing how to manage some of the local situations we have here at PHUs, so having timely negatives would really help." – PHU respondent

Several of the remaining respondents mentioned that the timeliness of the notification of negative results varied according to the laboratory. The notification of negative results was more timely through public laboratories and through laboratories that have ELR.

"Some labs send us negatives four times a day through ELR. Some send the negatives once a day, on the day. Some of the smaller labs might batch negatives together over two days before sending to us. Some slowdowns are also because of sample loads suddenly increasing … And then for manual roster imports, that takes up to twelve hours even after they've been received here by the Data Pipeline Team. It's a manual process that takes time, and so often ends up being a next-day thing. If we can move more laboratories to electronic transfer of their results, this will speed the process up with the negatives." – PHRB respondent

Two of the respondents also recalled specific incidents involving the delayed notification of negative results.

"Pretty much all the negative results enter NCIMS with a maximum delay of three days these days. But this is barring two instances where one particular private laboratory had a technical error and delayed notification of negatives to the Ministry by more than a couple of months. They had informed the health practitioners who had requested those tests, though. I've been told that this whole process has

now been reviewed with the lab and hasn't happened again. I think overall this process for the negatives has improved over time." – PHRB respondent

Additional interview comments for timeliness

Several of the respondents requested a note to be added to this report, mentioning that the most significant delays in public health action in NSW for COVID-19 were the steps before a diagnostic test result was available. Namely, these steps include the time taken for a symptomatic individual to seek testing, the time for a specimen to reach the diagnostic laboratory and the time for the test to be performed. Therefore, these respondents felt that many of the barriers to timely public health action for COVID-19 in NSW lie outside of the surveillance system.

Timeliness: In Summary

- The NSW COVID-19 surveillance system was timely at each stage of the pathway for the notification and initial public health actions for positive cases.
- Implementing ELR procedures for more diagnostic laboratories would lead to additional improvements to the timeliness of the system.

Data quality

For the NSW COVID-19 surveillance system, an evaluation of data quality means primarily assessing the completeness and accuracy of COVID-19 records in NCIMS.

In this evaluation, data quality is assessed both quantitatively, by reviewing NCIMS laboratory results and COVID-19 data completeness reports, and qualitatively, by interviewing stakeholders. The COVID-19 data completeness reports were generated by the PHRB Epidemiology Team. Within the reports were line lists of confirmed cases notified to the MoH in the 14 days prior to the report. Missing fields for each confirmed case were marked. The first data completion report for distribution outside of the Epidemiology Team was created on August 31, 2020. Information was extracted from NCIMS for 42 variables for each individual case. These variables were chosen by the PHRB Epidemiology Team due to their importance to outbreak response, surveillance of population subgroups, and state-level reporting. Since this date, data completion reports were created irregularly, at intervals of 7 days on average. They were sent to PHUs to assist with identifying important gaps in the COVID-19 data, so that staff could complete missing fields retrospectively, using any additional information that may be available locally. As at November 15, 2020, data completion reports had expanded to include 46 variables.

This evaluation examined the fortnightly data completion reports created on August 31, 2020 and November 15, 2020. These two reports were chosen because they represented the first data completion report, and the final report for the time period considered in this evaluation. A comparison was made between these two reports to determine whether there had been any improvements in data completeness over time.

For the evaluation, a full data completeness report was also created on December 22, 2020, including all cases from the first confirmed COVID-19 case in NSW, on January 25, 2020 until the end of data collection for this evaluation on November 14, 2020 inclusive. This full report was generated specifically for this surveillance system evaluation by PHRB Epidemiology Team staff on December 22, 2020. It allowed an assessment to be made of the data completeness for COVID-19 cases in NCIMS overall, taking into account periods of higher pandemic response activity in March and April 2020, which were not captured by the August and November 14-day data completeness reports. In addition, given that this data completeness report was created 5.5 weeks after the latest case in the report was confirmed, it also gave an indication as to whether there were adequate retrospective data review and completion processes within the NSW COVID-19 surveillance system.

The initial analysis of all three of these data completeness reports focused on fields identified by the NSW COVID-19 SoNG Appendix as those of the most critical importance, to be entered into NCIMS as soon as possible after the initial case interview was completed(31). These fields were “Place of disease acquisition”, “Source of local acquisition” and “Setting of possible exposure.” Of these fields, “Source of local acquisition” only needed to be completed for locally acquired cases. “Setting of possible exposure” was only required to be completed for cases who acquired their infections locally, but this source was identified to be outside of household transmission.

In addition to these fields, stakeholders interviewed in this evaluation were asked to nominate COVID-19 information in NCIMS that they required to carry out their roles, but were often found to be incomplete. Fields identified by respondents, in addition to the fields already named above, included:

- Aboriginal and Torres Strait Islander status – However, for the reporting of Aboriginal and Torres Strait Islander COVID-19 testing statistics, data from data linkage processes were used. Therefore, the information in the Aboriginal and Torres Strait Islander status field for an individual in NCIMS was used more for the purpose of individual case and close contact management.
- Ethnicity – This information was collected in NCIMS by the “Country of birth” and “Specific cultural or ethnic group” fields. For the reporting of COVID-19 testing by ethnic subgroups, data on country of birth from data linkage processes were used.
- Primary language(s) spoken – More than one option for each individual was allowed in NCIMS.
- Symptom onset date – For all symptomatic cases.
- Venues visited in infectious period
- Laboratory accession numbers for test specimens – These often needed to be entered into NCIMS manually.
- Specific locations of individuals in hotel quarantine – Such as hotel name, room number, and whether the individual was moved to a dedicated hotel for COVID-19 cases after they were confirmed as a COVID-19 case.
- Links between cases and contacts, and within transmission clusters
- Classification of close contacts – Close contacts should have had a “Contact – High Risk” classification in their COVID-19 event, rather than an “Unspecified”, “Possible” or “Excluded” classification.

Where the three data completion reports captured these fields, this was also reviewed. This was possible for the following fields:

- Aboriginal and Torres Strait Islander status

- Ethnicity
- Primary language(s) spoken
- Symptom onset date

A proxy field in the data completeness reports was used to review the completeness of links between cases and contacts. All cases where the source of acquisition was a household contact were reviewed specifically for whether the NCIMS number of their source household contact was completed. However, this only represented a small proportion of all cases in the surveillance system.

All variables in the data completeness reports were reviewed for percentage of completion, given that these fields were identified by the PHRB Epidemiology Team as being important to the reporting activities of the NSW COVID-19 pandemic response. Fields with lower than 50% completion were compared across the three reports to assess the evolution of data completeness over time.

A caveat against using the case data completeness reports to make inferences about the completeness of COVID-19 records in NCIMS is that interview respondents felt that data completeness had been much better for confirmed cases than for all other COVID-19 events in NCIMS. Therefore, the findings of the analyses in this evaluation may not be reliable indicators of the completeness of this information for all COVID-19 events captured by the surveillance system. Unfortunately, due to the volume of COVID-19 data, and the priorities of the pandemic response, data completion reports were not generated for other types of COVID-19 events in NCIMS.

Findings

Completeness of data entry for cases in NCIMS: Critical transmission fields

The data completeness report from August 31, 2020 contained 99 confirmed cases notified to the NSW MoH from August 17 to August 31 inclusive. The data completeness report from November 15, 2020 contained 73 confirmed cases notified to the MoH from November 1, 2020 to November 14, 2020 inclusive. Critical transmission fields in both reports were analysed and compared (Table C2). It is to be noted, however, that although the data for the two completeness reports are presented next to each other in the tables, they represent snapshots in time, and not the overall trend of data completeness in the NSW COVID-19 surveillance system.

The data completeness report for all COVID-19 cases from the beginning of the NSW pandemic response up to (and including) November 14, 2020 contained 4501 confirmed COVID-19 cases notified to the MoH, with the earliest notification on January 25, 2020. This report was analysed for the same three critical transmission data fields as those examined for the two 14-day data completeness reports above (Table C2).

Table C2 – Data completeness for critical fields, August and November 2020, and all cases up to November 14, 2020

Data field	Number of cases for whom field is complete, fortnight ending August 31, 2020 inclusive (%)	Number of cases for whom field is complete, fortnight ending November 14, 2020 inclusive (%)	Number of cases for whom field is complete, all COVID-19 cases until November 14, 2020 (%)
	(All cases: N = 99)	*(All cases: N = 73)*	*(All cases: N = 4501)*
"Place of disease acquisition"	98 (99)	73 (100)	4501 (100)
	(Subset of all cases: locally acquired cases; N = 75)	*(Subset of all cases: locally acquired cases; N = 11)*	*(Subset of all cases: locally acquired cases; N = 1874)*
"Source of local acquisition"	74 (99)	10 (91)	1874 (100)
	(Subset of locally acquired cases: epi-linked to a case or cluster; N= 38)	*(Subset of locally acquired cases: epi-linked to a case or cluster; N= 0)*	*(Subset of locally acquired cases: epi-linked to a case or cluster; N = 871)*
"Setting of possible exposure" for this subset	38 (100)	N/A	822 (94)

This comparison of the NCIMS data completeness reports shows high levels of completion for all the critical transmission data fields. This appeared to have been consistent over time.

These data indicate that retrospective data entry had occurred in the NSW COVID-19 surveillance system after the initial notification and investigation. In each of the August and November 14-day data completeness reports, there was one local case where the "Source of local acquisition" field was incomplete. By the time the all-case data completeness report was generated in December 2020, this field had been completed for both of these cases.

The "setting of possible exposure" field was complete for all the locally acquired cases that had been epi-linked in the data completeness report in August. None of the locally acquired cases belonged to this category in the data completeness report in November. However, it can also be seen in the all-case report that there may have been periods of time when the completion of this field had not been as high as was seen in the August and November 14-day reports, and that this may not have been possible to rectify with retrospective data entry.

Completeness of data entry for cases in NCIMS: Additional useful fields

Additional fields identified to be useful but frequently incomplete by interview respondents were also examined in all three data completeness reports (Table C3).

Table C3 – Data completeness for additional useful fields, August and November 2020, and all cases up to November 14, 2020

Data field	Number of cases for whom field is complete, fortnight ending Aug 31, 2020 inclusive (%)	Number of cases for whom field is complete, fortnight ending Nov 14, 2020 inclusive (%)	Number of cases for whom field is complete, all COVID-19 cases until Nov 14, 2020 (%)
	(All cases: N = 99)	*(All cases: N = 73)*	*(All cases: N = 4501)*
"Aboriginal or Torres Strait Islander" (5 options)	84 (85)	63 (86)	4275 (95)
"Primary language"	Not recorded	52 (71)	**1808 (40)**
"Country of birth"	68 (69)	57 (78)	3562 (79)
"Ancestry or ethnic origin"	**45 (45)**	37 (51)	**664 (15)**
Either "Country of birth" or "Ancestry or ethnic origin" complete	72 (73)	57 (78)	3582 (80)
"Symptomatic" (y/n/unknown)	87 (88)	58 (79)	4380 (97)
	(Subset of locally acquired cases: source of acquisition is "household contact of a confirmed case"; N = 25)	*(Subset of locally acquired cases: source of acquisition is "household contact of a confirmed case"; N = 5)*	*(Subset of locally acquired cases: source of acquisition is "household contact of a confirmed case"; N = 571)*
NCIMS ID number of source case for this subset	24 (96)	5 (100)	465 (81)
	(Subset of all cases: symptomatic cases; N = 69)	*(Subset of all cases: symptomatic cases; N = 38)*	*(Subset of all cases: symptomatic cases; N = 3923)*
"Date of first symptom onset"	69 (100)	39 (100)	3901 (99)

Key: Numbers in **bold** are fields with lower than 50% completion.

This comparison of data completeness reports shows that there were fields that had been highly complete consistently. These included the "Symptomatic" and "Date of first symptom onset" fields. In particular, the "Date of first symptom onset" field, which was only required for cases identified as being symptomatic, had close to 100% completion in all reports.

Other fields with high levels of data completeness included the NCIMS identification number of the source for cases whose source of infection acquisition was identified to be a household contact. This means that most cases who acquired COVID-19 from a household contact were appropriately epidemiologically linked in the household transmission chain. This level of completeness was lower in the all-case report than the 14-day reports from August and November. This may indicate that the completeness of this field was lower in cases dating from before August.

The "Aboriginal or Torres Strait Islander" field also consistently had completeness of 85% or above. However, this may have been due to "Not known" being one of the response options. The completeness was highest in the all-case data completeness report, at 95%, possibly indicating that retrospective completion of this field had occurred through data linkage activities.

The remaining fields examined showed different patterns of data completeness over time. The completeness of the “Ancestry or ethnic origin” field was 15% in the all-case completeness report. This may be due to the fact that this field was only introduced to the NSW COVID-19 case questionnaire after May 2020. Cases entered the NSW COVID-19 surveillance system prior to this date without the collection of this information. However, the completeness of this field remained low in August, at 45%, and in November, at 51%.

There were ongoing discussions among the PHRB Epidemiology Team about how best to capture data about the ethnic subgroups to which an individual may belong, in a manner that would be simple and useful for guiding targeted public health messaging and action. It was thought that combining the “Country of birth” field with the “Ancestry or ethnic origin” fields would provide sufficient information, and that the addition of the “Primary language” field would inform the choice of languages for communications. The “Country of birth” field showed higher levels of completeness, at between 69% and 79% in the data completeness reports. When combined with the “Ancestry or ethnic origin” field as intended, overall completeness was only marginally improved in the all-case completeness report, to 80%. The “Primary language” field was also poorly completed, at 40% in the all-case completeness report. However, the 71% completeness in the November 14-day report suggests that this may have improved over time.

Completeness of data entry for cases in NCIMS: Fields with lower than 50% completion in data completeness reports

The all-case data completeness report was analysed for fields with a proportion of completion lower than 50%. These fields were compared against those fields in the 14-day data completeness reports from August and November that also meet the lower than 50% completion criterion (Table C4).

Table C4 – Fields with lower than 50% completion in data completeness reports

Data field	Number of cases for whom field is complete, fortnight ending August 31, 2020 inclusive (%)	Number of cases for whom field is complete, fortnight ending November 14, 2020 inclusive (%)	Number of cases for whom field is complete, all COVID-19 cases until November 14, 2020 (%)
	(All cases: N = 99)	*(All cases: N = 73)*	*(All cases: N = 4501)*
“Interpreter needed”	**17** (**17**)	**13** (**18**)	**913** (**20**)
“Ancestry or ethnic origin”	55 (54)	37 (51)	**664** (**15**)
“Date isolation began”	79 (80)	50 (68)	**1057** (**23**)
“Primary occupation”	Not recorded	**15** (**21**)	**1184** (**26**)
	(Subset of all cases: primary occupation known; N = n/a)	*(Subset of all cases: primary occupation known; N = 15)*	*(Subset of all cases: primary occupation known; N = 1184)*
“Setting of primary occupation”	Not recorded	12 (80)	**382** (**32**)
	(Subset of all cases: setting of exposure known; N = 63)	*(Subset of all cases: setting of exposure known; N = 4)*	*(Subset of all cases: setting of exposure known; N = 871)*
“Setting of exposure date”	**31** (**49**)	4 (100)	619 (71)

Key: Numbers in **bold** are those where fields have lower than 50% completeness.

This table indicates that there are fields where the data completeness may have been consistently low over the course of the COVID-19 pandemic response, and those where data completeness may have improved over time. However, caution is needed when examining these data, as the August and November 14-day reports represent specific points in time.

Fields where data completeness remained low over time were “Interpreter needed” and “Primary occupation”. The “Interpreter needed” field had been part of the initial case data entry wizard since the commencement of the NSW pandemic response. It had remained a field that was often omitted, and was more often completed for cases that did require an interpreter compared to cases who did not.

The “Primary occupation” field had also been included in the first NSW COVID-19 case questionnaire. However, the completion of this field was not emphasised until early September 2020, when greater importance was placed upon identifying healthcare workers among cases. A brief review of the cases where this field was completed revealed that most of these cases worked in higher risk occupations such as healthcare. This may indicate that the completion of this field was prioritised for certain groups where their employment may have greater implications for public health actions. A related field, the “Setting of primary occupation” showed 80% completion in November for the cases where the “Primary occupation” field was completed. This field allowed the identification of types of workplaces. It had appeared as “usual location of occupation” in the paper case questionnaire since the beginning of the pandemic response, but was not introduced to the NCIMS data entry wizard until October 2020. This may explain its lower overall completeness, at 32%, in the all-case data completeness report.

Fields where data completeness may have had improved over time may be “Ancestry or ethnic origin”, “Date isolation began” and “Setting of exposure date”. “Ancestry or ethnic origin” was already discussed. The “Date isolation began” field recorded the date when a COVID-19 case ceased to represent a risk for onward transmission, and was reasonably complete in both the August and November 14-day data completeness reports. In the all-case data completeness report, this was much lower, at 23%, which may represent lower completion of this field prior to August.

The "Setting of exposure date" field recorded the date where the case had attended the likely exposure location, and was only required for cases where this exposure was known. It showed a possible improvement in completeness between August and November, at 49% and 100% respectively, noting that the November denominator number was low. The all-case data completeness report had 71% completeness for this field. Given that this field had been available in various forms since the first version of the NSW COVID-19 questionnaire, but had only become available in the NCIMS initial case data entry wizard in May 2020, this level of data completeness was likely to be due to retrospective data entry.

Completeness of laboratory results in the surveillance system

The NSW COVID-19 surveillance system was designed to capture the results of every test for SARS-CoV-2 performed by a NSW laboratory. In addition, it should also capture all positive results from interstate laboratories performed for residents of NSW. The completeness of all test results in the surveillance system is difficult to assess, because not every diagnostic laboratory notified the surveillance system of testing requests and the tests performed from these requests.

There were occasions where it became apparent that the COVID-19 diagnostic testing results within the surveillance system were incomplete. In two separate incidents in September 2020, it was found that due to a technical error related to uploading results through ELR, one particular private NSW diagnostic laboratory had not notified a total of 46,091 historical negative SARS-CoV-2 PCR results to the NSW COVID-19 surveillance system (Ref: Internal report). Detailed investigations into this incident were undertaken subsequently, and no further omissions of result notifications were discovered. In the absence of additional evidence, it is likely that the level of completeness of diagnostic laboratory notifications within the NSW COVID-19 surveillance system was high.

Interview findings

Interview question: "What is your perception of the accuracy and completeness of the data in the NSW COVID-19 surveillance system? Please give your answer as a rating from 1 representing 'very poor' to 4 representing 'excellent'."

Rating	Number of respondents (%) *N=20*
No rating given	1 (5)
4	6 (30)
3.5	5 (25)
3	7 (35)
2	1 (5)

A few of the respondents who gave ratings of 4 elaborated on aspects of the surveillance data that they found to be particularly satisfactory.

"I think we've never had a more complete data system, for any disease in NSW! We have all the negatives in there, and all the close contacts, and even some casual contacts too. It gives us pretty good confidence that we know what's happening. I think it's very high quality data too. We can still do better with some information about venues, to help us to be able to rapidly draw links by exposures. I think we're not quite there yet, but there's work going on to do that. Some of the questions might be better answered by a special outbreak analysis, rather than trying to expect a routine surveillance system to collect complex detail." – PHRB respondent

Some respondents felt that there were marked differences in the data quality for cases and for contacts and all other individuals in NCIMS. Several respondents felt that the quality of the data in the NSW COVID-19 surveillance system had improved over time, and gave a range of reasons for this. Most notably, the introduction of the Data Quality Team was mentioned by almost all these respondents. Additional new processes for improving the data quality in the system included data completeness reports leading to retrospective data entry, training of surveillance staff in data entry and data audits undertaken by PHUs.

"There's definitely been an improvement in the data quality with the Data Quality Team. Especially with contacts … there's now a consistent and routine way in how this information is entered. Also, the deduplications are now done by the Data Quality Team. This has reduced the workload of other teams, who were trying to manage these. A lot of people don't realise this, but this role … doing the deduplications, this is critical to the proper functioning and counting within NCIMS." – PHRB respondent

Additional concerns related to data quality were raised by some respondents, particularly concerning venues visited by confirmed cases.

"There have been some problems with misclassifications of contacts and venues. Quite often the initial information needs to be amended before it gets released published across media channels … so information around where and when exactly a case has been to a venue. Often there's not enough detail. And then when somebody goes back to dig deeper, then sometimes contacts have to be reclassified in terms of who the close and casual contacts are. And then that information might have gone out in the media already, and then needs to be retracted and corrected." – PHRB respondent

Data Quality: In Summary

- High levels of completeness in the data fields considered to be critical for cases captured by the NSW COVID-19 surveillance system
- Data quality improved over time, assisted by data linkage, retrospective data entry, the introduction of the Data Quality Team, and data completeness reports
- Data fields with the lowest levels of completeness were related to subgroup information, such as ethnicity and occupation

Acceptability

In the NSW COVID-19 surveillance system, acceptability would mean that individual members of teams in both the PHRB and PHUs were satisfied with the organisation of the system, and were willing to participate in their respective surveillance roles. However, the findings of this evaluation need to be considered in the context that NSW COVID-19 surveillance activities fell under the NSW Public Health Act. Therefore, there was a legal requirement for PHUs and PHRB teams to participate in the system.

In this evaluation, acceptability is assessed qualitatively, by interviewing staff members within the surveillance system about their satisfaction with the system in general, and with the tasks to which they were assigned within the system. In addition, other indicators of acceptability, such as data completeness and timeliness, are evaluated separately in their respective sections.

Findings

Interview question: "In general, how satisfied are you with the NSW COVID-19 surveillance system (not just NCIMS)? Please give a rating from 1-4, with 1 representing 'very dissatisfied' and 4 representing 'very satisfied'."

Rating	Number of respondents (%) *N=20*
No rating given	1 (5)
4	5 (25)
3.5	6 (30)
3	7 (35)
2	1 (5)

When asked about overall satisfaction with the NSW COVID-19 surveillance system, all but one interview respondent gave a rating of 3-4. Almost all of the responses mentioned that the surveillance system had adapted extremely well to the needs of the pandemic response, especially given the volume of the data that was entering and being processed by the system, and given the speed at which the system had to be established initially.

Many of the respondents who gave a rating of 3 stated that their ratings were not higher because in the initial months of the NSW COVID-19 response, some of the processes in place were inefficient and less straightforward than desired. Some actions took place on an *ad hoc* basis, without pre-existing structures or guidance. However, all these respondents went on to comment that significant improvements were made to the surveillance system in the subsequent months. They felt that at the time of their interviews, although further improvements could be made, the surveillance system was achieving its main objectives. One respondent expected the acceptability of the NSW COVID-19 surveillance system to be high:

"Here and at the PHUs, they've been happy to work with the surveillance system. I think because it's the system that we've used before. So it's really just an expansion of what we would normally do." - PHRB respondent

Interview question: "How satisfied are you with NCIMS as the information management system for the NSW COVID-19 surveillance system? Please give a rating from 1-4, with 1 representing 'very dissatisfied' and 4 representing 'very satisfied'."

Rating	Number of respondents (%) *N=20*
No rating given	1 (5)
4	2 (10)
3.5	6 (30)
3	10 (50)
2	1 (5)

Most respondents acknowledged that NCIMS was limited by its age, and that it had originally been designed for the routine surveillance of notifiable diseases in NSW. Other limitations mentioned by the respondents included not being able to keep track of clusters and transmission relationships in a straightforward manner, not having workflows to manage interstate traveller exemptions, not having the capacity to capture more detailed information for individuals (especially relating to ethnicity and source of exposure), and the back-end data tables refreshing on an hourly basis rather than instantaneously. However, it has been able to meet most of the information system needs for the NSW COVID-19 response, and to accommodate large volumes of data. This was summarised by two respondents:

"It's pretty great in what it's doing, with 3 million test results to deal with! It's been able to be surged to have greater capacity, but using it has highlighted some areas that can be improved in the way that we capture information … for example … linking cases to outbreaks." - PHRB respondent

The respondent with a rating of 2 used NCIMS for reporting.

"Now that I've been downloading data every day to put into biostatistics programs ... It's difficult to even do this. The wait time can be up to and over an hour, which is very challenging in terms of then being able to communicate with hospitals in a timely manner. Sometimes I've had to do things manually. In other surveillance roles, NCIMS has been great." - PHU respondent

Acceptability: In Summary

- High levels of acceptability from surveillance staff
- Improvements in processes over the initial months of the pandemic response
- NCIMS has limitations, especially as a tool for epidemiology, but fulfils basic surveillance requirements and is familiar to many staff members

Sensitivity

The sensitivity of a surveillance system is formally defined to be the proportion of positive cases detected by the system, out of the total number of positive cases in the target population(10). The total number of positive cases in the target population can often be unknown, and usually requires an alternative "gold standard" measurement against which comparisons can be made.

In a surveillance system, higher sensitivity is usually desirable, as this represents fewer cases not being captured(10). In general, there are several points at which a positive case may escape capture by the surveillance system.

1. An individual becomes infected, but does not seek medical care.
2. An infected individual seeks medical assistance, but the health professional chooses not to order the appropriate diagnostic test.
3. The appropriate diagnostic test is ordered, but there are false negative results.
4. A positive result is detected by the laboratory, but the laboratory omits to report this to the surveillance system.

Findings

For COVID-19, there is no "gold standard" reference against which the NSW surveillance system can be measured. Therefore, it is not possible to determine the sensitivity of the system as an exact proportion. However, inferences about the system can be made to allow a general descriptive assessment of its sensitivity.

Firstly, among the people infected by COVID-19, we can assume that a proportion did not present for medical assessment and testing, given that there were asymptomatic cases and symptomatic people who may not have recognised the symptoms of COVID-19. People may also have chosen not to seek healthcare for their symptoms, due to a variety of reasons. However, testing rates were generally considered to be high. As at November 14, a total of 3,266,821 diagnostic PCR tests for SARS-CoV-2 have been performed in NSW, representing 415 tests per 1,000 population(12). In addition, a notable group had included returned overseas or interstate travellers in hotel quarantine, who had been tested routinely regardless of symptoms. Among this population, testing rates had been close to 100%.

Among individuals who presented for medical assessment, the testing criteria had expanded over time to become more sensitive. The testing criteria used in NSW had followed the Series of National Guidelines (SoNGs) set out by CDNA, with minor amendments dictated by medical experts within NSW

Health. With sensitive testing criteria, and active dissemination of these criteria to health professionals, it is expected that the number of cases who attend for medical assessment but are not tested for COVID-19 would be low.

After the collection of a diagnostic test sample for COVID-19, the assumption is that the sensitivity of laboratory testing was as high as possible within NSW. Although different laboratories had different testing equipment and procedures, samples giving indeterminate results were sent to ICPMR, the reference laboratory, for confirmation. In the case of additional uncertainty, an expert panel composed of public health and laboratory specialists was often convened. This panel would then determine whether to include the test result in the positive case count, or whether additional testing was required. Therefore, one would expect that after diagnostic testing, the proportion of false negative cases of COVID-19 excluded from the surveillance system was low.

When a positive COVID-19 diagnostic test result was confirmed by the laboratory, it was notified by the laboratory staff to the PHRB and PHUs through a number of different processes, as discussed in the "System inputs and sources" section. The redundancies embedded within these processes aimed to ensure that every new case of COVID-19 was notified to the surveillance system.

Given that there was minimal loss of potential cases at the key steps highlighted above, it can be inferred that the sensitivity of the NSW COVID-19 surveillance system has been high. This is supported by modelling that from March to June 2020, the proportion of symptomatic cases ascertained for COVID-19 in Australia was 70-100%, which was the highest among developed countries(36).

Interview questions: "How well does the surveillance system capture all of the possible cases of COVID-19 in NSW? Do you suspect that there are groups that may be missed by the surveillance system?"

Among the respondents interviewed, the consensus was that the first time point described above would be the most likely reason for an infected individual to be undetected by the COVID-19 surveillance system. All respondents were confident that once an infected individual accesses healthcare, the likelihood for the infection to be undetected by the NSW COVID-19 surveillance system would be low.

"Overall, I think the system captures a high percentage of cases … we probably have the highest case ascertainment rate in the world. The populations that we're not capturing are probably some more vulnerable populations, and some CALD (culturally and linguistically diverse) communities." – PHU respondent

A number of other respondents also voiced the concern that the surveillance system may have been less sensitive to particular subgroups in the population. However, many respondents felt that this was not specific to COVID-19.

"It's pretty much what we have for all the passive surveillance systems in NSW. We're probably missing people from low healthcare seeking groups … there's anecdotal evidence about certain ethnocultural groups and maybe First Nations groups too. But I think it's more about the message to get tested not reaching everyone than the surveillance system itself." – PHRB respondent

Furthermore, concerns about lower sensitivity for Aboriginal and Torres Strait Islander groups were not corroborated by an analysis performed by the PHRB Epidemiology Team, showing that from 1 January to 3 October, 2020, testing rates among Aboriginal and Torres Strait Islander people were higher than those for people of other backgrounds for all age groups 25 and above (Ref: Internal document).

One respondent mentioned that the combination of data from multiple sources used by the NSW COVID-19 surveillance system could be used to assess the sensitivity of case detection.

"We have evidence that we are not missing cases because of lack of testing. Because it's not just NCIMS, but all our other data sources … we triangulate data from outside of NCIMS and those within NCIMS ... We are not missing cases in NSW because we are not seeing ED presentations or ICU admissions skyrocket." - PHRB respondent

Sensitivity: In Summary

- The surveillance system was presumed to be highly sensitive, as determined through a range of indirect indicators.

Stability

For the NSW COVID-19 surveillance system, stability would mean that the data stored within NCIMS are accessible and available whenever required by users, and for the system to be able to perform its basic functions, such as collecting and processing case notifications, despite potential strains placed on the system.

In this surveillance system evaluation, the stability of the system in general was assessed through interviewing stakeholders about their subjective experiences of working with the surveillance system. Stability from a technological point of view was examined through discussions with the NCIMS Team, reviewing outages and disruptions to the system and asking specific questions in stakeholder interviews. As well as this, interview respondents were asked about the stability of human resources in the NSW COVID-19 surveillance system, and specifically about the effectiveness of PHRB or PHU staff members working from home. The ability for staff to work from home is relevant to the COVID-19 surveillance system. Staff may need to be quarantined for a range of circumstances related to the pandemic itself, such as after undergoing diagnostic testing, interstate or international travel, or contact with a confirmed case.

Findings

Stability of the system as a whole

The stability of the whole NSW COVID-19 surveillance system involves the reliable functioning of a wide range of system components and processes. This evaluation examined stability mostly from the perspectives of technology and human resources. Interview respondents for this evaluation were also asked a general question about the reliability of the surveillance system as a whole.

Interview question: "We are going to look at the reliability of the point of view of your overall trust in the surveillance system, and also in terms of the absence of any malfunctions, failures or disruptions. With this in mind, please rate the reliability of the NSW COVID-19 surveillance system as a whole from 1 to 4, with 1 representing 'very unreliable and untrustworthy' to 4 representing 'very reliable and trustworthy'."

Rating	Number of respondents (%) *N=20*
No rating given	12 (60)
4	4 (20)
3.5	4 (20)

Twelve of the respondents could only answer this question from the perspective of their experiences with NCIMS, rather than with the whole system. All of the remaining eight respondents gave a rating of 3.5 to 4. Almost all of these respondents mentioned that although the system was not perfect, its stability has been excellent, given the complexity of the system and the volume of data.

Stability of technology, including NCIMS

In terms of technological instability experienced by users in the system, there have been occasions where there were disruptions to internet infrastructure. This occurred either on NSW Health networks, or in individual PHUs due to malfunctioning telecommunications systems in the local area, external to NSW Health. In addition, there were two instances in September 2020 where one particular diagnostic laboratory detected that large batches of historical negative diagnostic test results had not been sent to the PHRB, due to technical errors that were not recognised immediately.

Focusing on NCIMS alone, since the activation of the NSW COVID-19 pandemic response, there have been two version updates to Maven that have required pre-planned full outages of NCIMS (Personal communication: MoH NCIMS Team). Both outages lasted for under 15 minutes, and were scheduled for low-activity periods on the system. All staff members using NCIMS were informed prior to the outages via email and announcements on the NCIMS home page. Until the end of information gathering for this evaluation on November 14, 2020, there had not been a full unplanned outage of the COVID-19 part of NCIMS.

Specific measures were also introduced to improve the stability of NCIMS during the course of the NSW COVID-19 pandemic response. As at November 2020, the number of active servers for NCIMS had been scaled up to seven, from one active server in January 2020 (Personal communication: MoH NCIMS Team). As well as this, the three database servers were scaled up in size. The capability of NCIMS to send and receive HL7 messages was increased from 18,000 messages per day in January 2020 to 320,000 messages in November 2020. In terms of actual volumes of HL7 messages, NCIMS was receiving approximately 1,000 messages per day in January 2020. This had increased to receiving 22,000 messages per day in November 2020. An additional change occurred in July 2020, after it was identified that the process of sending daily close contact follow-up surveys directly through NCIMS introduced instability into the system. Until that point, eligible close contacts were enrolled in an electronic follow-up program where they would be asked to reply to a daily symptom survey sent to their smartphones through NCIMS. Responses were loaded into NCIMS automatically, and any responses requiring PHU follow-up would appear in an NCIMS workflow. This process was resource intensive for NCIMS, and limited the speed and reliability of the system. This was then replaced with smartphone surveys sent through the Whispir platform, which was integrated with NCIMS.

Interview question: "Now just focusing on the reliability of NCIMS when used for the NSW COVID-19 surveillance system, could you please give a rating from 1 to 4, with 1 representing 'very unreliable and untrustworthy' to 4 representing 'very reliable and trustworthy'."

Rating	Number of respondents (%) *N=20*
No rating given	0
4	8 (40)
3.5	6 (30)
3	6 (30)

It is notable that all 20 interview respondents gave ratings of 3 to 4 for this question. Respondents agreed that given the demands placed on NCIMS, it had functioned exceptionally well. Many respondents could remember specific events that they identified as failures or outages of NCIMS. For example, there were times when NCIMS stopped functioning, or slowed significantly, especially later in the evening, after 21:00. Some of the respondents believed the slow operation of NCIMS was due to many users being signed into system simultaneously. Some of the other respondents identified other causes, such as the technological burden of sending large volumes of close contact surveys. Many users reported improvements over time as the capacity of NCIMS increased.

"At the time when there are problems with NCIMS, the system is fairly well supported … by hardworking people who are able to get it back online. It's not a 'set and forget' process. It's mostly that people are able to work things out when they break." – PHRB respondent

Several respondents mentioned that a frequent source of frustration was that when multiple users accessed the same event record on NCIMS simultaneously, only the first user in the record was able to edit any data for this event, and all subsequent users were given view-only access. However, it was also pointed out that this particular feature of NCIMS may actually improve its stability, in that it prevents conflicting changes to records in the system.

When respondent concerns about the stability of NCIMS was discussed with the NCIMS Team, the explanation for some of the observed failures was that there were periods of time where heavy demand had caused NCIMS to run more slowly. This may have been interpreted by users as failures, because NCIMS did not respond as expected in a timely manner. For example, there was one week in July 2020 where one of the denormalised tables, a core part of the data storage structure within NCIMS, needed to be rebuilt by the NCIMS team. The workload that this task placed on NCIMS meant that there was a reduction in the capacity of the system to perform other tasks simultaneously. In addition, every evening around 22:00, the denormalised tables were updated, accounting for the slower functioning of NCIMS at this time. The automated nightly reports from NCIMS to NNDSS were originally also scheduled for this time. However, due to the strain that this placed on system resources, this task was rescheduled to 01:15 on a nightly basis. Outside of these times, a significant demand on NCIMS occurred when users ran COVID-19 reports within NCIMS. In order to limit this, the most resource-intensive line list reporting functions for COVID-19 in NCIMS were disabled in April 2020.

However, it was still possible to run other COVID-19 reports in NCIMS after this time, and this occasionally resulted in the slow running of the system for other users.

Contingency planning for NCIMS

Interview question: "Have you been affected by any failures or outages of NCIMS? If so, what contingency measures were in place? Are you aware of any contingency measures if an outage of NCIMS were to occur? Are you satisfied with these contingency measures?"

Seven of the twelve PHRB respondents were aware of some of the contingency measures for NCIMS outages in place, and felt that as far as they knew, these plans had been reviewed thoroughly. A member of the PHRB Epidemiology Team stated that there were additional specific contingency plans within this team, related to managing and reporting daily case numbers and statistics, if NCIMS was not accessible.

Outside of the PHRB, one PHU respondent felt that there would not have been a local contingency plan for NCIMS outage drafted at her PHU because their time had been occupied with the immediate tasks of the pandemic response. However, most of the PHU respondents were able to identify local workarounds that would be implemented, should there be any unexpected outages of NCIMS.

When contingency measures were discussed with the NCIMS Team, it was clear that there had been extensive planning around the possibility of a catastrophic failure of the information system, including the drafting and revision of a NCIMS Disaster Recovery Plan (Ref: Internal document). The most basic function of the NSW COVID-19 surveillance system of receiving case notifications would be unaffected, as laboratories would still telephone the PHRB Surveillance Officer with new cases. This would then be followed up by a written laboratory notification in the form of an email or facsimile. This new notification would be relayed to the PHRB Operations Team and the relevant PHU by both telephone and email, enabling public health actions to be carried out in a timely manner.

These manual processes would mean that the NCIMS Team would have time to restore NCIMS, even if it is to a read-only version initially, using database backups and a local repository of source code information. One interview respondent had mentioned that given NCIMS is a product that was custom-built for NSW Health, there may not be sufficient people with the appropriate skill set to assist with rebuilding and redeploying a new version of NCIMS rapidly. However, the NCIMS Team felt that this was less of a concern, because there were enough skilled team members locally, and outside of the NCIMS Team, there were also staff members with database expertise in eHealth NSW. Furthermore, there was evidence from past NCIMS failures, prior to COVID-19, that the NCIMS Team had been able to diagnose and resolve the cause of these problems in a timely manner without requiring significant external input. A respondent commented that the relationship between the PHRB and eHealth NSW meant that if there were more widespread systemic problems involving network access, this would be resolved quickly. Another respondent remarked that another potential reason that NCIMS could be inaccessible may be a server failure, and he was aware that there were backup NCIMS servers if this occurred.

Stability of surveillance system resources

The increase in the technological resources within the NSW COVID-19 surveillance system is discussed earlier in this "Stability" section. From a human resources perspective, a rapid increase in the number of staff in the NSW COVID-19 response was required at its activation in January 2020, across multiple teams in both the PHEOC and the PHUs. As at the end of September, when the PHRB Recruitment and Human Resources presented on the NSW COVID-19 workforce surge, more than 1,000 individual staff members had been employed by the NSW PHEOC/PHRB (Ref: Internal document). However, this presentation did not detail the number of staff who held roles that contributed towards the NSW COVID-19 surveillance activities. There has not been a similar summary of COVID-19 staffing in the PHUs.

Interview question: "Are there enough human resources in the NSW COVID-19 surveillance system? Please give your response as a rating from 1 to 4, with 1 representing 'definitely inadequate' to 4 representing 'completely adequate'."

Rating	Number of respondents (%) *N=20*
No rating given	0
4	3 (15)
3.5	4 (20)
3	8 (40)
2.5	1 (5)
2	4 (20)

Respondents gave a range of views in their assessment of the adequacy of human resources in the NSW COVID-19 surveillance system. Most respondents mentioned the initial surge in staff that was required to support the pandemic response. Some PHRB respondents felt that this was well coordinated, while others believed that this surge could have been better managed, with more reinforcements after the initial allocation of staff.

"This was definitely a key part of our effective response in NSW, especially at the start. We could surge a public health team that already knew the system that it was working within. And we had surveillance staff who were already working in infectious diseases surveillance." – PHRB respondent

"Initially we surged from within the Ministry, and did not hire brand new people for a very long time. And so some of the other things at the Ministry had to be put on hold. Or for people who couldn't put their other tasks on hold, it was very draining for a very long time having to manage both." – PHRB respondent

In the PHUs, the consensus was that there were significant difficulties in ensuring adequate staffing of the COVID-19 surveillance system initially in the pandemic response. For some PHUs, this staffing shortage was still ongoing at the time of interview.

"Our PHU is very small compared to others … In the thick of the pandemic, we really didn't have enough people at all. We had to find a lot of people to come and help, and train them before they could be effective members of our surge surveillance staff. It was unbelievably difficult." – PHU respondent

Several respondents saw a distinction between a surge in overall staff numbers, and the recruitment of staff with specific skills.

"It has been challenging to find enough staff to support the Labs Team … to find the right staff. Very few people know how laboratories work, how pathology works and have an interest in public health. And these people were also needed in the laboratories to help with all the COVID-19 testing. I'd say that certain teams have surged adequately, but this is not consistent across all of the teams in the PHRB." – PHRB respondent

"It's not just having enough people who can put the information into the surveillance system. It's also having people who are able to interpret the information that comes out of it." – PHRB respondent

The importance of training and ensuring that staff are up to date with the latest surveillance processes was also mentioned by several respondents.

"The human resources are hard to maintain in the 'in-between times' … how to keep people current when we might send them back to other roles when they're not needed for a surge." – PHRB respondent

Many respondents identified the sustainability of the human resources surge as a risk to the NSW COVID-19 surveillance system.

"It's absolutely not sustainable. A lot of funding has to go into maintaining the human resources in the surveillance system, especially at this level, and the pandemic is creating economic pressures." – PHRB respondent

"It's a huge effort … surging staff, getting them trained … in interviewing, and trained in using the database, and doing the analyses. To continue that will take ongoing commitment." – PHRB respondent

"We're running people very hard. And to be sustainable, we'll have to organise everything better." – PHRB respondent

Working from home arrangements

For reasons of confidentiality, statistics are not recorded about the number or frequency of PHRB or PHU staff members working remotely due to the quarantine requirements of COVID-19.

Interview question: "At times, various people working within the NSW COVID-19 surveillance system have had to work from home due to the quarantine requirements of COVID-19 itself. Has this been accommodated adequately by the system?"

Most of the respondents had personal experiences of working remotely, and felt that the systems in place had been adequate for their needs. Some respondents also mentioned that they have had team members who have needed to work from off-site locations, and they have not noticed any changes to the quality of work produced by their team as a result.

Several of the respondents commented that while the technology to allow working remotely had been very satisfactory, from an operational perspective, it had been difficult to carry out their tasks in the COVID-19 surveillance system offsite.

"We can get work done quickly from home, even though the internet connection at home might not be ideal. The technology is there. But the management doesn't like people working from home. Most of the senior people aren't familiar with the teleconferencing technology. When something needs to be done, they're not comfortable getting on Skype and calling people working from home. They prefer finding somebody who is there on the floor to get the job done." – PHRB respondent

"… in terms of the nature or culture of the public health response itself, especially within the PHRB, it has not been very flexible for working from home or working remotely … we should have a better think about what can be done on site, and what can be done remotely." – PHRB respondent

However, one respondent noted that executives in the NSW COVID-19 pandemic response actively encouraged working onsite.

"It's a business decision, to make sure that everyone's here. Most of the work is responsive. You need to be in the room to manage that. But we do have some people working offsite if they need to. They work on projects. We look at this on a case by case basis. But generally, the system can handle that." – PHRB respondent

One respondent identified that some additional barriers for PHU staff members working remotely were related to hardware requirements.

"The fact that NCIMS is accessible from everywhere definitely enables working from home. But there are still other barriers in the PHU setting. We don't have laptops, so we're very reliant on desktop. We're also using paper forms, so this limits being able to process case questionnaires from home if there's no scanner and printer at home." – PHU respondent

Stability: In Summary

- The stability of the NSW COVID-19 surveillance system was perceived to be high.
- NCIMS was a reliable information management system for the surveillance system.
- There was adequate planning for unexpected failures of NCIMS.
- The staffing surge required by the surveillance system was a substantial undertaking and was largely successful, with some specific shortcomings identified. There were ongoing challenges with sustaining this workforce.
- The surveillance system was mostly able to accommodate staff members being personally impacted by the pandemic and having to work remotely.

Usefulness

Usefulness denotes the degree to which the surveillance system serves an effective purpose, and is often included in surveillance system evaluations as part of the attribute of acceptability(10). However, a decision was made to examine usefulness as a standalone attribute in this evaluation, given that it was nominated as a priority by several stakeholders.

In this evaluation, usefulness is assessed qualitatively through stakeholder interviews. Respondents were asked about their satisfaction with the data analysis performed within the system, as well as their satisfaction with the outputs of the surveillance system, such as reporting. Respondents were also asked about whether they had experienced any changes to policies and processes as a result of the data generated by the surveillance system. Another end outcome that was used to assess usefulness was the public messaging from the NSW COVID-19 response about demographic factors, venues and activities associated with higher transmission risk, informed by the surveillance data.

Findings

Analyses and reporting of surveillance data

Interview questions:

"How satisfied are you with the analysis of the COVID-19 surveillance data that has been performed by staff members within the NSW COVID-19 surveillance system? Please give your answer as a rating from 1 representing 'very dissatisfied' to 4 representing 'very satisfied'."

"How satisfied are you with the outputs of the NSW COVID-19 surveillance system? This mainly includes reports, but also responses to stakeholder enquiries, datasets for PHUs and any other end products that include NSW COVID-19 surveillance data. Please give your answer as a rating from 1 representing 'very dissatisfied' to 4 representing 'very satisfied'."

Rating	Analyses of surveillance data Number of respondents (%) *N=20*	Reporting and other outputs Number of respondents (%) *N=20*
No rating given	5 (25)	4 (20)
4	8 (40)	10 (50)
3.5	3 (15)	1 (5)
3	2 (10)	5 (25)
2	2 (10)	0

Respondents who gave a rating of 4 to both questions felt that in general, the analysis and reporting from the NSW COVID-19 surveillance system was of high quality, and responsive to the needs of a diverse range of audience members.

"I'm very happy with the reports. They're very thorough and even include sewage testing results. But for busy people like me, we're still able to skim through the reports and get what we need, so they're reader-friendly." – PHU respondent

"I think data from the surveillance system has never been more available, really. The weekly reports are very timely. They are comprehensive and are published regularly, and then there are special in-depth focus reports done frequently too. And then we do some ad hoc analyses for various media enquiries, or other enquiries. And then there's also information available on the web … and in the media releases too. There's data made available on the government website, so people can actually get data to analyse themselves … Also, with the reporting, I think people generally think that's pretty good. There's been lots of positive feedback about the reports." – PHRB respondent

Three respondents felt that although the end products were of high quality, some improvements were still needed in the analysis of the surveillance data.

"There's great transparency and detail. The reports are maybe some of the best in the world! Where the analysis falls down is that sometimes at the PHUs, we want to look at things that aren't reported centrally … Normally, we can just pull the data out ourselves and do what we want with them. But with COVID we have to rely on what comes to us from the Ministry … They've been quite responsive. But it's still not the same as just being able to answer your own questions." – PHU respondent

Conversely, for five respondents, the main area of improvement was the reporting and other outputs from the NSW COVID-19 surveillance system.

"Some of the reporting can be slightly confusing in terms of wording for people who don't have a health background. It's hard to digest for people like me who have come from outside of the health fields. And yet I have to then communicate this information onwards and put it in layman's terms, when it's already difficult for me. Also with our responses to external enquiries, sometimes it's tricky in terms of how the question is actually interpreted by us. And there could be subtleties in the way that the question is answered that can be difficult to communicate. And the actual answer might need approval by several levels of people before it's ready to be sent back." – PHRB respondent

"The reporting on Aboriginal and Torres Strait Islander people … that featured vulnerability discourse in the past, but it's great that the Epi Team have taken feedback on board. They were responsive to feedback and have made changes." – PHU respondent

One respondent felt that both the analysis and the reporting aspects of the NSW COVID-19 surveillance system had improved over time, but were not yet ideal.

"We've been working on the feedback that we're getting. We're providing rapid information to a lot of stakeholders … That's probably taken a little bit of time, to get the detail and balance of our analysis and reporting right. But there's still a lot more to do with that to make it even better. Our audience is fairly broad. And there are certain groups, for example the LHDs, that have different use cases for our data as well. So we're having to work together with a range of people to identify the key questions that we want to provide answers to." – PHRB respondent

Public communication

Interview question: "In your opinion, how well has relevant information from the surveillance system been relayed to the public in terms of risk communication? Examples of this might be informing the public about venues with possible transmission, or the areas that we're targeting for increased testing. Please give your answer as a rating from 1 representing 'very poorly done' to 4 representing 'very well done'."

Rating	Number of respondents (%) *N=20*
No rating given	1 (5)
4	11 (55)
3.5	3 (15)
3	5 (25)

The eleven respondents who gave this aspect of the surveillance system a rating of 4 felt that in general, this was well done.

"We are sometimes communicating venue or hotspot information online within two hours of finding out about them! So it's very rapid, and done very well." – PHRB respondent.

"It has been done very well to a large degree … based on the number of people who have come forward for testing, based on the number of people who are doing the right thing in public with social distancing and wearing masks … And also when we call the close contacts from venues that we're worried about, most of them have already quarantined themselves at home." – PHRB respondent

"For the COVID response, there are so many parts of the surveillance system that have some responsibility for public communications … the Epidemiology Team, the Communications team, there's Operations too. So it's quite an impressive group effort, the way we've used the information we've collected … done analyses on risks like hospitalisation, and then made all that digestible for the public in a timely way, to inform them in their daily lives." – PHRB respondent

Most of the remaining respondents explained their ratings by stating that as with most other public communications, there were members of the community who were more difficult to engage.

"As with all public health communications, it's difficult to contact people who are consuming media information at a low level. Even with targeted messaging, there are always going to be people that you won't reach or engage with." – PHRB respondent

"In the end, it depends on the individual member of public. There are bottlenecks in information getting through to certain groups of people. But people are also starting to pick up on some of the terminology, they know what hotspots are, for example." – PHRB respondent

Some respondents remarked that improvements still needed to be made regarding the public communication of venues of concern.

"We're trying very hard to get the venue information to the public quickly. We often put it in the media on the same day. But there can be many inconsistencies, especially when there are third party app providers involved … there can be many issues with the data … We're sometimes just trying to rush it through despite these issues, and there can be errors with the venue information." – PHRB respondent

Changes to public health strategies and processes

Interview question: "Has anything that you do in your COVID-19 role changed as a result of the information from the NSW COVID-19 surveillance system? How about policies and strategies that have changed because of the surveillance data?"

From an internal processes point of view, several respondents from both the PHRB and PHUs stated that collecting and working with NSW COVID-19 surveillance data had led to constant adjustments in the data collection processes within the surveillance system. For example, the way that specific questions were being answered by cases or interpreted by interviewers led to changes in the wording of case questionnaires.

In addition, certain PHUs made internal structural changes, such as the allocation and rostering of surge staff, based on the demographic information in the surveillance system, such as ethnicity and First Nations status.

Respondents also reported that the information from the NSW COVID-19 surveillance system had been instrumental in guiding pandemic response strategies and actions.

"Well, to give an example, in our weekly epi reports fairly early on in the pandemic, we saw that the under-24 age group … they were not getting tested. So we started drafting a communications campaign for this age group. We had already pre-empted that the Chief Health Officer would look at this data and announce that we needed to improve testing in this group. So all of our comms materials were ready to go as soon as she had made that announcement. And this way, we made the under-24s into one of the most-tested groups in the state!" – PHRB respondent

"Influencing policy change is one of the key pillars of the surveillance system, really. Often the data is combined with local intelligence to make decisions. For example, the decisions around social distancing, where to place restrictions. So a big part of what the surveillance system tries to do is making sure that decision makers have the information in an understandable and timely way." – PHRB respondent

"It's certainly changed policy … I'd say in terms of pushing testing to the people who may not have been tested, in terms of identifying links among cases, and risk factors for cases … it's been vital to the response." – PHRB respondent

Additional examples given by respondents of local strategy changes in response to surveillance outputs included decisions on the locations of mobile testing clinics. One LHD reported changing its hospital and aged care facility visitor policies based on a combination of local and state-wide surveillance data.

Usefulness: In Summary

- The analyses and reporting from the NSW COVID-19 surveillance system have been comprehensive and have accommodated the changing needs of a range of stakeholders.
- Public communications using the information from the surveillance system has been mostly effective, with some potential for minor improvements in terms of accuracy of exposure venue information and language used.
- The outputs from the surveillance system have been useful for informing public health response strategies and policies.

Data security

According to the NSW Health Privacy Manual for Health Information (2015), data security is "a tangible set of physical and logical mechanisms which can be used to protect information held in hard and soft copy, digital format, within computer systems, via telecommunications infrastructure, etc" (p 1.04, (26)). In the NSW COVID-19 surveillance system, this includes data in a number of locations. As well as NCIMS, data security also needs to be considered for information in other digital forms such as emails and computer files, in physical forms such as printed and handwritten records on paper and on whiteboards, and in verbal forms such as information shared verbally in meetings and briefings.

There are no formal metrics for the security of a public health surveillance system(37). There has not been a formal data security assessment for the NSW COVID-19 surveillance system as a whole. However, as discussed in Section B of this report, in July 2018 an NCIMS security assessment was carried out by NSW Health and eHealth NSW, with the engagement of an external consultancy firm (Ref: Internal document). The findings of this report were revisited during the pandemic response in October 2020. This review concluded that all 30 findings from 2018 had been addressed, and that there were no further actions required to improve the security of NCIMS.

Findings

The structures and processes in place for cybersecurity across NSW Health are discussed in the "Data and system security" section. This section also included some discussion of areas where these security measures were suboptimal. Most notably, these were that certain laboratories were emailing identifiable patient information, and that the files saved in the Content Manager system were accessible to NSW Health staff outside the pandemic response.

Until the end of data collection for this evaluation on 14 November 2020, there have been zero known incidents of intentional data breaches or breach attempts in the NSW COVID-19 surveillance system (Personal communication: MoH NCIMS Team).

Interview question: "In your opinion, are the data in the NSW COVID-19 surveillance system secure? Please give a rating from 1 to 4, with 1 representing 'not secure at all', to 4 representing 'very secure'."

Rating	Number of respondents (%) *N=20*
No rating given	6 (30)
4	8 (40)
3.5	1 (5)
3	1 (5)
2.5	1 (5)
2	3 (15)

Six of the interview respondents declined to give a rating for the security of the NSW COVID-19 surveillance system, stating that they did not know enough about this. Most of the eight respondents giving a rating of 4 considered data security from the point of view of NCIMS only. It was felt that from the perspective of secure data storage and limiting access to unauthorised staff members, there were no reasons for concern. Several respondents remarked that they were comfortable accessing NCIMS from home, with the additional security measures in place for external internet networks.

Some of the respondents also commented that the creation of COVID-only NCIMS accounts for surge staff was an effective additional security measure. However, two of the respondents were concerned about the potential security implications of granting access to network drives to a large number of surge staff.

"NCIMS is very secure, and the IT system … is very secure. There are many security processes in place. But with the surge … there are a lot of people who have been given access to identifiable data. I'm unsure whether we have the measures to secure this more. So if you don't have a password, it is very difficult to get into the system. But if you have one, then you can go and access everything." - PHRB respondent

A few of the respondents mentioned the security risks of sending identifiable information without using secure file transfer software. Anecdotal information, such as the interview responses collected in this evaluation, suggested that this was a common practice in the pandemic response. One respondent from the PHRB also voiced dissatisfaction with the physical aspects of information security, such as locking computer screens when not in use.

Another concern raised was the security of information shared at PHRB briefing teleconferences. The PHRB Pandemic Response Coordination Team was requested by the PHRB executives to conduct random teleconference participant list checks to ensure that attendance was strictly limited to those invited. However, several shortcomings in this checking process were identified. The process involved scrolling through the list of participant names displayed on the teleconference screen, but participants were asked to choose the name that was displayed to other users, and there was no reliable way to verify that this name corresponded to the actual participant. Furthermore, participants who joined the teleconference via mobile phones appeared as "anonymous" in the list displayed, and there was no method to determine the identity of these participants.

Data Security: In Summary

- The NSW COVID-19 surveillance system was generally secure to external threats.
- There were several internal sources of security threats that required further attention to mitigate.

Confidentiality

The confidentiality of the NSW COVID-19 surveillance system is examined separately to data security in this evaluation. According to the NSW Health Privacy Manual for Health Information (2015), confidentiality is "a professional duty ... between a health practitioner and his or her patient that places restrictions on the disclosure of information provided by the patient as part of the care and treatment given by the practitioner" (p 1.01, (26)). In the context of the COVID-19 surveillance system, this means not disclosing identifiable information to parties that do not require this information to carry out public health actions, and to parties outside of NSW Health without receiving permission from PHRB executives to do so. In this evaluation, confidentiality is examined through interviews.

Findings

Interview question: "Do you feel that the NSW COVID-19 surveillance system maintains adequate levels of confidentiality? Please give a rating from 1 to 4, with 1 representing 'not adequate at all' to 4 representing 'very adequate'."

Rating	Number of respondents (%) *N=20*
No rating given	7 (35)
4	5 (25)
3	1 (5)
2.5	1 (5)
2	6 (30)

Seven of the respondents declined to give a rating for confidentiality. Three of these respondents felt that it was not possible to give a system-wide score, because maintaining confidentiality was more dependent on the choices and actions of individual staff members within the surveillance system.

However, another respondent, who gave a rating of 2, felt that individual staff practices around confidentiality should be addressed by the system. She believed that there were appropriate confidentiality policies in the surveillance system, but there was a gap was translating these to staff practices.

A variety of reasons were given by the respondents who rated the confidentiality of the surveillance system as 4. One respondent was satisfied with the confidentiality of the surveillance system because whenever there had been doubts about whether it was appropriate to give a particular piece of personal information to a third party, legal advice had been sought by PHRB teams. Another respondent viewed the confidentiality of the system from the perspective of media releases and public information, and felt that there had always been an emphasis on ensuring that individual cases and contacts were not identifiable through these channels.

Some of the other respondents viewed confidentiality from a policy point of view only. They felt that in terms of the policies and processes in place around confidentiality, the surveillance system was adequate. An example given of this was that all correspondence with NSW Police were mediated through the NSW Health Police Operational Centre Liaison Officer (POCLO).

"There are good processes in place ... When the police ask us for information, we direct them through the POCLO. We send our responses through the POCLO … The POCLO knows who's allowed to know what information, and it's all been agreed upon beforehand ... So we don't have to worry about giving confidential information to the wrong people." - PHRB respondent

The remaining respondents gave the confidentiality of the surveillance system scores of 2-3. All of these respondents stated that their main concern was around the communication of case and contact information by staff members working in the COVID-19 response. It was felt that emails containing sensitive and identifiable information about cases and contacts were sometimes sent within and between different teams in the MoH and PHUs, without adequate consideration of whether all recipients required this information to carry out public health actions.

Another respondent pointed out that in the first few months of the pandemic response, the surveillance system also corresponded with external parties, who had email addresses outside of NSW Health, regarding identifiable individual cases and contacts.

A further respondent from a local PHU felt that there were concerns around the sharing of information with LHD teams. While LHD teams have been a part of NSW Health, the respondent believed that they were requesting more information than was necessary for an appropriate LHD response to local COVID-19 cases.

"… I was on the local hospital eMR system, and found that the entire interview for one of these patients, including name and contact information of close contacts, was uploaded local hospital for everyone working at the hospital to see." - PHU respondent

In addition, a respondent was of the opinion that even though NSW Health releases only gender, age range, locality and risk group information about confirmed cases to the public, these details could still be identifiable in a small community.

"In some small communities, especially First Nations communities, cases can still be identifiable with the limited information that we release to the public … there's now some work on a COVID-19 dashboard using AI (artificial intelligence) and machine learning to create statistical noise around priority population groups that have small numbers, where cases may be easily identifiable. There is a lot more to be done in this area, and to think more creatively in areas like this in the surveillance system." - PHU respondent

Confidentiality: In Summary

- There was a comprehensive range of processes in place in the NSW COVID-19 surveillance system for maintaining confidentiality across different parts of the system.
- Individual staff member adherence to these processes for confidentiality was variable, and was suboptimal in some cases.
- A challenge identified was managing external stakeholder requests in a confidential manner. This was improving over time.
- Additional measures to ensure confidentiality in smaller communities would be a useful development.

Section D: Conclusions and Recommendations

Overall

This evaluation has shown that the NSW COVID-19 surveillance system was generally highly regarded by stakeholders.

In addition to the strengths of the system listed in this section, stakeholders suggested two factors that contributed to the satisfactory performance of the surveillance system.

Many stakeholders felt that the planning work within NSW Health in the years prior to the pandemic was crucial to the performance of the COVID-19 surveillance system when it was deployed. The preparations involved maintaining a skilled pandemic response workforce that could be called upon at short notice. This was achieved through regular training workshops for HPNSW staff and NSW Health Public Health Officer trainees. There was also groundwork in ensuring that the information management system was ready to respond. Some stakeholders commented on the speed of adapting NCIMS to record COVID-19 data as a positive feature of the NSW pandemic response. The development of human and technological capacity for outbreak response were combined in the PaNCIMS exercise in 2017, which was given as an example of preparedness by several stakeholders.

Stakeholders also commented that the surveillance system was highly valued by decision makers, with a general understanding of the role of timely and accurate data. There was interest from a high level in the operational aspects of the system, and ongoing investment in the resources required. Innovations in data collection and reporting were encouraged. Surveillance system staff were given feedback on how the system outputs were used to inform public health strategies.

Stated goals of the surveillance system

The nine stated goals of the NSW COVID-19 surveillance system, as set out by the NSW Surveillance Plan, had been met partly or fully as at November 14, 2020(16).

The areas where the surveillance system had performed well include goals 1, 2, 3 and 7. Goal 1 was to provide daily updates on the characteristics of COVID-19 cases. The surveillance system was able to achieve this in a timely and accurate manner, and to provide additional details on priority groups.

Goal 2 was to provide daily updates on deaths due to COVID-19. Generally, this was satisfactory. There was some reliance on treating clinicians to notify the surveillance system of new deaths. However, once this information was received, there were robust processes in place to verify the circumstances of the death, and to obtain permission from next of kin to release de-identified information through NSW Health Media.

Goal 3 was to provide daily updates on tests performed, and calculations of test positivity rates. This was viewed as a particular strength of the surveillance system by many stakeholders, and was made possible by using the surveillance system to track all diagnostic tests performed regardless of the result.

Goal 7 involved monitoring the impacts of COVID-19 on the tertiary healthcare system. This was achieved satisfactorily through monitoring COVID-19 emergency department presentations, hospital admissions and ICU admissions through several methods. However, there were stakeholder comments that this was undertaken better for public than for private hospitals.

Surveillance goals 4, 5, 6 and 9 were met more satisfactorily in certain settings and contexts. Goal 4 was to report on the performance of contact tracing. The creation of event records for contacts was made possible for COVID-19 on NCIMS. Having these records then allowed additional data for contacts to be collected, such as date of interview and isolation, and subsequent development of symptoms. However, it was widely perceived by stakeholders that this information was collected in a more complete and timely manner for household contacts than for contacts in other settings.

Goal 5 involved reporting on clusters, outbreaks and other community trends. A variety of strategies were used to achieve this, with some performing better. Strategies that were particularly effective included detailed collection of data for cases and contacts in clusters. Data linkage was particularly useful for identifying individuals who belonged to Aboriginal and Torres Strait Islander priority groups. Whole genome sequencing was used effectively to examine epidemiological relationships, and to monitor for introductions of new viral variants. Environmental surveillance through wastewater sampling was shown to be a sensitive method for detecting viral shedding in defined geographical areas. Syndromic surveillance for respiratory illnesses drew upon pre-existing surveillance mechanisms within NSW, and was identified as another useful source of information. Areas needing improvement included linking individuals within clusters, and tracking of venues of exposure in the community.

Goal 6 was to describe the clinical severity of COVID-19. The achievement of this goal was limited. Case interviews in NSW allowed for a wide range of symptoms to be recorded. In the initial weeks of the pandemic, these data added to the national evidence base for asymptomatic infection. There were special editions of the weekly surveillance report that included analyses of the symptoms of NSW cases. However, these analyses were performed infrequently. Clinical severity was also captured through monitoring hospital and ICU admissions of COVID-19 cases. This was thought to be effective.

Goal 9 was to undertake strategically targeted asymptomatic screening. Part of this goal was to carry out these screening activities in association with a known case. This was achieved effectively for cases in residential aged care facilities, where in response to a confirmed case, testing protocols were initiated to screen other residents and staff, often on a repeated basis. Another high risk setting where asymptomatic screening was particularly useful was the hotel quarantine system for newly arrived travellers. As at November 14, 2020, there was consideration of implementing asymptomatic screening to investigate outbreaks in other settings.

Goal 8, conducting serosurveys, was undertaken by external research partners, with some use of the NSW COVID-19 surveillance system data. These activities were not examined in this evaluation.

Strengths of surveillance system

To highlight features of the surveillance system that should be maintained and supported, the main strengths of the system identified in this evaluation are summarised into the following ten points:

Proactive and collaborative communication between all pandemic response teams

Stakeholders interviewed expressed that other teams in the response were willing to communicate frequently and promptly. A particular strength identified was the use of digital technology, such as video conferencing, to enhance communication.

Adaptability of the surveillance system to change

The rapidity of change in the pandemic response was emphasised as a considerable challenge by many stakeholders. However, most stakeholders also mentioned that a particular strength of the surveillance system was its ability to adapt to these changes and to maintain its performance despite ongoing adjustments.

Timely performance of the surveillance system at each stage of the pathway for notification of positive COVID-19 cases

Stakeholders indicated that the time taken between the detection of a positive COVID-19 result and the commencement of public health actions was extremely prompt. All steps along this pathway had been optimised for efficiency. Furthermore, there were performance indicators in place to monitor performance for many of these steps.

Implementation of strategies to improve data completeness and quality

Specific examples of effective strategies highlighted by multiple stakeholders were data linkage projects and the creation of the Data Quality Team. It was felt that the introduction of the Data Quality Team resulted in noticeable improvements.

Familiarity of NCIMS to many staff members, especially following recent training activities for using NCIMS in an emergency response

Stakeholders highlighted that the decision to adapt existing surveillance mechanisms to emerging outbreak threats was made well in advance of the pandemic. There were experienced staff in both the PHEOC/PHRB and the PHUs who had undergone training and who were already adept at using NCIMS for surveillance. These staff members provided assistance and support to newer staff.

Highly sensitive system, with monitoring and reporting of indicators of surveillance system sensitivity

It was generally believed by stakeholders that most undetected cases of COVID-19 in NSW would be due to factors outside of the performance of the surveillance system. Stakeholders also felt reassured of this assessment because it was corroborated by the surveillance system collecting a range of proxy indicators of sensitivity, such as testing rates in priority sub-populations, and the number of unplanned respiratory presentations to Emergency Departments.

A stable information management system in NCIMS

Despite undergoing multiple extensive changes to accommodate the needs of the pandemic, NCIMS was a reliable information management system. As at November 14, 2020, there had not been any unplanned system outages. There were ongoing efforts to ensure the stability of the system over the longer term, and thorough contingency planning for any potential unexpected failures in the future.

Adaptability of the system to human resource needs, such as the ability to surge staff numbers rapidly, and the ability to accommodate remote work

The evolution of the pandemic response in NSW had meant that the surveillance staffing requirements changed at short notice. In general, these requirements were met successfully, within relatively prompt timeframes. An additional challenge posed by the pandemic was the need for staff in the surveillance system to remain at home if symptomatic or if identified as a contact of a COVID-19 case. Surveillance staff members who had experienced this personally reported that the system was adequately flexible to allow this to occur, without any compromise in performance.

Comprehensive and responsive analysis and reporting that has been useful to decision-makers

Stakeholders who use the outputs of the surveillance system, such as the weekly surveillance reports, indicated that these products have been comprehensive, and have been responsive to the changing needs and priorities of a broad audience throughout the evolution of the pandemic. Many of the indicators and analyses were developed in consultation with relevant stakeholders, and refined through ongoing collaboration.

Security of data to external threats

Stakeholders felt that the surveillance data, once stored within the system, was secure from unauthorised access by external parties.

Recommendations

The Table of Recommendations provides a summary of the recommendations described in detail in the following section. It also outlines the feedback from principal stakeholders when these recommendations were presented to and discussed with them in October 2021.

Recommendation 1: Training and maintenance of skilled workforce

Three main actions are recommended.

Creation of NCIMS training checklist for all new surveillance system staff

The PHRB Epidemiology Team should develop an NCIMS training checklist for new users to be used as part of the orientation and onboarding process. This checklist should set out the skills that new surveillance staff need to have in terms of working with NCIMS and keeping updated with NCIMS changes. The delivery of training to complete this checklist can be adapted to local orientation processes at PHUs and at the PHRB. This may be accompanied by digital training materials developed centrally by the PHRB Epidemiology Team or NCIMS Team. This would ensure that the NCIMS training for new surveillance system staff is thorough and comprehensive, while remaining flexible to local needs and processes.

Continued development of surveillance system training material for pandemic response staff

The PHRB Epidemiology Team should review current training material for surveillance staff, and develop additional training material that cover:

- Roles and responsibilities of each team
- Communication processes
- NCIMS, as per the training curriculum already described
- Processes for linking cases, contacts and clusters, once developed
- Processes for recording exposure venue information, once developed
- Processes for recording WGS results

This would allow all surveillance staff to continue to be skilled in using the most current procedures in the surveillance system.

Development of a central repository of surveillance system user resources

The PHRB Epidemiology Team should establish a central, digital repository of relevant documents for staff within the NSW COVID-19 surveillance system. These documents could include standard operating procedures, user guides, the most current versions of questionnaires, change documentation, and any other resources that are considered useful. The most current version of documents should be clearly identifiable, with clear version dates. Major changes to existing documents should also be communicated through email. This should be additional to clearly marked updates in the central repository. Where there are changes to electronic questionnaires, these can be highlighted with text prompts visible to the user. This would enable pandemic response staff at all sites to have clarification about the most recent changes, and the most current procedures.

- **Attribute(s) addressed:** Simplicity, flexibility
- **Surveillance system goal(s) addressed:** 1, 2, 4, 5 and 6
- **Suggested time frame for completion:** Two months

Recommendation 2: Continued improvement of processes for transferring laboratory data

Two main actions are recommended.

Continued collaboration with non-ELR diagnostic laboratories to establish ELR processes

The PHRB Epidemiology Team and Laboratory Liaison Team, and the MoH NCIMS Team should continue to provide guidance and support for non-ELR laboratories to implement ELR processes for the reporting of COVID-19 diagnostic results. This may also involve making changes to the back end processes of NCIMS, and the capacity of NCIMS to receive and process higher volumes of electronic messages from the laboratories. This would result in more timely communication of diagnostic results, and reduce the human resources requirements for this process.

Continued collaboration with diagnostic laboratories to improve security of identifiable information sent to the PHRB

The PHRB Laboratory Liaison Team should discuss emailing practices with diagnostic laboratories that send identifiable patient information directly through email, without encryption or password protection. This discussion should include:

- Review of current diagnostic laboratory practices, and any challenges faced
- Potential alternative methods for the diagnostic laboratory to notify cases more securely

This would improve data security at the point of information entering the surveillance system.

- **Attribute(s) addressed:** Flexibility, data security
- **Surveillance system goal(s) addressed:** 1 and 3
- **Suggested time frame for completion:** Six months

Recommendation 3: Continued development of user-friendly processes to capture close contact and transmission cluster information

The PHRB Epidemiology Team should lead discussions with the PHRB Operations Team, the CCTT and PHUs to determine the processes and needs of all groups in terms of capturing links between cases and contacts, and between individuals and clusters. The Epidemiology Team should then draft proposals for possible improvements to these processes, to feed back to this discussion group for ongoing refinement and eventual implementation. This would allow staff across pandemic response teams in both PHRB and PHUs to obtain relevant outbreak information in a more useful format, and facilitate rapid epidemiological cluster analyses.

- **Attribute(s) addressed:** Simplicity
- **Surveillance system goal(s) addressed:** 4 and 5
- **Suggested time frame for completion:** Two months

Recommendation 4: Improve surveillance for venues of exposure

The PHRB Epidemiology Team should lead discussions with the PHRB Operations Team, the CCTT and the Communications Team to determine the requirements of all groups in terms of recording and reporting exposure venues. The Epidemiology Team should then draft possible solutions to feed back to this discussion group, and to refine and trial these draft solutions collaboratively, prior to implementation. This would allow more efficient management of and communication around exposure venues, and more effective investigations of these venues. There would also be a reduction in potential errors in reporting this information to stakeholders and public audiences.

- **Attribute(s) addressed:** Simplicity
- **Surveillance system goal(s) addressed:** 1, 4 and 5
- **Suggested time frame for completion:** Six months

Recommendation 5: Improvement of ethnicity and occupation data

Despite external database linkages recognised as a strength of the system, the NCIMS electronic fields related to ethnicity and occupation had the lowest percentages of completion. The PHRB Epidemiology Team should explore methods to improve both retrospective completion and ongoing data collection around variables related to ethnocultural and occupational subgroups. This could include the involvement of the Data Quality Team and additional data linkage activities. This could be incorporated into training activities outlined in Recommendation 1.

- **Attribute(s) addressed:** Data quality
- **Surveillance system goal(s) addressed:** 1, 2, 3, 4, 5 and 6
- **Suggested time frame for completion:** Six months

Changes since November 14, 2020

Since the final date of data collection for this project on November 14, 2020, the NSW COVID-19 surveillance system has continued to evolve. This was driven by a combination of continued internal monitoring and evaluation, and of subsequent developments in the pandemic, such as the introduction of vaccines and the new threats posed by variants of concern.

Recommendations from this evaluation, as they appear in this section, were presented to principal stakeholders on October 29, 2021. Their feedback from this discussion, as well as additional information from other stakeholders about ongoing surveillance system developments, are outlined here.

Recommendation 1: Training and maintenance of skilled workforce

The principal stakeholders agreed that it was a priority to ensure that the COVID-19 surveillance system workforce received appropriate and adequate training for their roles. It was also thought to be useful to continue to review staff training needs regularly as the pandemic response evolves.

Since November 2020, new information systems and tools have been added to the NSW COVID-19 surveillance system. One of these new platforms was the COVID-19 Case Assessment System (CCAS), which was used to assist with the management of confirmed cases. The NSW Health Education and Training Institute (HETI) collaborated with PHRB to develop online training modules for public health staff who were new to the platform.

Recommendation 2: Continued improvement of processes for transferring laboratory data

As at October 2021, most diagnostic laboratories had implemented ELR processes for reporting COVID-19 results. This included all public laboratories. The laboratories that had not implemented ELR were the smaller laboratories that processed very few diagnostic tests for SARS-CoV-2. For these laboratories, the outlay in implementing ELR would be prohibitive, and disproportionate to their testing volumes. Therefore, it was not expected that any of these outstanding laboratories would establish ELR processes. From the perspective of the principal stakeholders, the task of implementing ELR in as many diagnostic laboratories as practicable was complete.

In terms of improving the security of the clinical information sent from diagnostic laboratories to the COVID-19 surveillance system, this was thought to be part of ongoing efforts to refine communication processes with diagnostic laboratories that will continue to develop.

Recommendation 3: Continued development of user-friendly processes to capture contact and transmission cluster information

The principal stakeholders acknowledged that it was an ongoing challenge to capture this information in a way that met the needs of all teams in the surveillance system. They also felt that it was not necessarily a disadvantage that each team may choose to record the same information differently, given that this may fulfil different aims.

Since November 2020, there have been continued refinements to the processes to record information at a cluster level, and to link cases with close contacts. The introduction of CCAS was one of these refinements, which may have improved documentation about clusters for case management activities, but not necessarily for data analysis. For the purposes of the latter, new electronic fields had been introduced in the NCIMS case and close contact questionnaire wizards to capture information on settings of transmission more systematically. However, it was discovered that during periods of high workload, the completion of these fields was suboptimal.

Recommendation 4: Improve surveillance for venues of exposure

The NSW venue tracking digital platform was operational from September 2021, and allowed exposure venue information to be viewed more clearly and managed more effectively (Personal communication: PHRB Operations Team). This followed the introduction of the Venue Risk Assessment Team (later renamed the Venue Management Team) to the PHRB structure in July 2021. The role of this team was to assist PHUs in performing exposure risk assessments at venues of concern, and to follow up individuals who were determined to be high risk contacts through this assessment.

The principal stakeholders felt that these changes had improved the capability of the surveillance system to monitor venues substantially. Along with the state-wide introduction of quick response (QR) code check-in system for venues, as at November 2021, it was much more straightforward for surveillance system staff to assess, monitor and publish exposure venues of concern on the NSW Health website.

Recommendation 5: Improvement of ethnicity and occupation data

The data completeness snapshot of confirmed cases for PHUs was created on a more regular basis in 2021. The 2021 version of the snapshot continued to include fields related to ethnicity and occupation. PHU staff continued to review these snapshots, and completed data entry retrospectively where possible. Between July and September 2021, other HPNSW staff also assisted the PHRB Epidemiology Team with data entry for a range of variables, including ethnicity and occupation fields.

The principal stakeholders felt that during times of increased case volumes, the ethnicity and occupation fields had lower rates of completion. However, for cases and close contacts with high risk occupations, such as healthcare workers, the completeness of the field was generally satisfactory. Therefore, from a perspective of informing and prioritising public health actions in high risk settings, data completeness was thought to be adequate.

Appendix 1: NSW COVID-19 Surveillance activities and strategies

As at November 14, 2020, the main activities of the NSW COVID-19 surveillance system, designed to fulfil the stated surveillance goals (Table 1 in main report), were as follows(16).

Case-based notification

Surveillance goals addressed: Provide daily updates on the characteristics and time-trends of COVID-19 cases; Report on clusters, outbreaks and other community trends in COVID-19 related illness

The priority for the NSW COVID-19 surveillance system was to capture every confirmed case of COVID-19. This formed the official COVID-19 case count for NSW, and was the most basic function that the surveillance system was designed to perform. Case-based notification relied on laboratories and medical practitioners to notify HPNSW of all positive COVID-19 diagnostic test results (Figure B4 in main report).

Test-based surveillance

Surveillance goals addressed: Provide daily updates on tests performed to detect SARS-CoV-2 infection; Report on clusters, outbreaks and other community trends in COVID-19 related illness

In addition to the reporting of positive cases, the results of all other diagnostic PCR tests for SARS-CoV-2 performed in NSW were notified to the surveillance system. This was a feature that had not previously been a routine component of the NSW notifiable diseases surveillance system. However, at the commencement of the COVID-19 response, the NSW Minister for Health issued a directive to diagnostic laboratories to report all SARS-CoV-2 PCR test results. This was at the recommendation of the CHO and other senior staff within NSW Health, based on previous experience from the management of pandemic influenza in 2009 (Personal communication: PHRB Surveillance Team).

The primary rationale for requesting negative and other (such as indeterminate, inadequate specimen, technical error) test results was to obtain accurate denominator data in terms of the population being tested. This enabled public health staff to determine whether changes in case numbers were due to changes in testing patterns, or to true changes in the NSW population prevalence of COVID-19. In addition, testing data allowed assessment of whether adequate testing was occurring in the community, or whether additional public health messaging was required to increase the number of people presenting for diagnostic testing. This data was also analysed by population or geographic subgroups, in order to determine whether there were specific geographical areas where testing was inadequate, or particular subgroups that required more targeted public health actions. For example, if there were low COVID-19 testing rates in one particular subgroup, then public health messaging may need to be tailored to this specific subgroup. However, if the proportion of positive results were particularly high in another subgroup, where the testing rates were similar to the rest of the population, then this could represent an outbreak within this group, or that there were potential risk factors or behaviours that placed this subgroup at higher risk of infection.

From the point of view of case and cluster management, it was also useful to know all test results for close contacts to guide additional public health actions. For example, if it were known that all other individuals at the workplace of a confirmed case had tested negative subsequently, then there would be less concern about the risk of undetected transmission at this location, and fewer additional restrictions may be considered. This process of tracking close contacts in terms of testing was considered to be a novel feature of notifiable diseases surveillance in NSW.

Active surveillance of higher risk settings

Surveillance goals addressed: Provide daily updates on the characteristics and time-trends of deaths due to COVID-19; Report on the performance of contact tracing; Report on clusters, outbreaks and other community trends in COVID-19 related illness; Describe the clinical severity of COVID-19; Undertake strategically targeted asymptomatic screening

An active surveillance approach was adopted in specific settings where individuals were at higher risk of infection. So far, this approach was used mostly with relatively closed cohorts.

For example, after receiving notification of initial positive cases in an aged care facility, the risk assessment carried out by the PHEOC/PHRB and the local PHU would often lead to the compilation of detailed lists of all other residents and staff. The PHEOC/PHRB may subsequently develop a testing strategy where all individuals listed would undergo PCR testing for a range of respiratory viruses, including SARS-CoV-2, at regular intervals, in order to allow early detection of pre-symptomatic or asymptomatic infection among other members of the facility. This was similar to the public health approach normally used for outbreaks of influenza-like illnesses in NSW. Test results would then guide subsequent public health actions such as cohorting confirmed cases, making changes to the infection control arrangements at the facility, or determining that an outbreak had ended after a pre-determined length of time without positive test results being returned.

Another setting for active surveillance was within quarantine hotels, where since March 28, 2020, international or interstate travellers arriving in NSW were required to remain for 14 days upon arrival(4). If any respiratory symptoms developed for any individual in hotel quarantine, an urgent COVID-19 PCR test would be requested. Additionally, from May 15, 2020, PCR testing for SARS-CoV-2 started to be carried out routinely for each individual in hotel quarantine, on day 10 of their stay. On June 30, 2020, this program was expanded so that each traveller in hotel quarantine underwent testing on both day 2 and day 10 of their quarantine period, as well as additional testing prompted by any respiratory symptoms. This enabled overseas acquired cases to be detected early and managed appropriately, before there were opportunities for onward community transmission. This active surveillance program was coordinated by the PHRB Laboratory Liaison Team and NSW Health Pathology, in collaboration with Health Care Australia, the private company contracted to provide medical care to travellers in hotel quarantine. Each person in hotel quarantine was tracked individually in the NSW COVID-19 surveillance system, with their results recorded in NCIMS. This was considered to be a novel feature for the surveillance of notifiable conditions in NSW.

From March 29, 2020 until November 14, 2020, there were 548 overseas-acquired cases and 4 interstate-acquired cases detected, both through the active surveillance of travellers in quarantine hotels, and through symptom-driven testing in this population(12). The total number of COVID-19 PCR tests performed in quarantine hotels during this time period was 112,516.

Serosurveillance

Surveillance goal addressed: Conduct serosurveys to determine prevalence of SARS-CoV-2 infection

Serology for antibodies to SARS-CoV-2 was used for several purposes in the NSW pandemic response. Firstly, as part of the public health management of individual cases, serology may be carried out to provide additional information, such as plausible onset dates and infectious periods. This was used to guide actions such as isolating cases and contact tracing. The results of serological testing performed for this purpose were stored within NCIMS.

From a broader population perspective, serosurveillance was carried out by research teams at the National Centre for Immunisation Research and Surveillance (NCIRS) and the Kirby Institute, with the laboratory support of the Institute of Clinical Pathology and Medical Research (ICPMR)(Personal communication: PHRB Laboratory Liaison Team). This involved the systematic collection and testing of blood samples in order to assess the population prevalence of antibodies to SARS-CoV-2. The prevalence determined through this process could then form the basis of estimates of exposure and spread in the population, including the level of asymptomatic transmission. As well as this, monitoring individual changes in antibody titres over a period of time could assist with future vaccination policy. De-identified serology results for serosurveillance studies were not stored in NCIMS. However, some of the identifiable serology results performed for serosurveillance were uploaded into NCIMS through the ELR process.

Due to the ongoing nature of serosurveillance data collection, existing data to date were extracted for analyses covering specific time periods and settings. This allowed a more contemporaneous understanding of trends within a longitudinal surveillance process. Serosurveillance study results were disseminated through academic publications, and via the public communications channels of participating research organisations.

Virological / molecular epidemiological surveillance

Surveillance goal addressed: Report on clusters, outbreaks and other community trends in COVID-19 related illness

Whole genome sequencing (WGS) of SARS-CoV-2 from positive viral swab samples was undertaken in NSW since February 2020 (Ref: Internal report). Two laboratories in NSW have the capability of performing this, with ICPMR designated as the reference laboratory for SARS-CoV-2 WGS. According to a directive issued by the NSW Director of Public Health Pathology, all positive SARS-CoV-2 swab samples tested in public laboratories in NSW were required to be forwarded onto ICPMR for WGS. This was followed by a similar request from the PHRB executives to the private laboratories. The ICPMR laboratory team reviewed WGS results and prepared weekly WGS reports. These reports summarised new WGS results and analyses, and placed them within the existing NSW outbreak context and the local viral genomic landscape. This then facilitated the construction of the most probable transmission trees based on genomic evidence. All these findings and hypotheses were discussed at regular COVID-19 WGS teleconferences attended by the WGS Team at ICPMR, representatives of the PHRB Operations, Laboratory Liaison and Epidemiology Teams, and any interested staff members at PHUs. While SEALS Pathology also had the capacity to perform WGS for COVID-19, the sequencing that informed the NSW COVID-19 surveillance system was performed by ICPMR.

Within the COVID-19 surveillance system, WGS was used to determine the circulating strains of SARS-CoV-2 in NSW, and to monitor genomic changes in the virus over time. This also provided supplementary information about transmission pathways, where cases were assumed to be more closely related in terms of their source of acquisition if they were infected with viruses with more similar genomic sequences. Additionally, WGS formed the basis of surveillance for the introduction of novel viral mutations in travellers in quarantine. The sharing of sequencing information with other jurisdictions was undertaken by ICPMR outside of the surveillance system.

In addition, on some occasions, viral cultures were performed. This may have been requested by academic institutions for research purposes, or by PHUs, to guide case management. This was considered to be outside of the scope of the NSW COVID-19 surveillance system.

Syndromic surveillance / surveillance of respiratory illness

Surveillance goals addressed: Report on clusters, outbreaks and other community trends in COVID-19 related illness; Monitor impacts on the tertiary healthcare system

Prior to the pandemic, there was existing emergency department syndromic surveillance in NSW for a range of presentations. The Public Health Rapid Emergency Disease and Syndromic Surveillance (PHREDSS) system monitored public hospital emergency department (ED) presentations, including influenza-like illness (ILI) and various other respiratory symptoms(38).

Outputs from this system were reviewed daily by the Rapid Surveillance team at the MoH. Any signals of concern, as per a pre-determined set of criteria, were communicated immediately to the relevant MoH teams. A report based on these data was issued on a weekly basis. The report included statistics such as the number of weekly ED presentations for particular syndrome groups in NSW (Ref: Internal document). The syndrome group that was the most relevant for COVID-19 surveillance was "All respiratory problems / fever and unspecified infection". Syndrome groups were broken down further into sub-syndromes, and the number of weekly ED presentations for these were also reported. Relevant sub-syndromes for COVID-19 surveillance included: "Asthma / breathing problems", "Bronchiolitis", "Fever / unspecified infection", "Influenza-like illness", and "Pneumonia". If there were specific age groups, or particular LHDs where ED presentations had increased significantly according to pre-determined criteria, either from the previous week or from the five-year range, this was also included in the report. Other useful statistics included in the report include the weekly count of all unplanned ED admissions, admissions from ED to critical care wards by sub-syndrome, and admissions from ED to other hospital wards by sub-syndrome.

This report was disseminated to HPNSW, including the executives and medical advisors within the PHRB, and to the LHDs. The data on pneumonia and bronchiolitis presentations to ED was also published in the weekly COVID-19 Surveillance Report. Within the PHRB, this information is triangulated against other surveillance inputs to obtain a more accurate estimate of the community prevalence of COVID-19. For example, if there were low weekly numbers of new cases of COVID-19, and this corresponded to relatively low numbers of ED presentations for respiratory symptoms over the same time period, then this would support the argument that the rates of community transmission that had not been detected by the surveillance system would be low.

ED syndromic surveillance data also assisted with planning, in terms of the resources that may be required for all respiratory presentations and admissions to public hospitals.

In addition to PHREDSS, there was a pre-existing network of sentinel laboratories in NSW for the surveillance of respiratory viruses circulating in the community(39). This network of seven public and seven private laboratories reported weekly on the number and outcomes of tests undertaken for a range of respiratory viruses. These included influenza viruses, and several non-notifiable viruses, such as respiratory syncytial virus and rhinoviruses. This information was another indicator of the prevalence of respiratory illness in the community.

Another pre-existing syndromic surveillance strategy for respiratory illness was that aged care facilities were asked to notify the local PHU of any outbreaks of influenza-like illnesses, as defined by a set of criteria. This would trigger protocol for testing and investigation, which was amended to include COVID-19 testing.

Health facility impact monitoring

Surveillance goals addressed: Describe the clinical severity of COVID-19; Monitor impacts on the tertiary healthcare system

Certain measures of the utilisation of health facilities were included within the NSW COVID-19 surveillance system. These included the number of patients admitted to any hospital within NSW, either as an inpatient physically within a facility, or in a "Virtual Hospital". The "Virtual Hospital" arrangement was where the patient was physically at home or in a quarantine hotel, and was managed through a digital and telephone-based case management system.

In NSW, real-time public hospital admission and bed occupation information for individual patients was captured routinely by the Patient Flow Portal (PFP). The PFP was managed by the Health System Information and Performance Reporting (HSIPR) team. It also provided information on the number of patients admitted to ICU and the number of patients ventilated or receiving extracorporeal membrane oxygenation at a given time. The PHRB Epidemiology Team and the HSIPR team continued to cross-verify the information within the PFP and NCIMS, in order to ensure that the hospital admission and healthcare resource utilisation data for individuals within NCIMS were accurate and complete.

In addition, for public hospital admission analyses, information from the Admitted Patient Data Collection (APDC) managed by the Centre for Health Record Linkage (CHeReL) at the MoH was used(22). This dataset contained demographic and hospital admission information for all individuals who had had at least one admission to a public hospital in NSW. It was accessed through a data linkage process occurring every three weeks.

The data from PHREDSS, as mentioned, was also used to monitor the use of health facilities from a syndromic perspective, for all respiratory presentations to ED. As well as this, the PHREDSS data also recorded admissions for respiratory conditions from the ED to an inpatient ward, or to a critical care ward.

The information on health resource utilisation, gathered through the methods above, was reviewed by the PHRB executives and Epidemiology Team. The data that were deemed to be useful to other stakeholders were then published in the NSW COVID-19 Surveillance Report. These stakeholders included other teams in the MoH responsible for health resources planning, and LHD executives, who could use this information to direct local healthcare resources and public health actions.

Priority groups surveillance

Surveillance goals addressed: Provide daily updates on the characteristics and time-trends of COVID-19 cases; Provide daily updates on the characteristics and time-trends of deaths due to COVID-19; Provide daily updates on tests performed to detect SARS-CoV-2 infection; Report on clusters, outbreaks and other community trends in COVID-19 related illness; Describe the clinical severity of COVID-19; Monitor impacts on the tertiary healthcare system; Conduct serosurveys to determine prevalence of SARS-CoV-2 infection

Additional surveillance was carried out for specific population groups. This included populations that may benefit from targeted public health actions, such as people identifying as Aboriginal and Torres Strait Islanders. Individuals at higher risk of exposure and onward transmission, such as healthcare workers, aged care workers and disability workers, were also considered to be priority groups for surveillance.

Fields within NCIMS were available for COVID-19 surveillance staff to enter First Nations status and high risk occupations for each individual. This would include any person who had received a COVID-

19 diagnostic test, or had been identified as a contact of a known case. This information may be gathered from laboratory reports, during interviews or other correspondence with cases or close contacts. This information may also enter the surveillance system through linkages with other databases within the NSW MoH.

For First Nations status, as discussed, the APDC dataset contained demographic and hospital admission information for all individuals who have been admitted to a public hospital in NSW for any cause(22). Healthcare workers in the public sector were captured by the Stafflink dataset (see "Data linkage" section in main report).

The weekly Surveillance Report produced by the PHRB Epidemiology Team included data on cases to date in Aboriginal and Torres Strait Islander people(39). This was made publicly available on the NSW Health website. As well as this, the number of new Aboriginal and Torres Strait Islander cases was notified to the Centre for Aboriginal Health within NSW Health nightly. Between April and June 2020, a weekly internal report on new healthcare worker COVID-19 cases was issued by the Epidemiology Team and circulated internally within the MoH (Ref: Internal document). After June 2020, data on COVID-19 infections in healthcare workers was incorporated in the weekly Surveillance Report where relevant.

International border surveillance

Surveillance goals addressed: Provide daily updates on tests performed to detect SARS-CoV-2 infection; Report on clusters, outbreaks and other community trends in COVID-19 related illness

Since February 2020, staff from the Randwick PHU undertook symptomatic screening for COVID-19 at the International Terminal of Sydney Airport (Ref: Internal documents). Incoming travellers were screened with a temperature check and a short set of questions about respiratory symptoms. Individuals found to be febrile, or with respiratory symptoms, were then required to undergo on-site testing for COVID-19, before being transferred to the Special Health Accommodation (SHA), which were quarantine hotels offering a higher level of medical care. Travellers with severe respiratory symptoms may be transferred directly to a public hospital by ambulance. Information on the number of travellers screened, tested and transferred was emailed twice daily to the PHRB Surveillance Officer. The contact details and travel histories of symptomatic travellers tested or transferred were also sent to the Surveillance Officer. From February 2, 2020 to November 14, 2020, a total of 168,527 international arrivals had been screened for symptoms, with 1,753 of these arrivals being tested for COVID-19 and being transferred to the SHA or to hospitals.

Foreign cruise ship entry into Australia was suspended by the *Biosecurity Act 2015* on 27 March, 2020. Prior to this, symptomatic screening was also undertaken on incoming cruise ships docking at NSW ports (Ref: Internal documents). The surveillance aspect of this process was managed by the Randwick PHU, as an extension of a pre-existing infectious diseases surveillance program for inbound cruise ships prior to the COVID-19 pandemic. Within this program, information about passenger health and cruise itinerary was received from each incoming ship through Human Health Reports. In the COVID-19 response, this information was sent to an expert panel composed of senior public health staff, who performed a risk assessment and determined the appropriate public health actions that were to be undertaken for each cruise ship based on this risk assessment. These public health actions were then carried out by staff at the Randwick PHU. The information sent by the Randwick PHU to the NSW COVID-19 surveillance system for each cruise ship included risk assessment details, passenger and crew numbers, and the number of people who were symptomatic and are referred for PCR testing. Between 16 February, 2020 and 18 March, 2020, a total of 56 cruise ships docking in NSW were monitored by the surveillance system.

From March 28, 2020 onwards, inbound international travellers were required to enter hotel quarantine for 14 days after arrival. Travellers who were referred directly from the airport to healthcare facilities for further assessment were discharged back into quarantine hotels for the remainder of this period when their additional care was complete. The surveillance system for travellers in quarantine hotels was discussed under active surveillance of higher risk settings.

Environmental surveillance

Surveillance goal addressed: Report on clusters, outbreaks and other community trends in COVID-19 related illness

The NSW Sewage Sampling Research Program for SARS-CoV-2 RNA commenced in April 2020 (Ref: Internal documents). This was a project undertaken by the Environmental Health Branch of HPNSW, in collaboration with Sydney Water. As at November 2020, samples were taken from 78 water sites in NSW across all LHDs on a weekly basis(12). These samples were tested by Sydney Water, and any detections of SARS-CoV-2 RNA were notified to the PHRB Executives and Epidemiology Team. The PHRB executives would then determine, in conjunction with the relevant LHDs and PHUs, whether this detection corresponded to known cases in the catchment area, and whether any public health actions needed to be undertaken. This usually involved public messaging, through the Communications and the Media Teams, to encourage residents in the relevant catchment areas to present for diagnostic testing for COVID-19.

A detailed research and analysis plan accompanied the Sewage Sampling Research Program (Ref: Internal documents). The aims of the program were to assist with understanding population disease trends and to detect unrecognised community transmission. Sewage sampling for SARS-CoV-2 RNA occurred concurrently in other jurisdictions nationally and internationally. The NSW sewage sampling data was also shared with the ColoSSoS project, a national research initiative on wastewater surveillance for COVID-19, led by Water Australia(40).

Venue surveillance

Surveillance goals addressed: Report on the performance of contact tracing; Report on clusters, outbreaks and other community trends in COVID-19 related illness

Venue surveillance was a strategy that was not explicitly listed in the NSW COVID-19 Surveillance Plan, but was mentioned by several interviewed stakeholders as an additional component of the NSW COVID-19 surveillance system.

From the earliest versions of case questionnaires, confirmed COVID-19 cases were interviewed about venues that they had visited while infectious, thereby potentially transmitting the infection to others. Questions to identify potential venues where the case had acquired their infection was introduced to the questionnaire in May 2020. However, there had not been a systematic method for capturing venues of concern until July 2020, when a venue tracking spreadsheet was developed by the Epidemiology Team, who worked closely with the Operations Team to maintain and refine the document. This information was reviewed multiple times daily by members of both teams, including team leaders and managers. New venues of particular concern were discussed with PHRB executives and PHUs. This allowed decisions around public health actions to be made, such as whether a particular venue needed to be identified publicly.

As at November 14, 2020, the processes of identifying and tracking venues of concern, and publicising these venues, were undergoing further development. At this time, PHRB staff members were collaborating with Service NSW, a government agency external to NSW Health, to develop a quick response (QR) code system to facilitate accurate recording of the venues visited by confirmed cases, and to compile lists of attendees at the venue who may have been exposed to the case.

Appendix 2: Timeline of COVID-19 events in 2020

Sources: Internal documents, personal communication, official Parliament of Australia chronology (4), Communicable Diseases Network Australia Series of National Guidelines on Coronavirus Disease (COVID-19) (41)

		COVID-19 events	NSW COVID-19 surveillance system events
Jan	13	First recorded case of 2019-nCoV acute respiratory disease outside of China	
	20		First 2019-nCoV event created on NCIMS as an "Other Condition" (excluded case)
	21	Novel Coronavirus 2019 added to notifiable diseases list in NSW; Activation of PHEOC; First NSW case definitions developed; ICPMR able to test for SARS-CoV2	
	22		"Novel Coronavirus 2019" first appeared as a notifiable condition in NCIMS
	23	First 2019-nCoV SoNG published by CDNA	First ELR Novel Coronavirus 2019 result received in NCIMS from ICPMR (negative result); First version of NCIMS case questionnaire and data entry wizard for Novel Coronavirus 2019 cases became available – included fields that allowed recording of asymptomatic cases, and infection acquired "At Sea" on cruise ships
	25	First confirmed Novel Coronavirus 2019 cases in NSW	
	26		First Novel Coronavirus 2019 statistics and line lists sent to NIR
	27	First international flight contact tracing exercise undertaken by NSW; SEALS Pathology able to test for SARS-CoV2	
	28	Daily NSW HPLT meetings commenced	
	29	System of daily media updates every morning established	Daily confirmed case symptom follow up functionality available in NCIMS
	30	WHO declares 2019-nCoV to be a PHEIC	
	31		Daily close contact symptom follow up surveys started to be sent from NCIMS

		COVID-19 events	NSW COVID-19 surveillance system events
Feb	1	Australian border restrictions for foreign nationals travelling directly from China	
	2	Recommendation for asymptomatic close contacts to self-quarantine for 14 days at home (SoNG v1.2)	Data from Sydney Airport Novel Coronavirus 2019 screening first sent to PHEOC Surveillance Officer
	6	First "2019-nCOV acute respiratory disease, Australia: Epidemiology Report" published by the NIR Surveillance Team	
	7	Requirement added for a confirmed case to have 2 negative PCR results 24 hours apart before release from isolation (SoNG v1.5)	
	11	WHO officially assigns the name COVID-19 to the disease caused by SARS-CoV2	
	15	"Person under investigation" category added to COVID-19 case definition (SoNG v1.7)	
	16		Data from cruise ship arrivals first sent to PHEOC Surveillance Officer
	17	All passengers and crew on board the *Diamond Princess* cruise ship deemed to be close contacts (SoNG v1.8)	
	18		Welfare check telephone calls commenced for international arrivals in home quarantine
Mar	1	First Australian COVID-19 death (WA)	
	2	First community-acquired cases (NSW); Specific mention of China removed from suspect case definition (SoNG v1.14)	
	3	Inclusion of severe community-acquired pneumonia (without history of travel) in suspect case definition (SoNG v1.15)	
	4	First NSW COVID-19 death	
	10	All international travel included in suspect case definition (SoNG v1.18)	Fields to enter IgG, IgA and IgM serology results for COVID-19 became available in NCIMS
	11	WHO classification of COVID-19 as a pandemic; Australian national recovery data first published in the COVID-19, Australia	

		COVID-19 events	NSW COVID-19 surveillance system events
		Epidemiology Report by the NIR Surveillance Team	
	13	Major revision of COVID-19 SoNG: version 2.0 published; close contacts added to suspect case definition; casual contact definition removed	
	16	Requirement for contact tracing ceased for arrivals on international flights on or after this date; all travellers arriving in Australia on or after this date are required to self-quarantine at home for 14 days (SoNG v2.1)	
	18	Human biosecurity emergency declared in Australia	1st NCIMS COVID-19 initial case interview data wizard guide written – with specific instructions on the "Place of Acquisition" field for international and interstate arrivals; final PHEOC ID numbers assigned to new confirmed cases – stopped using the line list whiteboard
	19	Disembarkation of passengers from the *Ruby Princess* cruise ship in Sydney	Automated case welfare check surveys started to be sent via SMS messaging from NCIMS
	20	Closure of Australian borders to all non-residents and non-citizens	
	21	Release from isolation criteria for cases changed so that most cases managed at home do not require clearance swabs (SoNG v2.2)	
	24	Introduction of probable case definition; risk stratification of suspect case definition (SoNG v2.3)	
	28		Failure of SMS welfare check surveys from NCIMS; end of automated daily surveys being sent and completed directly through NCIMS
Apr	17	Infectious period for COVID-19 cases changed to 48 hours prior to the onset of symptoms (SoNG v2.6)	
	19		Recovery interviews commenced
	24	Enhanced testing beyond suspect cases recommended (SoNG v2.7)	

		COVID-19 events	NSW COVID-19 surveillance system events
May	1	Asymptomatic cases first mentioned in SoNG (SoNG v2.8)	First NSW COVID-19 Weekly Surveillance Report published online
	8		“Loss of taste/smell” added to list of symptoms on NCIMS COVID-19 initial case interview wizard
	13	Confirmed and probable case definitions revised to include serological criteria; COVID-19 death defined (SONG v2.10)	
	23		Recovery interviews stopped
	26		Began to report the number of tests, rather than the number of people tested in NSW
	28	Major revision of COVID-19 SoNG: version 3.0 published; individuals without any COVID-19 specific testing results no longer qualifying as probable cases; advice on identifying and testing potential upstream contacts; definitions and broader guidelines given for outbreaks in high risk settings	
	31	Australian National Disease Surveillance Plan for COVID-19 released	
Jun	4	Release from isolation criteria for cases changed so that healthcare workers no longer require clearance swabs; detailed additional guidance for the management of asymptomatic cases (SoNG v3.1)	
	10		PHEOC became PHRB
	12	Loss of smell or taste added to clinical criteria for suspect cases (SoNG v3.2)	
	30		
Jul	5	Incoming international passengers limited to 450 per day at Sydney Airport	
	6	Closure of NSW/Vic state border	
	18	Costs of NSW hotel quarantine payable by returned travellers	
	20	Incoming international passengers limited to 350 per day at Sydney Airport	

		COVID-19 events	NSW COVID-19 surveillance system events
	24		COVID-19 NCIMS Data Entry Guide for Contacts released to PHUs
	27		Process to re-develop NCIMS denormalised tables began
	29		Additional daily metrics for public health measures reported to NIR by PHRB Surveillance Officers
Aug	11		NSW COVID-19 SoNG Appendix first released to PHUs
	28		Latest revision to the NSW COVID-19 Case Questionnaire – Initial Interview released
Sep	7		First batch of un-notified negative COVID-19 laboratory results discovered
	11		Second batch of un-notified negative COVID-19 laboratory results discovered
Oct	1	Trans-Tasman travel bubble entered into effect	
	4		COVID-19 NCIMS Data Entry Guide for Initial Case Interview Wizard version 2.0 released to PHUs
Nov	14		End of data collection for surveillance evaluation
Dec	22		Data completeness report created for all cases up to Nov 14 2020

Appendix 3: The Notifiable Conditions Information Management System (NCIMS)

Background

The basic features of NCIMS are discussed in the main body of this evaluation report. This section gives additional details about the features of NCIMS relevant to the NSW COVID-19 surveillance system.

Software development and maintenance

Maven was the name of the commercial software at the core of NCIMS. The vendor of Maven was Conduent Inc., based in the United States of America. The decision to use Maven as the foundation was made after a tendering process in 2008. After NSW Health purchased Maven initially, the vendor worked with staff at the MoH to create NCIMS, with an initial two-year period of software adaptation and customisation. NCIMS was implemented as the information management system for the NSW notifiable conditions surveillance system in 2010. Since that time, NSW Health has continued to pay an annual fee to the vendor, which covered ongoing software support and updates.

The routine maintenance, updating and administration of NCIMS was carried out by the MoH NCIMS Team. This team was also responsible for user training, and for adapting NCIMS to meet new requirements, such as adding new notifiable conditions to those stored in the system. For more substantial modifications, the NCIMS Team may choose to undertake these independently, or to involve the vendor, depending on the technical complexity of the task. This type of vendor assistance incurred additional costs, based on the hours and human resources required.

A review process for all aspects of NCIMS was planned for 2020, as this would mark 10 years since NCIMS was first operational. The purpose of this review process was to determine whether NCIMS would continue to meet the needs of NSW Health in the coming years, or whether migration to a new information system would be preferable. However, due to the human resources demands of the COVID-19 pandemic response, this review process was postponed.

User accounts

Users of NCIMS were given individual, password-protected accounts. This login information is linked to the user's account and access information for other NSW Health systems. Prior to the activation of the NSW COVID-19 response, there were 350 individual NCIMS user accounts, belonging to staff members working within NSW Health, in both HPNSW and the PHUs. For a new account to be created, the team manager of the new user needed to send a request to the NCIMS team. The new user was required to complete online training and to sign a confidentiality agreement that was countersigned by the user's team manager.

Security and access

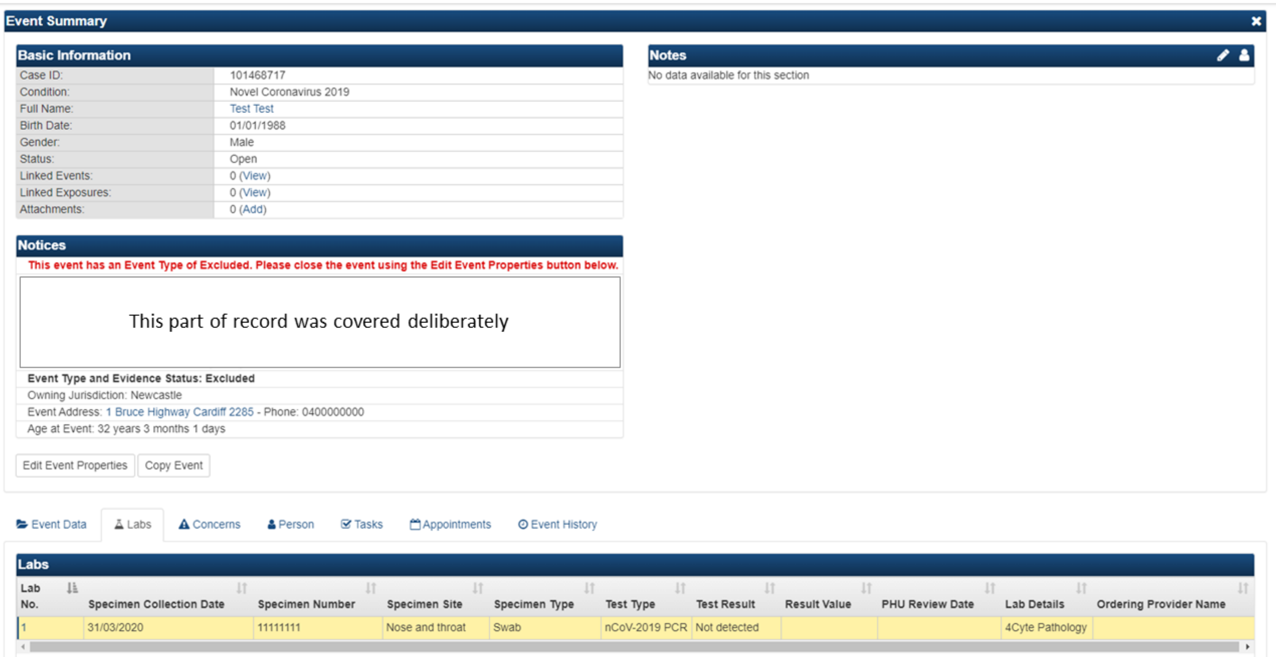
The security of NCIMS was reviewed with the assistance of an external consultancy firm in 2018 (additional details in main text Part B: Data and system security).

Day-to-day access to NCIMS required password only, if the user was connected to a NSW Health internet network. If the user was connected to an external internet network, two-factor authentication was required to enter NCIMS, with an additional access code sent to the user's NSW Health email account or verified mobile phone number.

Events in NCIMS

Within NCIMS, notifications and records were organised by condition. This meant that for example, each individual with any COVID-19-related information would have a "COVID-19 event" record in NCIMS (example in Fig IIIa). This information could include any laboratory test results, laboratory test requests, or identification as being a contact of a confirmed case. This record would be identified in NCIMS by a unique event ID. Each event would contain all test results for only this particular condition, within a pre-determined period of time, for one particular person. The event would also contain contact and demographic information for the individual, and any additional information that may be useful for the public health management of this event. This event was separate from any other records belonging to the same individual. This meant that for example, a user viewing a COVID-19 event record would not be able to access any information related to any other conditions for this individual, without exiting from this record.

Figure IIIa - Main screen of an example COVID-19 event record in NCIMS



The creation of this event was triggered by the first notification, through any means, of an individual as a possible case or close contact of a specific notifiable condition. For COVID-19, this was usually automatic, with the first laboratory result that entered NCIMS for this person for this condition. Subsequently, another automatic process in NCIMS assigned the person event to a PHU based on the address of the individual, which was usually available as part of the initial laboratory notification.

NCIMS had the capacity to be customised for each notifiable condition in terms of the type of information that could be collected and stored. There was a master list of standard electronic data fields that could be enabled or disabled for particular conditions. Examples of these fields included check-boxes for specific symptoms, such as cough or headache, or risk factors, such as cigarette smoking or pregnancy. In addition, new fields could be created for individual conditions, to assist with collecting data that is particular to the condition. An example of this for COVID-19 was the symptom of "loss of taste or smell", which was not a feature of any other notifiable conditions previously in NCIMS. The decision of the fields to be included was made jointly by medical advisors within HPNSW and the surveillance team in CDB or EHB, guided by national experts through SoNGs and discussions within NSC or CDNA meetings.

For each event record in NCIMS, the demographic information collected used similar data entry fields and formats regardless of the notifiable condition. This enabled an automatic process in NCIMS to identify events for different conditions belonging to the same individual person. The address field of the event also triggered another automatic process in NCIMS to assign the event to a corresponding PHU, known in NCIMS as the "owning jurisdiction". This was based entirely on geographical location, and the field remained "unassigned" if the address was not found within NSW. The assignment of owning jurisdiction could be amended manually.

The laboratory notification information in NCIMS was stored in a specific section of each event. This may be a notification of a laboratory test requested to be performed, or the notification of a test result. For most conditions within the NSW notifiable conditions surveillance system other than COVID-19, negative results and test requests were not collected. The decision about the types of laboratory notifications that were recorded in NCIMS for a particular notifiable condition was made by senior medical staff in HPNSW, with input from HPNSW laboratory and surveillance team members. Laboratory notifications could enter NCIMS through several processes (see Section B: System inputs and sources).

Case definitions for each condition in NCIMS were determined by senior medical staff, usually in close alignment with the case definitions in the CDNA SoNGs. The classification of a particular case based on case definitions was recorded in NCIMS. For COVID-19, as at November 14, 2020, the case classification field had the options of: "confirmed case", "probable case", "possible case" or "excluded case". The classification of an event could be changed manually, or automatically when pre-set list of features in a new laboratory notification were met. Algorithms existed within NCIMS to dictate which of these categories take precedence and could be overridden with subsequent developments. For example, a confirmed case who subsequently received a negative result during their recovery would remain with a confirmed case classification. It was also possible for a user to lock a classification manually so that subsequent automatic changes could not be made.

In addition to demographic and laboratory data, other relevant public health information could be recorded for each event in NCIMS. This included risk factors, exposure and onward transmission details, symptom history and contact tracing information. As well as this, documentation of public health and case management actions carried out or planned was possible for each event. This information could be entered into NCIMS through several methods, depending on the notifiable condition and the processes at each PHU or HPNSW. If a case interview was carried out using a paper-based form, this could be scanned and uploaded as an attachment to an event. This process allowed prompt sharing of public health information with other NCIMS users after the case interview was performed. In addition, any information gathered can be recorded in the relevant electronic data entry fields within each event. This was useful for data extraction and analysis. Data entry wizards were electronic forms that could be designed for a notifiable condition to facilitate the completion of the most essential fields. These fields were chosen from all fields that were available for the event, and compiled into a single wizard form. Additionally, each event has a section for free-text notes, to record information not able to be captured by the electronic data fields, such as ongoing progress and follow up.

As discussed in the "Information management system" section of the main report, another category of event records were "outbreak events". NCIMS links between individuals and outbreaks were frequently created manually. However, links could also be created in NCIMS through batch importing a line list of contacts of a confirmed case.

Additional features of notifiable condition management using NCIMS

Editing and read only permissions

In the management of a notifiable condition, multiple parties may be involved. In order to prevent more than one user editing the same data field of an event simultaneously, only the first user accessing the event was granted editing permission. Subsequent users who access this event were given read-only permission, until the editing user exited the record or was inactive for longer than 30 minutes.

Searching

As at November 14, 2020, searching for an event within NCIMS could be carried out through two main methods. A simple keyword search function was designed to respond to queries based on one piece of information, such as a last name, an event ID or a specific word. The function then returned any matching events across all of the notifiable conditions in NCIMS which the user has permission to view. However, the sensitivity and specificity of this function were limited. An advanced search function was also available, where a number of search criteria, such as first name, last name, event and notifiable condition, could be entered simultaneously, in order to narrow the list of search results. However, while this search function was not case sensitive, the spelling of a search term needed to be an exact string match to the corresponding field in the event.

Event deduplication

Occasionally, multiple notifications of one specific new result may arrive in the surveillance system simultaneously, through different sources. The deduplication process, to merge these records, occurred both automatically through NCIMS, and manually through members of the PHEOC/PHRB Epidemiology Team. This process was essential for ensuring that the case and testing numbers reported by the surveillance system were accurate, and that duplicate management did not occur for any cases.

Events with Unknown Condition workflow

This is often because of an error when NCIMS reads the ELR feed and cannot determine the notifiable condition that is associated with a particular result. This event would then need to be reviewed manually by a MoH NCIMS user with access to all notifiable conditions in NCIMS, usually one of the PHRB Surveillance Officers or a HPNSW staff member.

Changes to NCIMS for COVID-19

Many of the changes described in detail here were outlined in the "Information management system" section of the main report.

New user account type

A new user account type in NCIMS was introduced for COVID-19 surge staff, restricting browsing and editing access to COVID-19 data only. This meant that if a particular COVID-19 case had events in NCIMS for any other notifiable condition, this would not be visible to the staff members with accounts limited to COVID-19. The process of requesting and approving COVID-19 NCIMS accounts was streamlined for surge staff. This involved an existing NCIMS user emailing a request on behalf of the new user to the NCIMS Team, with the PHRB Deputy Controller in copy for new PHRB users, and the PHU Director in copy for new PHU users. When a surge user leaves the COVID-19 response, the relevant manager was requested to inform the NCIMS Team to remove access as soon as possible. The NCIMS Team also reviewed the list of existing users every six months.

New workflows

As at November 14, 2020, 33 new COVID-19-specific workflows had been added to NCIMS, relating to both data quality and public health action for case and contact management. These included workflows for case and contact management, such as "COVID events for notification interstate". There were also workflows for data quality monitoring, such as "Contacts in mandatory quarantine with data quality issues."

In addition, COVID-19 events appeared in nine workflows that extracted events from all notifiable conditions in NSW. Of particular note was the "Inform CDB – High Priority Events" workflow, which listed new notifications of specific conditions, including COVID-19. This workflow was eventually separated into one specifically for COVID-19, and one for other notifiable conditions.

Data entry wizards

New data entry wizards were created for COVID-19 events, for both cases and contacts. These wizards were designed to align with each version of the paper-based COVID-19 Case Questionnaire and Close Contact Questionnaire. Additionally, specific individual electronic data entry fields, such as "COVIDSafe App in use", were created for COVID-19.

Contact events

The "contact" classification of a person event record was enabled for COVID-19. Prior to COVID-19, this was only used for a small number of other public health management situations, such as close contact screening for tuberculosis. This classification allowed an individual to be listed as a discrete record in NCIMS, without any clinical or laboratory evidence of infection with a notifiable condition, facilitating the monitoring and public health management of contacts.

To create a contact event, basic demographic details needed to be entered into NCIMS. Where there were a small number of contacts, this was often completed manually by either PHU or PHRB staff. For lists of ten or more contacts, it was often more efficient to send these details to the Data Quality Team to request batch uploading into NCIMS. However, for this to be actioned, a spreadsheet conforming to a specific template needed to be created for each list of contacts, which was often time-consuming. Contact events in COVID-19 could be further sub-classified as high risk or low risk.

Data quality

An innovation of the COVID-19 response was to have a dedicated team responsible for the systematic monitoring and improvement of the data quality for a particular condition in NCIMS. This role was assigned to the Data Quality team within the PHRB Epidemiology Team.

Use of text messaging tools

Another novel development during the pandemic was to use NCIMS as a communication platform with cases and close contacts. When new cases and close contacts were entered into NCIMS with a valid mobile phone number and consent for text message follow-up, an automatic process was triggered to send a daily short message service (SMS) text message containing a welfare check survey. Replies to this survey were then received into NCIMS. Where considerable time had elapsed without a reply to the survey, the individual would then appear in a dedicated NCIMS workflow of cases or close contacts requiring a welfare check telephone call.

This manual telephone call process became the only method for daily case and close contact follow up in late March 2020, after the NCIMS survey process was disabled, and was mainly carried out by the CCTT. It had been part of the role of CCTT to undertake daily telephone follow up for cases who do not have access to an internet-enabled mobile phone, or choose not to be followed up via SMS.

The new Whispir platform continued to be used beyond November 14, 2020. At the end of November 2020, Whispir sent out links to more than 4000 electronic surveys daily.

Appendix 4: Interviewees in NSW COVID-19 Surveillance System Evaluation

A total of 20 stakeholders were interviewed for this NSW COVID-19 surveillance system evaluation (Table IVa). They represented six PHUs (three metropolitan and three regional) and a range of teams in the central state-wide pandemic response (PHRB Epidemiology and Surveillance, PHRB Operations, PHRB Laboratory Liaison, PHRB Data Quality, PHRB Executive, MoH NCIMS, MoH Media, SHEOC). There was a range of experience among the interviewees, both in terms of familiarity with NCIMS, and with communicable disease control.

Table IVa – Characteristics of stakeholders interviewed for the NSW COVID-19 surveillance system evaluation

Characteristic of stakeholder		Number	Percentage (n=20)
COVID-19 work location:			
PHRB and MoH		14	70
PHU	Total	6	30
	Metropolitan PHU	3	15
	Regional PHU	3	15
Familiarity with NCIMS:			
Used NCIMS frequently prior to COVID-19		11	55
Used NCIMS occasionally prior to COVID-19		1	5
Never used NCIMS prior to COVID-19		8	40
Use of NCIMS for COVID-19:			
Does not use NCIMS		3	15
Uses NCIMS	Total	17	85
	Data collection and entry	13	65
	Data cleaning and management	10	50
	Information retrieval	15	75
	Data analysis	10	50
	New process development and training	4	20

	Back end development and maintenance	2	10
Public health experience:			
	Previous experience of pandemics or large outbreaks	11	55
	Communicable disease control experience, but no large outbreaks	5	25
	No prior experience in communicable disease control	4	20

Appendix 5: Interview guide used for NSW COVID-19 Surveillance System Evaluation

Preamble / informal verbal consent:

- Today I'd like to have a chat about COVID-19 surveillance in NSW in general, from your perspective in your particular COVID-19 role.
    - Surveillance in this sense means the entire process from collecting COVID-19 information from an individual (for example, test results, case/contact interviews), all the way through analysis and interpretation to influencing policy change and the public health strategy. Your particular role may sit within only a part of this process and this is fine – just talk about what it is like for you, and what you can observe.
- This project is covered by the Public Health Act – no formal ethics approval has been required, but I'd still like to ask for your permission to be interviewed, as matter of courtesy.
- I will be writing a surveillance report, which will be one of the chapters of my MAE, and may also be presented to PHRB executives. For most of the people I interview, I would like to de-identify in the report. However, may be difficult to fully de-identify certain people because of their specific COVID-19 role. If you'd like, I can always show you a draft to see if you are happy with how you are quoted.
- I would like to record this interview (voice only) for accuracy of information – especially due to the amount of specific details that might be exchanged. Is this OK?
- Any questions/concerns before we start?

Part A: Background about respondent

- What is your role in the COVID-19 response?
- When did you start in this role? (Month +/- year)
- Were you working in NSW Health before COVID-19? Which part of NSW Health and what were you doing?
- Prior to starting in your COVID-19 role, had you done any public health work for any previous large outbreaks or pandemics? If so, which outbreak, and what did you do?
- Prior to starting in your COVID-19 role, were you involved in any routine surveillance roles within the NSW notifiable conditions surveillance system in general? If so, what did you do?
    - Prior to COVID-19, would you say that your knowledge of the notifiable diseases surveillance system in NSW was (please give rating from 1-4) 1: very poor to 4: excellent?
    - Were you familiar with NCIMS prior to COVID-19?

Part B: Working within the COVID-19 response

Purpose

- What are the most important objectives of the COVID-19 surveillance system to you in your specific role?
- Do you use NCIMS in your COVID-19 role? In what capacity?

Simplicity

- How well do the different parts of the surveillance system communicate with each other (for example, between the PHRB and PHUs, between PHUs, between different teams in the

PHRB)? Please give your answer as a rating from 1 representing 'very poorly' to 4 representing 'very well'.

- What is your general impression of the user-friendliness of NCIMS as a whole during COVID-19? Please give your response as a rating from 1 representing 'very difficult to use' to 4 representing 'very easy to use'.
- How easy is it to enter COVID-19 data into NCIMS? Data entry could include completing the case or close contact wizard, uploading scanned questionnaires, manually entering laboratory results or writing progress notes in each event. Please give your response as a rating from 1 representing 'very difficult' to 4 representing 'very easy'.
- How easy is it to search for COVID-19 information in NCIMS? Please give your response as a rating from 1 representing 'very difficult' to 4 representing 'very easy'.
- How easy is it to extract COVID-19 information from NCIMS? Examples of this could be checking laboratory results, or finding exposure information for a case or contact, or retrieving clinical information. Please give your response as a rating from 1 representing 'very difficult' to 4 representing 'very easy'.
- Are there particular structures or processes within the NSW COVID-19 surveillance system that are more complex than required or expected?

Flexibility

- In a rapidly evolving pandemic, the surveillance system needs to be adaptable to new changes, but not change so much that it is difficult for users to keep up. In your opinion, how well have new changes been communicated to you? Please give your response as a rating from 1 representing 'very poorly communicated' to 4 representing 'very well communicated'.
- Now thinking about NCIMS specifically, and thinking about all of the changes that you have perceived to be major: how easy has it been to navigate your way around NCIMS after each of these changes? Please give your response as a rating from 1 representing 'very difficult' to 4 representing 'very easy'.
- How well has the NSW COVID-19 surveillance system integrated with the information systems in place at PHUs? Please give your answer as a rating from 1 representing 'very poorly' to 4 representing 'very well'.
- How well has the NSW COVID-19 surveillance system integrated with other NSW data systems? Please give your answer as a rating from 1 representing 'very poorly' to 4 representing 'very well'.
- How well has the NSW COVID-19 surveillance system integrated with national data systems? Please give your answer as a rating from 1 representing 'very poorly' to 4 representing 'very well'.

Timeliness

- What has your experience been of the timeliness between the laboratory detecting a new positive case and the case being notified to the surveillance system, through any means? Please give your response as a rating from 1 representing 'unacceptably slow or delayed' to 4 representing 'very timely'.
- What has your experience been of the timeliness between the notification of a new positive case and public health actions being carried out? Please give your response as a rating from 1 representing 'unacceptably slow or delayed' to 4 representing 'very timely'.
- What has your experience been of the timeliness of collecting information from case interviews, and for this information to be available to the rest of the surveillance system? Please give your response as a rating from 1 representing 'unacceptably slow or delayed' to 4 representing 'very timely'.

- What has your experience been of the timeliness of collecting information from close contact interviews, and for this information to be available to the rest of the surveillance system? Please give your response as a rating from 1 representing ‘unacceptably slow or delayed’ to 4 representing ‘very timely’.
- What has your experience been of the timeliness of negative diagnostic COVID-19 results being notified to the surveillance system, through any means? Please give your response as a rating from 1 representing ‘unacceptably slow or delayed’ to 4 representing ‘very timely’.
- Do you feel that there is a bottleneck in timeliness of the system (a particular process within the surveillance system that limits its timeliness in achieving its purposes)?

Data quality

- What is your perception of the accuracy and completeness of the data in the NSW COVID-19 surveillance system? Please give your answer as a rating from 1 representing ‘very poor’ to 4 representing ‘excellent’.

Acceptability

- In general, how satisfied are you with the NSW COVID-19 surveillance system (not just NCIMS)? Please give a rating from 1-4, with 1 representing ‘very dissatisfied’ and 4 representing ‘very satisfied’.
- How satisfied are you with NCIMS as the information management system for the NSW COVID-19 surveillance system? Please give a rating from 1-4, with 1 representing ‘very dissatisfied’ and 4 representing ‘very satisfied’.

Sensitivity

- How well does the surveillance system capture all of the possible cases of COVID-19 in NSW? Do you suspect that there are groups that may be missed by the surveillance system?

Stability

- We are going to look at the reliability of the point of view of your overall trust in the surveillance system, and also in terms of the absence of any malfunctions, failures or disruptions. With this in mind, please rate the reliability of the NSW COVID-19 surveillance system as a whole from 1 to 4, with 1 representing ‘very unreliable and untrustworthy’ to 4 representing ‘very reliable and trustworthy’.
- Now just focusing on the reliability of NCIMS when used for the NSW COVID-19 surveillance system, could you please give a rating from 1 to 4, with 1 representing ‘very unreliable and untrustworthy’ to 4 representing ‘very reliable and trustworthy’.
- Have you been affected by any failures or outages of NCIMS? If so, what contingency measures were in place? Are you aware of any contingency measures if an outage of NCIMS were to occur? Are you satisfied with these contingency measures?
- Are there enough human resources in the NSW COVID-19 surveillance system? Please give your response as a rating from 1 to 4, with 1 representing ‘definitely inadequate’ to 4 representing ‘completely adequate’.
- At times, various people working within the NSW COVID-19 surveillance system have had to work from home due to the quarantine requirements of COVID-19 itself. Has this been accommodated adequately by the system?

Usefulness

- Obviously, not everyone uses the “raw” data within NCIMS. Some people engage with the surveillance data after it has been analysed and interpreted as responses to media enquiries, or weekly Epi reports.

    - How satisfied are you with the analysis of the COVID-19 surveillance data that has been performed by staff members within the NSW COVID-19 surveillance system? Please give your answer as a rating from 1 representing 'very dissatisfied' to 4 representing 'very satisfied'.
    - How satisfied are you with the outputs of the NSW COVID-19 surveillance system? This mainly includes reports, but also responses to stakeholder enquiries, datasets for PHUs and any other end products that include NSW COVID-19 surveillance data. Please give your answer as a rating from 1 representing 'very dissatisfied' to 4 representing 'very satisfied'.
  - In your opinion, how well has relevant information from the surveillance system been relayed to the public in terms of risk communication? Examples of this might be informing the public about venues with possible transmission, or the areas that we're targeting for increased testing. Please give your answer as a rating from 1 representing 'very poorly done' to 4 representing 'very well done'.
  - Has anything that you do in your COVID-19 role changed as a result of the information from the NSW COVID-19 surveillance system? How about policies and strategies that have changed because of the surveillance data?

Data security and confidentiality

- In your opinion, are the data in the NSW COVID-19 surveillance system secure? Please give a rating from 1 to 4, with 1 representing 'not secure at all', to 4 representing 'very secure'.
- Do you feel that the NSW COVID-19 surveillance system maintains adequate levels of confidentiality? Please give a rating from 1 to 4, with 1 representing 'not adequate at all' to 4 representing 'very adequate'.

Part C: Concluding remarks

- Are there specific features or improvements you would like to see in the COVID-19 surveillance system in NSW?
- Any other comments you'd like to make specific to your role?

Thank you very much for participating in this interview today. You have given me many very helpful insights. Please do not hesitate to email me if you have any additional thoughts!

Appendix 6: Completeness of whole genome sequencing data

The process for entering WGS results into NCIMS is described in the "System inputs and sources" section. Briefly examining the completeness of WGS results recorded in the NSW COVID-19 surveillance system, the NCIMS ID numbers for the cases who underwent SARS-CoV-2 WGS from November 7, 2020 to November 14, 2020 were obtained from an ICPMR line list that had been sent to the Data Quality Team for data entry. This particular week was chosen because it was the final week of the data collection period for this evaluation, and most likely represents the most updated impression of an evolving situation, for the evaluation period. It needs to be noted that the individuals whose samples were sequenced in this week may have been notified to the NSW COVID-19 surveillance system earlier, as it required time for a specimen for WGS to reach ICPMR from the initial diagnostic laboratory, and time for the WGS laboratory processes to take place. The NCIMS records for these individuals with WGS results were checked to determine whether the results, made known to the PHRB through the ICPMR line list, were then documented in the corresponding COVID-19 event (Table VIa).

Table VIa – WGS results recorded in NCIMS for cases sequenced November 7-14, 2020

	Count for week November 7-14, 2020	WGS results recorded in NCIMS (%)
Locally acquired cases sequenced	2	0 (0)
Overseas acquired cases sequenced	12	12 (100)
Total cases sequenced	**14**	**12 (86)**

It can be observed that the completeness of WGS results in NCIMS for that week was vastly different for locally acquired cases that were sequenced (0 of 2), compared to that for overseas acquired cases (12 of 12). It is likely that this difference was due to the PHRB Data Quality Team (DQT) having responsibility for the data entry of cases in hotel quarantine, whereas data entry for most other locally acquired cases were undertaken by PHUs. The DQT were already involved in the management of WGS data in NCIMS, and had protocols in place for the entry of these data. Clearly, due to the small absolute numbers, these results were not necessarily representative of the completeness in NCIMS of all WGS results received to date. Additional analyses need to be performed on data from a range of weeks after November 2020, if there are ongoing concerns about the completeness of WGS data in NCIMS.

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NSW COVID-19 Surveillance System
- An evaluation

Covering period January 21, 2020 to November 14, 2020

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Acknowledgement of country

This presentation today is held on Cammeraygal Land, which has also sustained the NSW COVID-19 pandemic response for the past 22 months.

On behalf of the PHRB I would like to pay our respects to Elders past and present.

We acknowledge all Aboriginal and Torres Strait Islander people in NSW, especially our Indigenous colleagues, advisors, and all First Nations voices advocating for better outcomes during and after the pandemic.

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Outline

- Background to evaluation
- Methodology
- A description of the system
- Findings by attribute
- Conclusions
- Recommendations
- Discussion

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Background to this evaluation

- MAE surveillance evaluation project
- Requested by PHRB Executive
- Main aims
  - To describe the structure and evolution of the initial months of the NSW COVID-19 surveillance system
  - To assess the attributes of this system against the objectives of stakeholders
- Followed steps set out in the CDC surveillance evaluation guidelines
- Planning commenced in May 2020
- Data collection: June – December 2020
  - With data cut off date of November 14, 2020
  - Stakeholder interviews: September – November 2020

"It's just the rapidity … of the changes! They're very difficult to keep up with." – PHU respondent

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Methodology

Main sources of information:
- Own work experience in PHEOC/PHRB
- Stakeholder interviews
  - 20 stakeholders interviewed
  - 3 stakeholders in critical roles interviewed with more open-ended question guides
  - All other stakeholders interviewed with set question guides
- Review of surveillance documents, including:
  - *Enhanced surveillance plan for COVID-19 in NSW*
  - NSW SoNG appendices
  - Weekly COVID-19 Surveillance Reports
  - NSW COVID-19 Situation Reports
  - Data completeness snapshots
  - Questionnaires and NCIMS data entry guides

			Number	Percentage
COVID-19 work location				
	PHRB and MoH		14	70
	PHU	Total	6	30
		Metropolitan PHU	3	15
		Regional PHU	3	15
Familiarity with NCIMS				
	Used NCIMS frequently prior to COVID-19		11	55
	Used NCIMS occasionally prior to COVID-19		1	5
	Never used NCIMS prior to COVID-19		8	40
Use of NCIMS for COVID-19				
	Does not use NCIMS		3	15
	Uses NCIMS	Total	17	85
		Data collection and entry	13	65
		Data cleaning and management	10	50
		Information retrieval	15	75
		Data analysis	10	50
		New process development and training	4	20
		Back end development and maintenance	2	10
Public health experience				
	Previous experience of pandemics or large outbreaks		11	55
	Communicable diseases experience, but no large outbreaks		5	25
	No prior experience in communicable diseases		4	20

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Description of the NSW COVID-19 Surveillance System (1)

21/01/2020: Activation of PHEOC

25/01/2020: First confirmed COVID-19 case in NSW

02/03/2020: First community-acquired COVID-19 case in NSW

10/06/2020: PHEOC became PHRB

Population under surveillance
All individuals within NSW

Condition under surveillance
COVID-19 ("Novel Coronavirus 2019")
As at November 14, 2020:
- 4,486 cases in NSW
- 53 deaths

Case definitions:
- As guided by CDNA SoNGs
- Many iterations

Legal context
- NSW: Notification of positive results required under the NSW *Public Health Act 2010*
- Australia: COVID-19 surveillance activities also fall under the *Biosecurity Act 2015*

Organisational context
Commonwealth level:
- NIR
- CDNA
- AHPPC

NSW level:
- SEOC and SHEOC
- Health:
  - HPNSW
  - NCIMS
  - Media
  - Pathology
- PHUs/LHDs

Within the PHRB:
- Epidemiology and Surveillance Team
- A range of other teams with surveillance roles

Information management
- Notifiable Conditions Information Management System (NCIMS)
- Interfaces and linkages with other sources
- Additional line lists and spreadsheets

Novel features of system
- Notification of all COVID-19 diagnostic results
- Collection of individual information for contacts of confirmed cases
- Tracking all individuals in hotel quarantine

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Description of the NSW COVID-19 Surveillance System (2)

- Set out in the *Enhanced surveillance plan for COVID-19 in NSW*
  - Dynamic document
  - Stated goals and surveillance strategies described in this presentation: from November 2020

Goal	Case-based notification	Test-based surveillance	Active surveillance of higher risk settings	Serosurveillance	Virological / molecular epidemiological surveillance	Syndromic surveillance / surveillance of respiratory illness	Health facility impact monitoring	Priority groups surveillance	International border surveillance	Environmental surveillance	Venue surveillance
1. Provide daily updates on the characteristics and time-trends of COVID-19 cases	✓							✓			
2. Provide daily updates on the characteristics and time-trends of deaths due to COVID-19			✓					✓			
3. Provide daily updates on tests performed to detect SARS-CoV-2 infection		✓						✓	✓		
4. Report on the performance of contact tracing			✓								✓
5. Report on clusters, outbreaks and other community trends in COVID-19 related illness	✓	✓	✓		✓	✓		✓	✓	✓	✓
6. Describe the clinical severity of COVID-19			✓				✓	✓			
7. Monitor impacts on the tertiary healthcare system						✓	✓	✓			
8. Conduct serosurveys to determine prevalence of SARS-CoV-2 infection				✓				✓			
9. Undertake strategically targeted asymptomatic screening			✓								

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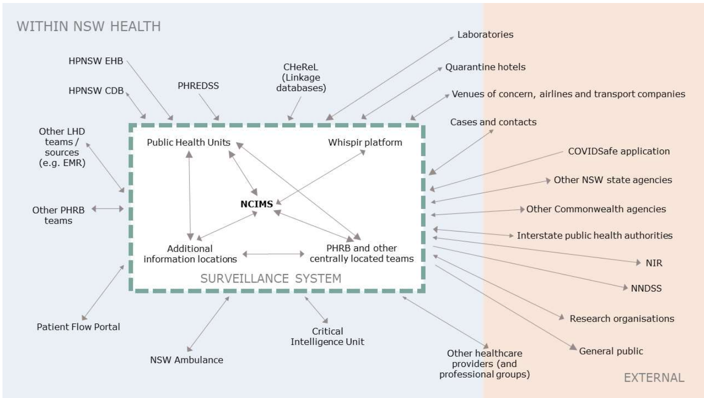
Description of the NSW COVID-19 Surveillance System (3)



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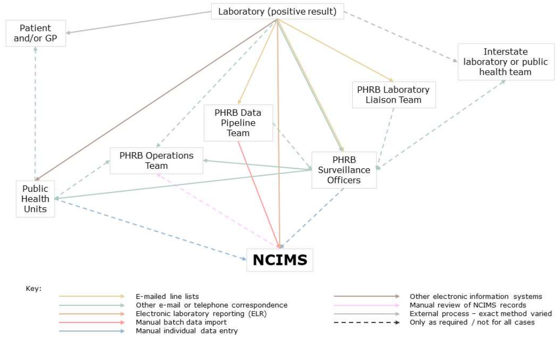
Description of the NSW COVID-19 Surveillance System (4)

- Many methods for positive results to be notified
- Many redundancies built into the system to ensure the arrival of positive results
- Accommodates variations between laboratories, LHDs/PHUs



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Description of the NSW COVID-19 Surveillance System (5)

Notifiable Conditions Information Management System **(NCIMS)**

- In use for notifiable condition surveillance in NSW since 2010
  - Individual records based around notifiable condition "events"
  - Use in a pandemic context tested in PaNCIMS exercise in 2017
  - Covered by the Notifiable Conditions Data Security and Confidentiality Policy Directive (2012)
- "New" features for COVID-19:
  - New account type for surge staff
  - Recording all diagnostic results
  - Recording contacts
  - Case / close contact follow-up
    - Recording daily symptoms
    - Sending surveys
    - Interface with Whispir
  - COVID-19 specific workflows, data entry fields, data entry wizards
  - New ELR laboratories
  - Rebuilding of data tables in the back end, increases in capacity

"It's pretty great in what it's doing, with 3 million test results to deal with!" – PHU respondent

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Findings: Overall

- Excellent planning and preparation
- Highly valued by decision makers
- Stated goals of surveillance system fully or partly met

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Findings by attribute: Simplicity and Flexibility

Attribute	Findings from stakeholder interviews	Findings from reviewing additional information
Simplicity	• The NSW COVID-19 surveillance system was rapidly evolving and perceived to be complex • The decision to use NCIMS for recording close contacts and transmission clusters added to the complexity of the system • The processes for recording surveillance data outside of NCIMS (such as venue information or WGS results) were less straightforward than expected	• Dedicated training was required for new staff to use NCIMS *(Source of information: review of training materials)*
Flexibility	• Overall, the system was highly flexible to the continual developments of the pandemic response • Improvements could be made in the timeliness and user-friendliness of communications about changes to system processes • There were many useful interfaces between the NSW COVID-19 surveillance system and external information systems. Integration across interfaces with external systems was identified as an area that can be improved	• The system adapted well to changes, sometimes pre-empting new developments *(Source of information: timeline review)*

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Findings by attribute: Timeliness and Data Quality

Attribute	Findings from stakeholder interviews	Findings from reviewing additional information
Timeliness	• Implementing ELR procedures for more diagnostic laboratories would lead to additional improvements to the timeliness of the system	• The system was timely at each stage of the pathway for the notification and initial public health actions for positive cases *(Source of information: weekly Surveillance Reports)*
Data Quality	• Data quality improved over time, assisted by data linkage, retrospective data entry, the introduction of the Data Quality Team, and data completeness reports	• High levels of completeness in the data fields considered to be critical for cases captured by the NSW COVID-19 surveillance system • Data fields with the lowest levels of completeness were related to subgroup information, such as ethnicity and occupation *(Source of information: review of data completeness reports)*

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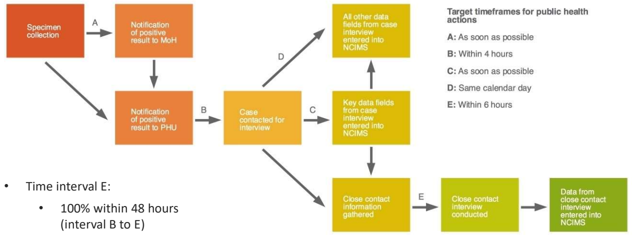
Timeliness of public health action for positive cases

- Target timeframes from the NSW COVID-19 SoNG Appendix
- Data collection was not able to capture whether these exact targets were met
- Time interval A:
  - 79% within 1 day by Nov
  - Satisfactory for 89% stakeholders
- Time interval B:
  - 100% within 1 day
  - Satisfactory for 100% stakeholders
- Time interval C and D:
  - No formal analysis
  - Satisfactory for 94% stakeholders



- Time interval E:
  - 100% within 48 hours (interval B to E)
  - Satisfactory for 93% stakeholders
- Negative results:
  - Satisfactory for 82% stakeholders

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Data completeness for confirmed cases

Data field	Number of cases for whom field is complete, fortnight ending August 31, 2020 inclusive (%)	Number of cases for whom field is complete, fortnight ending November 14, 2020 inclusive (%)	Number of cases for whom field is complete, all COVID-19 cases until November 14, 2020 (%)
	(All cases: N = 99)	(All cases: N = 73)	(All cases: N = 4501)
"Place of disease acquisition"	98 (99)	73 (100)	4501 (100)
	(Subset of all cases: locally acquired cases; N = 75)	(Subset of all cases: locally acquired cases; N = 11)	(Subset of all cases: locally acquired cases; N = 1874)
"Source of local acquisition"	74 (99)	10 (91)	1874 (100)
	(Subset of locally acquired cases: epi-linked to a case or cluster; N= 38)	(Subset of locally acquired cases: epi-linked to a case or cluster; N= 0)	(Subset of locally acquired cases: epi-linked to a case or cluster; N = 871)
"Setting of possible exposure" for this subset	38 (100)	N/A	822 (94)

Data field	Number of cases for whom field is complete, fortnight ending August 31, 2020 inclusive (%)	Number of cases for whom field is complete, fortnight ending November 14, 2020 inclusive (%)	Number of cases for whom field is complete, all COVID-19 cases until November 14, 2020 (%)
	(All cases: N = 99)	(All cases: N = 73)	(All cases: N = 4501)
"Interpreter needed"	**17 (17)**	**13 (18)**	**913 (20)**
"Ancestry or ethnic origin"	55 (54)	37 (51)	**664 (15)**
"Date isolation began"	79 (80)	50 (68)	**1057 (23)**
"Primary occupation"	Not recorded	**15 (21)**	**1184 (26)**
	(Subset of all cases: primary occupation known; N = n/a)	(Subset of all cases: primary occupation known; N = 15)	(Subset of all cases: primary occupation known; N = 1184)
"Setting of primary occupation"	Not recorded	12 (80)	**382 (32)**
	(Subset of all cases: setting of exposure known; N = 63)	(Subset of all cases: setting of exposure known; N = 4)	(Subset of all cases: setting of exposure known; N = 871)
"Setting of exposure date"	**31 (49)**	4 (100)	619 (71)

Key: Numbers in **bold** are those where fields have lower than 50% completeness.

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Findings by attribute: Acceptability and Sensitivity

Attribute	Findings from stakeholder interviews	Findings from reviewing additional information
Acceptability	• High levels of acceptability from surveillance staff • Many surveillance processes improved over the initial months of the pandemic response • NCIMS had limitations, but fulfilled basic surveillance requirements and was familiar to many staff members	
Sensitivity	• General perception that the surveillance system was highly sensitive	• Presumed to be highly sensitive, as determined through a range of indirect indicators *(Source of information: weekly Surveillance Reports)*

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Findings by attribute: Stability and Usefulness

Attribute	Findings from stakeholder interviews	Findings from reviewing additional information
Stability	• NCIMS was a reliable information management system • There was adequate planning for unexpected failures of NCIMS • The staffing surge required by the surveillance system was a substantial undertaking and was largely successful, with some specific shortcomings identified • There were ongoing challenges with sustaining the workforce • The surveillance system was mostly able to accommodate staff members being personally impacted by the pandemic and having to work remotely	
Usefulness	• The analyses and reporting from the NSW COVID-19 surveillance system have been comprehensive and have accommodated the changing needs of a range of stakeholders • Public communications using the information from the surveillance system has been mostly effective, with some potential for minor improvements in terms of accuracy of exposure venue information and language used • Outputs from the system had been useful for informing public health response strategies, policies and communications	

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Findings by attribute: Data Security and Confidentiality

Attribute	Findings from stakeholder interviews	Findings from reviewing additional information
Data security	• The NSW COVID-19 surveillance system was generally secure to external threats • There were several internal sources of security threats that required further attention to mitigate	
Confidentiality	• A comprehensive range of processes was in place in the system for maintaining confidentiality • Individual staff member adherence to processes for confidentiality was variable • A challenge identified was managing external stakeholder requests in a confidential manner – this was improving over time • Additional measures to ensure confidentiality in smaller communities would be a useful development	

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Conclusions: Strengths of the system

1. Proactive and collaborative communication between all pandemic response teams
2. Adaptability of the surveillance system to change
3. Timely performance of the surveillance system at each stage of the pathway for notification of positive COVID-19 cases
4. Implementation of strategies to improve data completeness and quality
5. Familiarity of NCIMS to many staff members, especially with recent training activities for using NCIMS in an emergency response
6. Highly sensitive system, with monitoring and reporting of indicators of surveillance system sensitivity
7. A stable information management system in NCIMS
8. Adaptability of the system to human resource needs, such as the ability to surge staff numbers rapidly and the ability to accommodate remote work
9. Comprehensive and responsive analysis and reporting that has been useful to decision-makers
10. Security of data to external threats

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Recommendation 1 – Training and maintenance of skilled workforce

Attributes addressed:
Simplicity, flexibility
Suggested time frame for completion:
Two months

Action
Creation of NCIMS training checklist for all new surveillance system staff

Action
Continued development of surveillance system training material for pandemic response staff

Action
Development of a central repository of surveillance system user resources

People to involve
- PHRB Epidemiology Team
- PHUs
- MoH NCIMS Team

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Recommendation 2 – Continued improvement of processes for transferring laboratory data

Attributes addressed:
Flexibility, data security
Suggested time frame for completion:
Six months

Action
Continued collaboration with non-ELR diagnostic laboratories to establish ELR processes

Action
Continued collaboration with diagnostic laboratories to improve security of identifiable information sent to the PHRB

People to involve
- PHRB Epidemiology Team
- PHRB Laboratory Liaison Team
- MoH NCIMS Team

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Recommendation 3 – Continued development of user-friendly processes to capture close contact and transmission cluster information

Attribute addressed:
Simplicity
Suggested time frame for completion:
Two months

Action
Continued collaboration between pandemic response teams to improve the way that clusters and close contacts are recorded and linked in the surveillance system

People to involve
- PHRB Epidemiology Team
- PHRB Operations Team
- CCTT
- PHUs
- MoH NCIMS Team

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Recommendation 4 – Improve surveillance for venues of exposure

Attribute addressed:
Simplicity
Suggested time frame for completion:
Six months

Action
Continued development of user-friendly processes to document and share information regarding venues of exposure among pandemic response teams

People to involve
- PHRB Epidemiology Team
- PHRB Operations Team
- CCTT
- MoH Communications Team
- PHUs

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Recommendation 5 – Improvement of ethnicity and occupation data

Attribute addressed:
Data quality
Suggested time frame for completion:
Six months

Action
Development of process to improve both retrospective and prospective completion of data in NCIMS fields related to ethnicity and occupation

People to involve
- PHRB Epidemiology Team
- PHRB Data Quality Team

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Acknowledgments

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- Jana Sisnowski
- Kwendy Cavanagh
- Suhasini Sumithra

All interviewed stakeholders

Questions?

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Discussion

Overall	**Recommendation 1:** Training and maintenance of skilled workforce	**Recommendation 2:** Improvement of processes for laboratory data transfer	**Recommendation 3:** Development of processes to capture close contact and cluster information
Recommendation 4: Improve surveillance for venues of exposure	**Recommendation 5:** Improvement of ethnicity and occupation data		

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Counting Butterflies

Teaching, Presentations and Other Activities

Teaching and other activities: Prologue

In a strange way, this part of the thesis reminds me of the moving house, in that after the large items are out of the way, all of the smaller items need to be organised into something manageable. It induces a headache just trying to figure out how many cardboard boxes might be needed. Here are the odds and ends of my placement.

Other activities: COVID-19 pandemic response

I probably cheat slightly when I say that half my MAE was in the pandemic response, in that I also count my surveillance evaluation project on COVID-19. I was requested by my field supervisor to capture my pandemic response activities in a separate reflective essay in this chapter.

Other activities: Communicable Diseases Branch

As somebody with a woeful attention span, it was probably not difficult to see that in a busy state public health organisation like HPNSW, any attempts to focus solely on the MAE over these two years failed spectacularly. This was fuelled further by the pandemic. When the Delta wave made landfall, CDB were called upon to assist PHUs with managing non-COVID cases and outbreaks. The clinician in me was more than happy to speak to real patients on the phone, and to take advantage of this opportunity to learn to do PHU work.

Outbreaks I took responsibility in managing included:

- Enterovirus causing hand, foot and mouth disease and viral meningitis: eventually genetic typing revealed that the virus responsible for the outbreak was Coxsackievirus B5
- Invasive meningococcal disease outbreak on the Northern Beaches

Outbreaks I assisted with managing included:

- Multi-resistant *Staphylococcus aureus* skin infections among workers at a network commercial facilities in southwestern Sydney
- Cryptosporidiosis, throughout NSW
- Acute post-streptococcal glomerulonephritis in Western NSW
- Systemic *Pseudomonas aeruginosa* infections associated with skin piercing, cases throughout NSW
- Several influenza-like illness (ILI) outbreaks in aged care facilities
- *Salmonella* Hvittingfoss, throughout NSW

Additionally, I assisted with the public health management of individual cases of the following conditions:

- *Legionella pneumophila* and *Legionella longbeachae*: this also involved tracking exposure sites of potential concern for *L. pneumophila*
- Invasive meningococcal disease (individual cases not in clusters): this included assisting with case interviewing, contact tracing, and the organisation of clearance antibiotics and vaccination for close contacts
- Conjunctival and genital site *Neisseria meningitidis* notifications

- Influenza: with very few cases, each new case received a greater amount of attention from senior staff; I assisted with coordinating confirmatory testing of positive samples at the reference laboratory
- Pertussis
- Measles: although there were no confirmed cases of measles during my time at CDB, there were several suspected cases where testing and proactive contact tracing had to occur urgently
- Malaria in returned travellers and migrant workers
- Dengue in returned travellers
- Alphaviruses: Ross River virus and Barmah Forest virus
- Murray Valley encephalitis: I wrote a brief report of this case for a general public audience, published in the CDB Communicable Diseases Weekly Report (CDWR) online, also shown in this chapter
- Creutzfeldt-Jacob disease: following cases up for public health risk factors by interviewing GPs and next-of-kin, and reviewing any relevant reports from surgical procedures

I assisted with some of the reporting activities in CDB. I was responsible for the fortnightly NSW jurisdictional report to CDNA from April 2021 to January 2022. As outlined in the Epidemiological Study chapter, I prepared weekly presentations to report on international trends and outbreaks of communicable diseases. As a doctor, I was also sometimes asked to review documents with clinical content. Additionally, I took on responsibility for the following administrative tasks:

- Secretariat for non-COVID NSW Health Protection Leadership Team (HPLT) meetings, which involved taking minutes at meetings and maintaining Action Item lists
- Public Health Network Epidemiological Grand Rounds presentations
- Chairing weekly CDB Surveillance Meetings
- Coordinating the compilation, approval process, and distribution of the CDWR
- Workflow management in the NSW Notifiable Conditions Information Management System (NCIMS)

Other activities: Miscellaneous

Within HPNSW, I was also one of the organisers of the R Coding club, maintaining the mailing list, and organising and publicising fortnightly R Club meetings, which involved creating promotional graphics. Another HPNSW activity featured in this chapter is my laboratory visit to the Medical Entomology Laboratory at the Institute for Clinical Pathology and Medical Research (ICPMR).

At the same time as my MAE, I used my field placement at HPNSW as a training placement towards a Fellowship with the Australasian Faculty of Public Health Medicine. I also maintained my continued professional development activities as a GP, attending RACGP COVID-19 webinars, and completing COVID-19 vaccinator training. Additionally, I was part of an Australia-wide network of early career epidemiologists, and assisted with organising monthly teleconferences.

Teaching

One of my favourite aspects of working in HPNSW is that there is teaching and learning every day. It would be impossible to outline all the informal teaching activities that I undertook.

I completed the following teaching activities required by the MAE:

- "The Kid with a Cough": a teaching session on Indigenous public health to the first year MAE cohort, prepared with two of my classmates (26/03/2021)

- Lesson From the Field on spatial epidemiology; I was also one of the two student LFF coordinators (02/07/2021)

Additional teaching activities included:

- “Arbovirus Surveillance in NSW”, delivered to HPNSW CDB (10/08/2021)
- “The very honest guide to working with GPs”, delivered to HPNSW CDB (30/11/2021)
- Monthly presentations at the HPNSW Journal Club, which I organised. The presentations from Journal Club are in the “Presentations” document

Other presentations

An unfortunate discovery is that no matter how many presentations I give, I am still as nervous beforehand as if it were my very first one. In this chapter, I list, in a separate document, many of the times when I have had to overcome those butterflies over the last two years to speak in public. Some of the slides are included.

Acknowledgments

So many people assisted me in completing all these activities described. The full list of acknowledgements are in the “Epi-logue” at the end of this thesis.

NSW COVID-19 Pandemic Response

The first thing I did, on my very first day at Health Protection NSW (HPNSW), was to follow my new Field Supervisor into the crowded COVID-19 Bunker. The COVID-19 response came to be my main task at Health Protection NSW until Course Block 2. Despite facing many pressures, especially in the initial months of the pandemic, this was an intense but immensely rewarding learning experience, under the direction of many leaders whom I admired and respected greatly.

Operations Team

I began, as many "clinical" people did, in the Operations Team. I was new to the Incident Management Structure, and went into this role not knowing what it might be all about, apart from the fact that surgical operations were probably not required.

On that very first day, we were notified of two new cases at the same school. My supervisor looked around the room for people he could send out to assess the situation, having already sent a team out to another school. I decided to jump right into the deep end and put up my hand. To this day, I am still surprised that he let me do it, when I was so new at the game that I was completely and blissfully ignorant of any potential complexities. Sure, I was with a couple of more senior staff members, who shouldered the political and media pressure, while I was allowed to bask in the "field" part of field epidemiology, assembling Excel spreadsheets of close contacts from class lists. Sadly, that was probably the peak of my self-confidence for the rest of the pandemic response. Every day after that, I learned about yet more complexities, and the COVID-19 situation in NSW also evolved to become more politically charged. I became more and more anxious that whatever I was doing, however straightforward it was, might just land me, and others around me, in the full media floodlight of a sticky situation.

I helped manage a few school-based clusters at the beginning, which included setting up some of the mass text messaging to parents, and being overwhelmed at the volume of replies. One of the first lessons I learned was that as a clinician, as much as I wanted to reply to everyone individually and offer telephone advice, this was simply not feasible. I observed the reorganisation of the inbound calls processes with fascination. I appreciated how communication with the public was viewed as a core part of the proactive pandemic response, with several relatively large centralised teams from the beginning (including the Communications Team, Media Team, inbound call centre and Contact Tracing Team), and not as a scrambling afterthought that only arose when there was a message to disseminate.

With these initial school clusters under my belt, I was asked to assist with reviewing the initial draft of a protocol for managing cases at schools. I remember feeling proud when a senior staff member told me that my opinions were important because I had become "a bit of a COVID-19 schools specialist", maybe just one of a few in the world. Of course, I was completely dejected one day when I arrived for my Operations shift to discover that the new school cluster was assigned to somebody else. Wasn't I the "specialist"? Have I done a bad job? It was difficult to let go of my role, and unfortunately, I had to keep learning this lesson several times in the next few months. Another cluster that I managed involved a cohort of foreign military personnel. I had daily teleconferences with the Australian Defence Force medics who were coordinating the care and the international military relations for this group. I knew each member of the cohort not just by name, but by military rank and whether they preferred going to the beach or to church on the weekend. Miraculously, I was indulged in terms of being allowed to take care of this cluster until they were safely allowed to return home, but not before several team leaders rolled their eyes at my inflexibility and inability to share.

I performed slightly better when it came to interviewing cases and close contacts. We did this for PHUs sometimes when their capacity was limited. We also phoned cases and contacts for interviews in special circumstances, such as when there was a push from higher ups to collect recovery data, which involved hundreds of interviews over the space of one weekend, or when other states requested our assistance. However, there was also a stressful experience that made me reluctant to use the telephone for a while. I was given the responsibility of managing a particularly articulate and affluent group of unhappy returned travellers (with ready access to legal resources) who found themselves unexpectedly in hotel quarantine when international travel restrictions changed. It was my job to manage their release from hotel quarantine and to assist them with clearance for their journeys home to major cities around Australia before state borders closed. Obviously, the timing and ticket availability of the flights themselves were outside of my control, but I still bore the brunt of these frustrations. They asked a senior staff member to give them attention, and I had to ask, embarrassingly, for backup. Later, when things settled down, I had a chat with this senior staff member to debrief. Although I felt both guilty for involving him, and upset on his behalf, there was a part of me that was somewhat relieved that he, too, was shaken by his dealings with this group of travellers. We discussed how sometimes, it didn't feel fair that a small number of people could take up a disproportionate amount of resources, both emotional and in terms of time, just because they were more vocal.

In many ways, the Operations Team was a challenging space to work in, especially for somebody who was new to the public health sphere in New South Wales. Not only were there new factual knowledge to master in terms of structures and processes, but I also did not have the organisational knowledge to navigate pre-existing relationships, conflicts and preferences. The layers of pre-existing context meant that quite often, there was information did not know that I did not know. I would have asked more questions if at the time, I knew to ask those questions.

Many of my colleagues assumed that having had clinical experience, I would find many of the tasks in the Operations Team intuitive. I was fortunate to have had the opportunity to have more senior mentors in public health who also, like me, had a background general practice. We had frequent discussions about how the GP approach of taking initiative for decisive action, and solving problems creatively through the filter of clinical judgement, could sometimes be at odds with what we were asked to do in the pandemic response. In the Operations team, we needed to follow protocols exactly, and to wait for proposed actions to be discussed with and approved by a range of actors before proceeding. The GP inclination to take a longitudinal view, and to spend time building relationships, was antithetical to the shift work rhythm of Operations, where staff members were assigned to different clusters almost daily. Looking around me, I could see that there were medical teammates who thrived in this environment, but I made the decision of leaving the Operations Team to dedicate my attention to my growing role in the Epidemiology and Surveillance Team.

Epidemiology and Surveillance Team

The surveillance tasks within the NSW COVID-19 response was initially part of the Operations Team. I was identified by MAE alumni within the Ministry as a suitable candidate for training as the Surveillance Officer on duty, and began with being rostered for two surveillance shifts per week. As case numbers and data needs increased, a separate Epidemiology and Surveillance Team was created. I became part of a small team of four dedicated Surveillance Officers.

I must admit that it took me some time to understand the purpose of the Surveillance Officer. If new positive cases were uploaded into the surveillance system electronically already, why did somebody have to sit there and keep count? For many weeks initially, I just followed the checklist that I was given for each shift as the duty Surveillance Officer, and performed my tasks because I was asked to, not necessarily because I understood them. The need to meet multiple reporting deadlines in every shift was already terrifying enough that I had limited capacity to focus on much else. Beyond positive cases, it was my job to keep track of a range of other indicators, like negative cases and airport screening. Every night, I sent information about new cases to stakeholders, such as NSW Ambulance, the Centre for Aboriginal Health, and researchers at NCIRS. I assisted with the daily NSW reporting to the National Incident Room. When we eventually created new internal dashboards and external reports, I generated some of the numbers to populate them. I helped my teammates with information requested by government officials and our Media Team. There was also the data cleaning aspect to the job. I found that much more straightforward to understand. I just had to decide whether "John Smith" was the same person as "John B. Smyth", and repeat that a few hundred or thousand more times for other names.

For me personally, a breakthrough moment was when I came up with the ICU tracking spreadsheet. It was very simple, and did exactly what its name suggested in that it was a way for us to keep track of the daily cases in ICU. The fact that it was adopted by the other Surveillance Officers meant much more to me. It signalled that I understood enough of what was required in a situation to innovate, ever so slightly.

Innovating was what my Epidemiology and Surveillance teammates had been doing for many weeks already. I continued to watch in dumbfounded awe as they pre-empted future data needs, rebuilding questionnaires to collect new data weeks before the last minute request came from the Minister himself: "Can you tell us, within the next hour, how many people fit description XYZ?" Why yes, we could, thanks to their preparation. Sometimes the external pressures were more complex, such as when the COVIDSafe mobile application for contact tracing was introduced to the country. I attended the training teleconference with my colleagues. I was still trying to understand what the application could and could not do, and the steps that I had to take to extract the data collected. My forward-thinking teammates had already identified all the pitfalls in its implementation in NSW, and came up with procedures to incorporate COVIDSafe in our existing case follow up. Blindly, I followed the standard operating procedures document that they had drafted, relieved that somebody else had figured it all out. Fortunately, COVIDSafe was a short-lived exercise. My clever teammates quickly came to the conclusion that it did not collect any useful additional data for us, and even received the blessings of our Chief Health Officer to tell this to the other states at a conference.

The learning in the Epidemiology and Surveillance team did not just stop with observation. Despite being pressured for new data every day, other staff members in the team always made time to answer my questions, however basic. I assisted our NIR Focal Point with weekly cluster number reporting, and our discussions about the difficulties in translating complex transmission events into neat numbers became a regular learning activity. I discussed my misgivings about our methods for ethnicity data collection with another senior staff member whom I admired greatly, and was blown away by the comprehensiveness of her response. When I was finally given my own special surveillance project of creating weekly reports on new healthcare worker infections, the colleague who guided me in the initial project design went to great effort to explain the rationale behind each of her suggestions, and the potential limitations that it may introduce to the analysis. The senior staff member to whom I submitted this report each week was willing to think aloud with me in terms of the political sensitivities of some of my wording, but without micromanaging my writing style. Through examining potential healthcare clusters in greater detail, I also learned to work with information generated through whole genome sequencing (WGS). For a few weeks, I had cases who were discussed at the weekly WGS teleconference with laboratory experts.

The Surveillance Officer job became my favourite role in the entire pandemic response. People who knew about my clinical background would sometimes tell me how sorry they were that my skills were “wasted” in this position. Little did they know about how rewarding it felt to have a defined role in the pandemic response, or the meditative effect of eight thousand deduplications. I would do that over telephoning a litigious returned traveller any day. The other Surveillance Officers in our initial team of four still remain close friends two years later. Yet it was not without its challenges. I was obviously new to the information systems and processes involved in the surveillance of notifiable diseases in NSW. Unfortunately, in the context of a pandemic response, the team did not have the luxury of time for me to figure out how to work with these databases, especially where there were biostatisticians with special expertise around. When the team started to move beyond just gathering daily numbers, to more detailed epidemiological analyses published in weekly surveillance reports, additional project tasks were allocated to Epidemiology and Surveillance Team members at the start of every shift. I continued to volunteer for these project tasks, but each time, my offer was declined ever so gently and politely, in favour of teammates with far greater experience and skill. None of this is a criticism, of course. Everything that occurred was perfectly reasonable, just perhaps not ideal for me personally. As each shift went by where I was overlooked for extra “epi” jobs, I started to lose confidence in my own ability to analyse data and to code. When opportunities did arise, eventually, to try R for some of our Surveillance Officer tasks, I balked and chose to use Excel instead. It was not until the following year, when I started analysing my own data at my own pace for non-COVID-19 MAE projects that I started to rediscover my interest in coding.

Of course, the Surveillance Officer role eventually provided me with my MAE surveillance evaluation project. My personal experiences working in the Epidemiology and Surveillance Team, and the relationships that I built during this time, proved to be invaluable to my project.

Additional supporting activities

I had wanted to join the Planning Team for a short while, just to see what it was all about. At the beginning, the name of the team confused me. Surely, “having a pandemic” was not part of the organisational five-year plan? While I did not have any opportunities for any shifts on the Planning Team, through my musical interests and experiences, I was able to assist them in a policy review on singing and wind instrument playing. Unfortunately, the outcome was disappointing in that I had to recommend against some of the activities that I enjoyed. The consolation was that I had the satisfaction of seeing how this review document informed subsequent policy developments in NSW.

Finally, something that everyone else had forgotten about, but of which I remain proud to this day, were the ideas that I implemented for the educational benefit of my colleagues in the pandemic response. I could see that many of my colleagues, drafted from other areas of NSW Health, were not always familiar with the microbiological laboratory tests used for COVID-19. I collaborated with our Laboratory Liaison Team to create the very first “Bunker Ed” lunchtime education session. The success of this activity meant that I also organised a second session, in conjunction with colleagues at NCIRS, to discuss some of their initial COVID-19 research findings in school settings. I used my graphics design skills to create the promotional posters for both events. Lunchtime learning sessions still continue in the NSW pandemic response to this day, now under the portfolio of the Response Support Team.

Epilogue

Like many others around me, I had endured all the early challenges of the pandemic with the expectation that at some point we would reach some kind of an equilibrium, and that things would finally stop changing so quickly. I had a few months to settle into the rhythm of the Communicable Diseases Branch when seemingly out of nowhere, the Delta strain of SARS-CoV2 was upon us in NSW. I was fortunate enough not to be sent back to the pandemic response full-time, but I did try to play my part among the rapidly escalating numbers. I spent some time each week assisting the Epidemiology and Surveillance team with improving data completeness for cases and close contacts, relieved that I could still navigate my way around the COVID-19 part of the computer system after so many months away. The work that I was assigned decreased before the epidemiological curve had even peaked, as decisions were made to stop reporting on data field after data field. I discovered that my final lesson from the pandemic response was to let go of the dream of perfect data.

Acknowledgements

The Manager of the Operations Team remarked recently that since the beginning of the pandemic, more than a thousand staff members had rotated through the NSW COVID-19 response. I would like to thank a substantial proportion of this number, for all that I have learned from them, and all their support and camaraderie during this whirlwind introduction to public health in NSW. A special mention must be given to the "Original Surveillance Boss Girls", Kwendy Cavanagh, Jana Sisnowski and Suhasini Sumithra. Additionally, I would like to thank team leaders, managers, other senior staff, and our esteemed NSW Chief Health Officer, Dr Kerry Chant. In the first few months of the pandemic response, Dr Chant allowed me to attend her presentations at RACGP COVID-19 webinars in person, from her office. It was an invaluable learning experience observing her in action. I would like to thank both my supervisors, Dr Stephanie Williams and Dr Jeremy McAnulty for all their guidance and support while I tried to make sense of the situation around me. Especially Jeremy, who recognised the immense learning value of the pandemic response, and believed in me when I had doubts about the projects that I undertook.

I would also like to thank the MAE staff at ANU for their work in our first Course Block to prepare us to be thrown into pandemic work when we arrived at our field placements. Their research survey into the role of MAE scholars in COVID-19 work at field placements also gave me a useful framework on which to base this reflection. I would also like to thank the wider MAE community at the NSW Ministry of Health for advocating for my learning needs when I did not even know what those needs were.

Laboratory Visit Report – ICPMR Medical Entomology Laboratory

The Institute of Clinical Pathology and Medical Research (ICPMR) was the public health reference laboratory for testing related to COVID-19. This meant that during the pandemic response, there was a significant increase in the laboratory workload. As well as this, visitors to ICPMR increased the risk of COVID-19 exposure for essential laboratory staff. Due to these factors, we could not proceed with a full laboratory visit to ICPMR during my MAE.

Medical Entomology Laboratory Visit – 18 January 2021

As part of my role in the Environmental Health Branch (EHB), I assisted with compiling the weekly reports of the NSW Arbovirus Surveillance and Mosquito Monitoring Program (ASMMP). To assist with the interpretation of the weekly mosquito data received from the Medical Entomology Laboratory, two of my EHB colleagues and I were invited to visit the laboratory.

The ICPMR Medical Entomology Laboratory commenced its work in mosquito identification and viral isolation from mosquitoes in 1988. Currently, for the ASMMP, the laboratory receives the contents of all mosquito traps each week, and identifies (by species and gender) and quantifies the mosquitoes within these traps. After these steps, the mosquito specimens are then processed for RNA detection of a range of arboviruses. In addition to work related to the ASMMP, the laboratory offers an identification service for insect specimens, and advises on the public health management of a range of insects of significance to health, such as bed bugs and mites. The laboratory is also responsible for providing the larvae used for wound debridement programs in NSW. The ICPMR serology laboratory is the state reference laboratory for human arboviral serology. However, this laboratory was not open for visit at the time.

We were met by Stephen Doggett, the Head of the Medical Entomology Laboratory, who gave us presentations both on the work of the laboratory, with a focus on the ASMMP, and on a range of insects of medical significance commonly found in NSW. We were introduced to his team, and shown the process of mosquito identification under the microscope. We were also shown some of the other daily activities of the Medical Entomology Laboratory, including the feeding of a blood meal to larvae being grown for wound debridement.

Additional reflections: Collaboration with public health laboratories

In lieu of being able to visit the other public health laboratories within ICPMR, I was asked to reflect on how some of my other work at HPNSW have demonstrated the importance of close collaboration with public health laboratories. Fortunately, Dr Roy Byun, my manager in the Communicable Diseases Branch (CDB) Respiratory / Vaccine-Preventable Diseases / Vector-Borne Diseases Team, was both an epidemiologist and a microbiologist who held a secondary role as the CDB Laboratory Liaison Officer. Collaboration with public health laboratories was part of the daily work of our team, as demonstrated by the following vignettes.

Vignette 1: Enterovirus investigation

In February 2020, there were separate increases in emergency department presentation signals for meningitis and hand, foot and mouth disease. Staff at two public hospital diagnostic laboratories also noted an increase in the number of positive enterovirus specimens. In response, CDB commenced an investigation into this outbreak. Enterovirus infections are not notifiable under the *Public Health Act 2010* in NSW. Therefore, part of the investigation involved liaising with individual laboratories for positive specimens to be forwarded to the South Eastern Area Laboratory Services (SEALS), the reference laboratory for enteroviruses in NSW. Sequencing performed at SEALS confirmed that most of the outbreak strain was Coxsackievirus-B5, which is not known to be associated with an increased incidence of severe outcomes. This investigation showed the importance of maintaining relationships with laboratories, in that it relied on laboratories to alert CDB of the outbreak, and to assist with the investigation, beyond what is required in state legislation.

Vignette 2: Environmental whole genome sequencing

Whole genome sequencing (WGS) was used widely for COVID-19 investigations. However, it was also used for CDB and EHB investigations this year. In a few cases, WGS proved useful for linking human cases with environmental samples. In the investigation of a cluster of Legionella pneumophila cases, WGS linked one of the human cases to an environmental sample collected from a cooling tower. In the *Salmonella* Saintpaul MJOI described in Chapter 4, WGS linked food items to human cases with the outbreak sequence. In a *Pseudomonas aeruginosa* outbreak involving a skin piercing franchise, WGS linked human infections to samples of a cosmetic product. All of these investigations required liaison with the genomics team at ICPMR, so that they were aware of the hypothesised links being investigated, and could test accordingly.

Vignette 3: The return of influenza

Very few influenza cases were notified in NSW after the restriction of international arrivals in March 2020. With each positive case that was detected, there was significant public health interest as to the likely source of acquisition. The WHO Collaborating Centre (WHO-CC) for Reference and Research on Influenza, in Melbourne, requested to sequence each confirmed positive sample. This required the coordination with each individual diagnostic laboratory and with ICPMR, the NSW state reference laboratory for influenza, to confirm positive samples, and to forward these samples to the WHO-CC for typing and sequencing.

As a clinician, I was already aware of the importance of communicating queries clearly to diagnostic laboratories. Additionally, all these MAE experiences have impressed on me the importance of public health laboratories to the work of a field epidemiologist.

Communicable Diseases Weekly Report

Week 26

For further information see NSW Health infectious diseases page. This includes links to other NSW Health infectious disease surveillance reports and a diseases data page for a range of notifiable infectious diseases.

Murray Valley encephalitis

One case of Murray Valley encephalitis (MVE) virus infection was notified in this reporting week. The case, a man in his seventies, had recently travelled to and undertaken outdoor activities in the Northern Territory, where the MVE virus was detected in the local mosquito population at the time.

MVE is a rare but serious mosquito-borne virus that is transmitted by the bite of *Culex* mosquitoes. It is more commonly found in some parts of northern Australia and Papua New Guinea. In NSW, MVE is very occasionally diagnosed in patients who live or travel west of the Great Dividing Range, usually after periods of heavy rainfall. The presence of MVE virus in the environment is monitored through the NSW Arbovirus Surveillance and Mosquito Monitoring Program. This includes surveillance of chicken flocks, trapping mosquitoes for virus testing, and surveillance of human cases.

Most people infected with MVE virus infections do not show symptoms, or develop a mild illness with fever, headache, nausea and vomiting. A small proportion may develop severe disease involving encephalitis, an infection of the brain. Symptoms of encephalitis include severe headache, increasing confusion, drowsiness and loss of coordination. It can progress to seizures, loss of consciousness and even death. People with encephalitis usually require treatment in hospital. Some people who recover will remain with permanent neurological complications.

There is currently no specific treatment for Murray Valley encephalitis, or vaccine to prevent infection.

Travellers to northern Australia are advised to protect themselves year-round against mosquito bites, which can reduce the risk of infection from both MVE virus and Kunjin virus. People in NSW are also advised to avoid mosquito bites in the summer months and after periods of heavy rainfall by:

- Covering up with a loose-fitting long-sleeved shirt and long pants when outside
- Applying mosquito repellent to exposed skin
- Taking special care during peak mosquito biting hours, especially around dawn and dusk
- Removing potential mosquito breeding sites from around the home and screen windows and doors
- Taking extra precautions when travelling or camping in areas with a higher risk of mosquito-borne diseases.

Further information

- Murray Valley Encephalitis (MVE) factsheet
- Mosquitoes are a health hazard factsheet
- Vector borne diseases pages

Presentations and teaching activities

Audience, date	Details of activity
Own MAE cohort and MAE teaching staff	"3 minute talk" • A brief presentation to introduce myself and my past public health experience to the cohort
ASEAN scholars in own MAE cohort, 28/02/2020	"The Australian Healthcare System" • A tutorial about the organisation of the Australian healthcare system to the MAE ASEAN scholars
Own MAE cohort and MAE teaching staff, 03/03/2020	"The Australian Healthcare System" • An interactive quiz-based teaching session on the Australian Healthcare system during Course Block 1
Own MAE cohort and MAE teaching staff, 21/08/2020	Field Report • Course Block 2 requirement • A presentation on MAE work undertaken to date
Health Protection NSW staff, 24/02/2021	"Take me to your reader" • HPNSW Journal Club February meeting • Organised and chaired meeting • Presented and discussed a paper on face mask recommendations in Denmark and a paper on altmetrics • Moderated discussion and questions about papers
Own MAE cohort and MAE teaching staff, 04/03/2021	Field Report • Course Block 3 requirement • A presentation on MAE work undertaken to date
Health Protection NSW staff, 24/03/2021	"Bug Lunch" • HPNSW Journal Club March meeting • Organised meeting, including guest speaker • Chaired meeting and moderated discussion / questions to guest speaker
First year MAE cohort and members of own MAE cohort, 26/03/2021	"The Kid with a Cough" • Teaching session at Course Block on Indigenous Health • Group activity with two other MAE classmates
Health Protection NSW staff and Australasian Faculty of Public Health Medicine assessors, 28/04/2021	"Exotic Vaccination Destinations" • HPNSW Journal Club April meeting • Organised and chaired meeting • Presented and discussed a paper on the Ebola vaccine and a paper on the malaria vaccine

Audience, date	Details of activity
	• Presentation also used as a formative oral presentation assessment for AFPHM • Moderated discussion and questions about papers
Health Protection NSW staff, 26/05/2021	"I spy with my little eye … A syndrome starting with JC" • HPNSW Journal Club May meeting • Organised and chaired meeting, including recruitment of trainee as guest speaker • Presented and discussed a paper on web-based infectious diseases surveillance • Moderated discussion and question about papers
Health Protection NSW staff, 23/06/2021	"(Bush)fire and flood and other such phenomena" • HPNSW Journal Club June meeting • Organised and chaired meeting • Presented and discussed 3 journal articles related to health effects of environmental exposures: wildfire smoke in Washington State USA, radiation from the Fukushima Disaster Japan, heat-related mortality in Tokyo • Moderated discussion and questions about papers
Half of own MAE cohort (LFF Group 1), 02/07/2021	"A Journey Through Space": Lesson from the (geo-coded) field • LFF on spatial epidemiology • Preparatory material distributed a fortnight prior to presentation
Communicable Diseases Branch, Health Protection NSW, 10/08/2021	"Arbovirus surveillance in NSW" • A presentation to the Communicable Diseases Branch on the arbovirus surveillance work of the Environmental Health Branch, including a summary of the 2020/2021 season
14th Mosquito Control Association of Australia (MCAA) Conference, incorporating the 13th Arbovirus Research in Australia Symposium, 30/08/2021	"Summary of the 2019-2020 and 2020-2021 Arbovirus Surveillance Season in NSW" • A presentation of the most recent NSW arbovirus surveillance and mosquito monitoring seasons to counterparts in other jurisdictions of Australia
Communicable Diseases Branch, Health Protection NSW, 26/10/2021	"What's Bugging the World: Epidemiological Week 42, 2021" • Horizon scanning of inbound international flights to Australia, international border reopening, and infectious disease outbreaks / incidence globally
HPNSW stakeholders, 29/11/2021	"The NSW COVID-19 Surveillance System: An evaluation"

Audience, date	Details of activity
	• Presented the findings and recommendations of my surveillance evaluation project
Communicable Diseases Branch, Health Protection NSW, 02/11/2021	"What's Bugging the World: Epidemiological Week 43, 2021"
Communicable Diseases Branch, Health Protection NSW, 09/11/2021	"What's Bugging the World: Epidemiological Week 44, 2021"
Communicable Diseases Branch, Health Protection NSW, 16/11/2021	"What's Bugging the World: Epidemiological Week 45, 2021"
NSW Public Health Response Branch staff, NSW Chief Health Officer, Director and staff from the Public Health Division of the Oregon Health Authority, 19/11/2021	"NSW-Oregon Confab" Presented some of the findings of my epidemiological study project at a joint experience sharing meeting between NSW and the State public health authority of Oregon, USA
NSW Public Health Response Branch and Communicable Diseases Branch staff, 19/11/2021	"The impact of international travel restrictions on notifiable conditions in NSW in 2020" • Presented the findings and recommendations of my epidemiological study project
Communicable Diseases Branch, Health Protection NSW, 23/11/2021	"What's Bugging the World: Epidemiological Week 46, 2021"
Communicable Diseases Branch, Health Protection NSW, 30/11/2021	"The Very Honest Guide to Working with GPs"
Communicable Diseases Branch, Health Protection NSW, 30/11/2021	"What's Bugging the World: Epidemiological Week 47, 2021"
Communicable Diseases Branch, Health Protection NSW, Daily 01/12/2021 to 24/12/2021	"Infectious Diseases Advent Calendar" Daily online microbiology quiz
Communicable Diseases Branch, Health Protection NSW, 07/12/2021	"What's Bugging the World: Epidemiological Week 48, 2021"
Communicable Diseases Branch, Health Protection NSW, 14/12/2021	"What's Bugging the World: Epidemiological Week 49, 2021"
Communicable Diseases Branch, Health Protection NSW, 21/12/2021	"What's Bugging the World: Epidemiological Week 50, 2021"
Communicable Diseases Branch, Health Protection NSW, 11/01/2022	"What's Bugging the World: Epidemiological Week 1, 2022"
Communicable Diseases Branch, Health Protection NSW, 18/01/2022	"What's Bugging the World: Epidemiological Week 2, 2022"

Audience, date	Details of activity
NSW Arbovirus Surveillance and Mosquito Monitoring Program staff and stakeholders, Health Protection NSW and ICPMR, 19/01/2022	"NSW Arbovirus Surveillance and Mosquito Monitoring Program (ASMMP): 10 Year Data Review" • Presented the findings and recommendations of my data analysis project
Communicable Diseases Branch, Health Protection NSW, 25/01/2022	"What's Bugging the World: Epidemiological Week 3, 2022"

The Kid With A Cough

A sharing session with our friends in MAE21

Margy, Mikala and Anny

Firstly and most importantly

Acknowledgement of Country

Learning objectives

1. To provide some practical perspectives of working with Indigenous groups in communicable diseases prevention and control, including outbreak situations.
2. To discuss some of the scenarios that might be encountered when working with Indigenous data.
3. To discuss the idea of Indigenous data sovereignty, and to introduce the work of the Indigenous Data Sovereignty Collective, if people are not already familiar with this.
4. To allow the group to continue to explore strengths-based approaches through practical examples.
5. To introduce some of the people and groups that may be relevant when working with First Nations communities.
6. To demonstrate that it can be fun and rewarding to work with First Nations communities!
7. To discuss some of the similarities and differences working with other cultural groups.

An introduction to us

Margaret (Margy)

Kardu Kura Thipmam

Placement: Menzies School of Health Research

Larrakia Country (Darwin), NT

Experience: Many years of work as an Aboriginal Health Practitioner in Darwin (both clinical and administrative)

Mikala (Mik)

Gamilaraay

Placement: ANU, NCEPH, Aboriginal and Torres Strait Islander Health team

Ngunnawal / Ngambri Country (Canberra), ACT

Experience: Public Health, Aboriginal and Torres Strait Islander Health and Wellbeing and Disability

Anny

1st generation Chinese Australian

Placement: Health Protection NSW

Cammeraygal Country (St Leonards), NSW

Experience: GP for migrant communities, asylum seekers, remote Indigenous communities in Central Australia

Now let's start with a story

The notification

- 6 year old girl
- Remote Aboriginal community
- Pertussis
- Laboratory does not know vaccination status
- Sample collected 3 days ago

```
00 Start Patient  :      Montana CAMPBELL
01                       Yuendumu Community, NT 0872
04                       Birthdate: 14/09/1994     Age:  6     Sex:  F
09
10 Your Reference :
11 Lab  Reference :      20-45892259
15 Phone Enquiries:
19
21 Referred By    :      RMP RMP Yuendumu CAHS
22        Copy To :
23 Addressee      :      OFFICER COMMUNICABLE DISEASE
29
00 Start of Result:
01 Specimen       :
03 Requested      :      28/10/2020
04 Collection     :      28/10/2020  00:00
05 Name of Test   :      MISC PCR
06 Reported       :
07 Confidential   :      N
08 Test Category  :      R
09
10 Normal Result  :      N
11 Requested Tests:      MPC
12 RequestComplete:      N
99
01
01   MOLECULAR BIOLOGY
01
01     PCR Analysis
01
01     Collection site:                    Respiratory tract swab(s)
01
01
01     Bordetella pertussis by PCR         Detected
01
01     Bordetella parapertussis by PCR     Not Detected
01
```

What information would you like right now?

Listen to Christine, the Senior Surveillance Officer for Vaccine-Preventable Diseases at Health Protection NSW, discuss her initial thoughts with this notification (if it happened in a remote Aboriginal community in NSW)

Some friendly reminders about pertussis

- Caused by *Bordetella pertussis* (a bacterium)
- Notifiable in every State and Territory
- Incidence in the NT:
  - 10 years between 2009-2019: 36 - 379 cases per year
  - In 2020: 15 cases (reflects national decrease in pertussis notifications)
- Vaccine preventable:
  - On the childhood immunisation schedule of every State and Territory
  - Acellular vaccine
  - In the NT, funded for pregnant women from 20 weeks gestation onwards

NORTHERN TERRITORY GOVERNMENT

NT **Immunisation** Schedule

Children (up to 19 years)

July 2020

Age	Disease	Vaccine Brand	Dose No.	Reconstitute	Route of administration	Notes
Birth	Hepatitis B	H-B-Vax II or Engerix-B paediatric	1	×	Birth	Give within 7 days of birth
6 weeks	DTPa-HepB-IPV-Hib	Infanrix hexa	1	✓	IMI	ALL CHILDREN
	Pneumococcal	Prevenar 13	1	×	IMI	ALL CHILDREN
	Rotavirus	Rotarix	1	×	ORAL	Dose 1 must be given by 15 weeks of age
	Meningococcal B	Bexsero	1	×	IMI	Aboriginal children. Prophylactic paracetamol
4 months	DTPa-HepB-IPV-Hib	Infanrix hexa	2	✓	IMI	ALL CHILDREN
	Pneumococcal	Prevenar 13	2	×	IMI	ALL CHILDREN
	Rotavirus	Rotarix	2	×	ORAL	Dose 2 must be given by 25 weeks of age
	Meningococcal B*	Bexsero	2	×	IMI	Aboriginal children. Prophylactic paracetamol
6 months	DTPa-HepB-IPV-Hib	Infanrix hexa	3	✓	IMI	ALL CHILDREN
	Pneumococcal	Prevenar 13	3	×	IMI	Aboriginal children
						Medically at risk – please refer to the Australian Immunisation Handbook for details
6 months to under 5 years	Influenza	See *Additional Notes - Influenza*	Annually	×	IMI	ALL CHILDREN If receiving vaccine for the first time in their life and aged 6 months to under 9 years: give 2 doses, 1 month apart. 1 dose annually thereafter.
12 months	Measles-mumps-rubella	Priorix or MMR II	1	✓	SC OR IMI	ALL CHILDREN
	Meningococcal ACWY	Nimenrix	1	✓	IMI	ALL CHILDREN
	Pneumococcal	Prevenar 13	3 or 4	×	IMI	ALL CHILDREN
	Meningococcal B*	Bexsero	3	×	IMI	Aboriginal children. Prophylactic paracetamol
	Hepatitis B	H-B-Vax II or Engerix-B paediatric	4	×	IMI	Premature infants under 32 weeks or under 2000g at birth
18 months	Measles-mumps-rubella-varicella	Priorix-tetra or ProQuad	2	✓	SC OR IMI	ALL CHILDREN
	Haemophilus influenzae type b	Act-HIB	4	✓	IMI	ALL CHILDREN
	DTPa	Infanrix or Tripacel	4	×	IMI	ALL CHILDREN
	Hepatitis A	VAQTA	1	×	IMI	Aboriginal children
4 years	DTPa-IPV	Infanrix IPV or Quadracel	5	×	IMI	ALL CHILDREN
	Hepatitis A	VAQTA	2	x	IMI	Aboriginal children who have not had 2 doses previously
	Pneumococcal	Pneumovax 23	1	×	IMI	Aboriginal children
						Medically at risk – please refer to the Australian Immunisation Handbook for details
5 - 15 years	Influenza	See *Additional Notes - Influenza*	Annually	×	IMI	Aboriginal children. If receiving vaccine for the first time in their life and aged 6 months to under 9 years: give 2 doses, 1 month apart. 1 dose annually thereafter.
12 years	Human Papillomavirus	Gardasil 9	1 and 2	×	IMI	ALL CHILDREN minimum 6 month interval between doses 1 and 2

Activity: Who can you ask? Where can you find information? Brainstorm as a group

Please use the following Menti link:

Go to **www.menti.com** and use the code **7569 9042**

Activity: Who can you ask? Where can you find information? Some of our thoughts …

- Google / Google Images / Google Maps
- Social media
- Friends and colleagues in public health / research
- Disease Control Unit in Alice Springs
- People at the local clinic: Clinic Manager, RANs, GPs, AHPs, support staff
- Other health professionals outside of the clinic: Visiting specialists, visiting midwives, hospital staff in the larger towns, regional hospital ALOs, the DMO on call, other RFDS staff
- Other people in the local community: school teachers, business manager (in some communities), Elders (if you can reach any), local council representatives (Central Desert Regional Council
- Other health records: electronic hospital records, electronic clinic records, pharmacy records, AIR for immunisation status
- **The case herself … and her family! (But difficult to do over the phone)**

The community: Yuendumu - first you ask Google

- Remote community in the NT
- Population: Approximately 1,000 Warlpiri people
- The Yuendumu School has around 260 students
- Alice Springs Hospital is the closest hospital to Yuendumu which is 350km away (3.5-4 hour drive)

The community: Yuendumu - You also ask your Indigenous colleagues

Your Indigenous colleagues also give you some general advice: Working in any Aboriginal community - Things to consider

- Understand context
- Identify risks and barriers
- Be mindful of unknowns
- Identify resources and partners
- Involve community members in the planning process and make connections early
- Identify pressing needs
- Work in a creative and flexible manner in response to the changing needs of the community
- Follow protocols
- Respect Indigenous values and knowledge
- Ensure working relationships are based on reciprocal two-way learning
- Implement culturally competent practices and strategies
- Conduct services "in language" (the first language of local people) or, failing this, have translators or people who can present information in plain, accessible language

More about working with First Nations communities

Some other important questions to keep in mind if you're asked to work with First Nations communities who may be at risk of/or in the middle of a disease outbreak:

- Who are the traditional owners in this area?
- What Aboriginal organisations are operating in this area?
- Who are their leaders?
- Is there an Aboriginal health organisation? Is it community-controlled? State controlled?
- Have I/do I need to build relationships with those people and those organisations?

Next, you call the clinic in the community and ask to speak to the GP there

Remember: The notification did not give a specific GP name, only that it was ordered by the Rural Medical Practitioner (RMP) at the Yuendumu Clinic

Listen to Dr Philippa Binns talk about the role of a remote GP in this situation

Unfortunately, the test was actually ordered last week by the Remote Area Nurse, who is away this week

- GPs are not in remote communities every week
- Remote Area Nurses (RANs) have a lot more authority to act compared to "usual" GP practice nurses in other settings
- Can prescribe according to guidelines, order basic tests, or escalate by phone to the District Medical Officer (DMO) on call
- RAN work is tough! Have to make sure that RANs get enough leave
- You decide to ask the Clinic Manager and the Aboriginal Health Practitioners at the clinic for more information, and ask them to perform some contact tracing

How does contact tracing work in a remote community? What are some things to be aware of?

- Right patient – front counter
- Information gathering - in consultation
  - If you have any clinical suspicion, this is where contact tracing begins – document everything it may seem irrelevant at the time but might be vital information later.
  - Child's living situation – main carer and household and parents if child not with them.
  - Transient population – travel for ceremonies, Sorry Business, and other events.
  - Time – reference events or seasons.
  - Plan – discuss concerns and treatment plan. Reassure and support carer.

After all your questions, you obtain the following information

Personal medical history:

- Born at 37 weeks gestation at Alice Springs Base Hospital
- Some gaps in vaccination on AIR: had Hep B at birth in Alice Springs, then 18 month immunisations in Yuendumu
- Skin infections (including boils), middle ear infections
- This time:
  - Brought to clinic by grandma
  - Throat swab was taken because of coughing for a week
  - COVID-19 negative: a separate lab result was sent

After all your questions, you obtain the following information

Social situation:

- Identifies as Warlpiri
  - Mum's family mostly in Yuendumu
  - Dad's family mostly in Papunya
- Mostly lives in Yuendumu community with grandma and extended family
  - A few other children regularly stay in the household: 3 year old, 8 year old, 9 year old
  - Pregnant cousin in the house on most days: about 35 weeks pregnant
- Mum is in Alice Springs a lot of the time:
  - Mum is currently pregnant, about 29 weeks
  - Last saw mum approximately 2 weeks ago: unsure of the exact date
- Sometimes stays with aunty in Papunya
  - Aunty has a 3 month old baby in her household
  - Hasn't been to aunty's place for about 3-4 weeks, but is about to go again in the coming week
- Goes to school in Yuendumu (Grade 1)
- Nobody else with similar symptoms - no obvious source

Just as you're about to develop a plan of action, you notice:

	Matched Record 1	Matched Record 2
Condition:	Pertussis - Confirmed	Pertussis - Confirmed
Full Name:	Montana CAMPBELL	Montana NANGALA
Birth Date:	14/09/1994	01/09/1994
Gender:	F	F
Street:		Stuart Highway
Suburb / town:	Yuendumu Community	Alice Springs
State:	NT	NT
Postcode:	0872	0870

Do these records belong to the same child? What do you look at to help you decide?

Do these records belong to the same child?

What information do you use to determine this?

- Name
  - Study showed that by the age of 4 years, 30% of Aboriginal children in the NT had changed their names at least once
- Date of birth
  - More of an issue with the older population, where birth records had often been poorly kept
  - Different concept of time and date
  - AIHW Hospital Records study: approximately 11% of dates of birth were likely to be a guess / approximated
- Address
  - Study showed that by the age of 4 years, 18% of Aboriginal children in the NT have had at least 1 address change

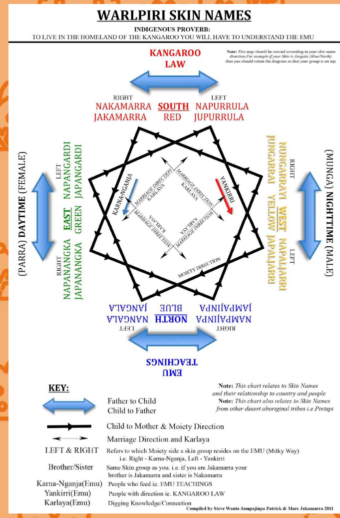
The name on the second record, Montana Nangala, is a skin name

Skin names

The name on the second record, Montana Nangala, is a skin name

- What is a skin name?
- How does that help the AHP to figure out if this is the same child?

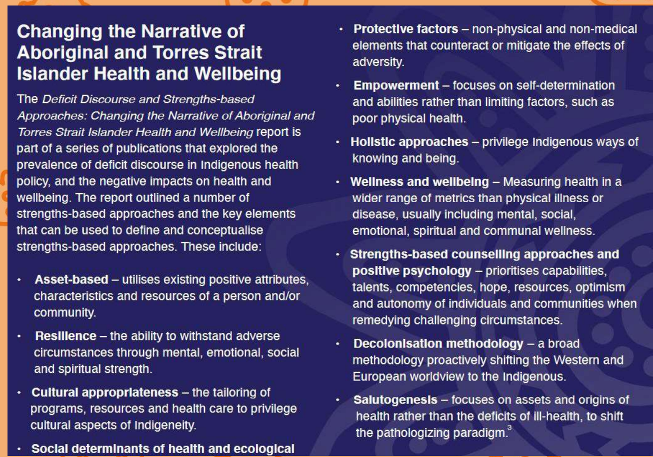
(Diagram is in the “magnifying glass” folder)



Indigenous data sovereignty: a global movement

Indigenous Data Sovereignty is the right of Indigenous peoples to govern the collection, ownership and application of data about Indigenous communities, peoples, lands, and resources. Its enactment mechanism, Indigenous data governance is built around two central premises: the rights of Indigenous nations over data about them, regardless of where it is held and by whom; and the right to the data Indigenous peoples require to support nation building and rebuilding.

What is a strengths based approach?



Changing the Narrative of Aboriginal and Torres Strait Islander Health and Wellbeing

The *Deficit Discourse and Strengths-based Approaches: Changing the Narrative of Aboriginal and Torres Strait Islander Health and Wellbeing* report is part of a series of publications that explored the prevalence of deficit discourse in Indigenous health policy, and the negative impacts on health and wellbeing. The report outlined a number of strengths-based approaches and the key elements that can be used to define and conceptualise strengths-based approaches. These include:

- **Asset-based** – utilises existing positive attributes, characteristics and resources of a person and/or community.
- **Resilience** – the ability to withstand adverse circumstances through mental, emotional, social and spiritual strength.
- **Cultural appropriateness** – the tailoring of programs, resources and health care to privilege cultural aspects of Indigeneity.
- **Social determinants of health and ecological**
- **Protective factors** – non-physical and non-medical elements that counteract or mitigate the effects of adversity.
- **Empowerment** – focuses on self-determination and abilities rather than limiting factors, such as poor physical health.
- **Holistic approaches** – privilege Indigenous ways of knowing and being.
- **Wellness and wellbeing** – Measuring health in a wider range of metrics than physical illness or disease, usually including mental, social, emotional, spiritual and communal wellness.
- **Strengths-based counselling approaches and positive psychology** – prioritises capabilities, talents, competencies, hope, resources, optimism and autonomy of individuals and communities when remedying challenging circumstances.
- **Decolonisation methodology** – a broad methodology proactively shifting the Western and European worldview to the Indigenous.
- **Salutogenesis** – focuses on assets and origins of health rather than the deficits of ill-health, to shift the pathologizing paradigm.[3]

Indigenous data reporting in outbreaks: a look at COVID-19 in an Australian State

During the pandemic, one of our Indigenous epidemiologists noticed something that didn't look quite right in a COVID-19 Surveillance Report. She went about changing this. Here is the story of what happened.

NOTE: Political sensitivities! Please make sure that nothing leaves this forum.

Indigenous data reporting in outbreaks: a look at COVID-19 in an Australian State

Before:

Aboriginal people

Aboriginal people are considered to be a vulnerable group for serious COVID-19 disease due to their high burden of chronic disease. Additionally, transmission within Aboriginal communities is likely to be high due to factors such as high number of people per household and barriers to accessing healthcare.

No cases in Aboriginal people were reported in the week ending 24 October. In total, 45 Aboriginal people have been diagnosed with COVID-19, representing 1% of all cases in NSW. The last case of COVID-19 in an Aboriginal person was reported on 6 September.

Indigenous data reporting in outbreaks: a look at COVID-19 in an Australian State

After:

Aboriginal people

Aboriginal and Torres Strait Islander communities are recognised as a priority group due to key drivers of increased risk of transmission and severity of COVID-19 which include mobility, remoteness, barriers to access including institutional racism and mistrust of mainstream health services, crowded and inadequate housing, and burden of disease.

No cases in Aboriginal people were reported in the week ending 21 November. In total, 45 Aboriginal people have been diagnosed with COVID-19, representing 1% of all cases in NSW. The last case of COVID-19 in an Aboriginal person was reported on 6 September.

Activity: A review of some other examples of First Nations text on government COVID-19 websites

Breakout rooms:

- Read excerpts
- Questions:
    - What is good?
    - What can be improved?
    - How does this reflect a strengths-based narrative?

Activity: A review of some other examples of First Nations text on government COVID-19 websites

Come back to discuss: What general thoughts did people have?

A reminder of the questions:

- What is good?
- What can be improved?
- How does this reflect a strengths-based narrative?

Back to pertussis!

The team decides that the record belongs to the same child: Montana Nangala Campbell, 6yo girl

Immediate priorities: How will you manage Montana for whooping cough?

- Check guidelines: Not on CARPA, but GP will use SoNG for pertussis
- Antibiotics: GP will prescribe the appropriate antibiotic according to the SoNG
  - Which one is available at the clinic? (Otherwise would have to wait for supplies from the pharmacy in Alice Springs, and this would take too long)
  - Can Montana swallow tablets? Antibiotics will likely need to be in syrup form, which might have refrigeration requirements
  - Don't pick one that needs to be given 4 times a day!
  - Do you give the antibiotic to grandma to take home and give to Montana? Or do you get them to come in every day for the antibiotic to be administered by the nurse? Or do you get the AHP to do a home visit every day?
- Education about the infection and the mode of transmission
  - The SoNG recommends giving a fact sheet: Would this be helpful in a remote community?
- Exclusion from school and avoiding high risk contacts
  - No school until 5 days of antibiotics completed
  - Keep away from pregnant cousin and 6 month old baby at aunty's place (Papunya) until 5 days of antibiotics completed (the Papunya family are from Dad's side so would need to negotiate with them too)
  - How is this managed?

Back to pertussis!

Immediate priorities for contacts:

How do you manage the household close contacts?

- Education for everyone at home:
  - Watch out for symptoms of whooping cough!
  - How is this practically achieved?
- Pregnant cousin in household in Yuendumu:
  - Antenatal care through the Yuendumu clinic: has already had pertussis immunisation this pregnancy
  - 35 weeks pregnant, but dates uncertain: the local public health doctor decides to give her prophylactic antibiotics for pertussis even though they would normally be given to women in their final month of pregnancy (36 weeks and above)

Back to pertussis!

Immediate priorities for contacts:

How do you manage the close contacts at school?

- You need to tell the parents of everyone else in Montana's class to watch out for symptoms of whooping cough. How do you tell them?
- What do you say when they ask you which child has whooping cough? How does confidentiality work in a remote community?

Given that Montana has not been adequately vaccinated, you want to make sure that Mum (in Alice Springs) has received her pertussis immunisation during this pregnancy

- How do you reach Mum in Alice Springs?

Back to pertussis!

Longer term priorities:

How do you make sure that Montana gets her other vaccines?

- She will need to be put on a catch up schedule!
- How do we make sure that the 3 year old in the household receives 4 year old immunisations?

Outcomes: Montana

- Took entire course of antibiotics as prescribed
- Stayed well, apart from cough that took another couple of weeks to go away
  - Explained to grandma and another aunty that if Montana took all of her antibiotics, she is no longer infectious, even if she keeps coughing for a bit longer
- Stayed at home:
  - Luckily, pregnant cousin was already due to go down to Alice Springs to wait to give birth: did take her prophylactic antibiotics for pertussis
  - Did not go to school for that week: local clinic staff were able to deliver Montana's school lunches to her home
  - Did not go to aunty's place in Papunya
- Catch up immunisation schedule commenced
  - Next doses on clinic recall list
  - Discussed this at length with grandma about why all these injections are now needed
- Mum's antenatal service in Alice Springs contacted
  - Midwife was appreciative of the phone call, reassures us that Mum has already had her antenatal immunisations

Outcomes: COVID-19

The First Nations communities in Australia have done incredibly well during COVID-19: It is not a success story that is often shown in mainstream media. (Why not?)

Here are some snippets from the Close the Gap Report 2021:

communities prevented this from happening. As of 13 December 2020, a total of 147 cases of COVID-19 had been reported among Aboriginal and Torres Strait Islander people (out of the total 28,031 Australian cases)[15] with no deaths nationally and no cases identified in remote Aboriginal communities. The number of cases among Aboriginal and Torres Strait Islander people is **six times lower** than the rest of Australia.[16]

"[Australia's] First Nations have managed this pandemic better than anyone in the world. It was supposed to be a disaster, but because they acted so responsibly, it was a model of how to prevent an epidemic in a high risk population. [This extraordinary result] just shows what happens when Aboriginal leadership is listened to."

Professor Fiona Stanley (non-Indigenous)

We've included the relevant pages of this report in the Resources folder.

Aboriginal and Torres Strait Islander Health: Who's who?

- National Aboriginal Community Controlled Health Organisation (NACCHO)
  - Peak State/Territory bodies – AMSANT, ACHWA, VACCHO, AHCSA, QAIHC
  - Member services – Clinics, rehabilitation services
- Stolen Generations – Link Up Services
- Legal Aid Services
- Land Councils
- Research – Lowitja Institute, Australian Indigenous HealthInfoNet, AIATSIS, SAHMRI

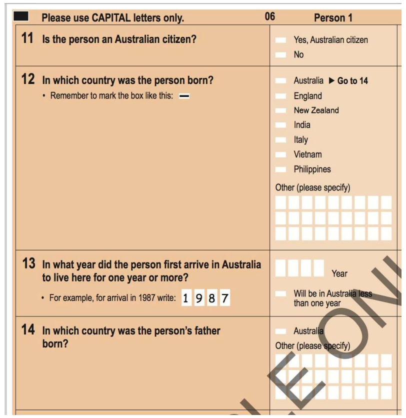
Moving onto CALD communities

Data considerations for CALD communities

A huge topic worthy of many discussions on its own! (Which is what we had during the COVID-19 response!)

Listen to A/Prof Bette Liu, Epidemiologist at UNSW and Data Linkage Team Leader at the NSW Public Health Response Branch, share some thoughts about CALD data.

Data considerations for CALD communities



Please use CAPITAL letters only. 06 Person 1

11 Is the person an Australian citizen?
- Yes, Australian citizen
- No

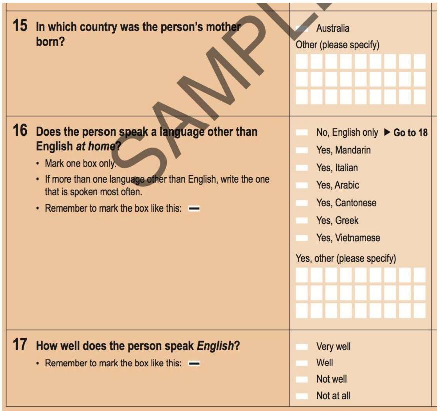
12 In which country was the person born?
- Remember to mark the box like this: —

- Australia ▶ Go to 14
- England
- New Zealand
- India
- Italy
- Vietnam
- Philippines
- Other (please specify)

13 In what year did the person first arrive in Australia to live here for one year or more?
- For example, for arrival in 1987 write: 1 9 8 7

- Year
- Will be in Australia less than one year

14 In which country was the person's father born?
- Australia
- Other (please specify)



15 In which country was the person's mother born?
- Australia
- Other (please specify)

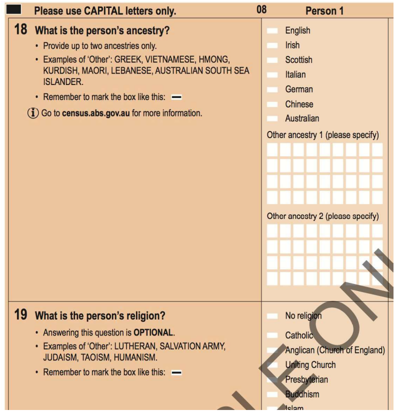
16 Does the person speak a language other than English *at home*?
- Mark one box only.
- If more than one language other than English, write the one that is spoken most often.
- Remember to mark the box like this: —

- No, English only ▶ Go to 18
- Yes, Mandarin
- Yes, Italian
- Yes, Arabic
- Yes, Cantonese
- Yes, Greek
- Yes, Vietnamese
- Yes, other (please specify)

17 How well does the person speak *English*?
- Remember to mark the box like this: —

- Very well
- Well
- Not well
- Not at all

Data considerations for CALD communities



Please use CAPITAL letters only. 08 Person 1

18 What is the person's ancestry?
- Provide up to two ancestries only.
- Examples of 'Other': GREEK, VIETNAMESE, HMONG, KURDISH, MAORI, LEBANESE, AUSTRALIAN SOUTH SEA ISLANDER.
- Remember to mark the box like this: —

(i) Go to **census.abs.gov.au** for more information.

- English
- Irish
- Scottish
- Italian
- German
- Chinese
- Australian
- Other ancestry 1 (please specify)
- Other ancestry 2 (please specify)

19 What is the person's religion?
- Answering this question is **OPTIONAL**.
- Examples of 'Other': LUTHERAN, SALVATION ARMY, JUDAISM, TAOISM, HUMANISM.
- Remember to mark the box like this: —

- No religion
- Catholic
- Anglican (Church of England)
- Uniting Church
- Presbyterian
- Buddhism
- Islam

Communicating with CALD communities

In your Resources folder: A piece of research from the University of Melbourne about communication with Asian communities during COVID-19

References

- Australian Bureau of Statistics (2016) '2016 Census Sample Household Form'.
- Communicable Diseases Network Australia (2015) 'Pertussis: CDNA National Guidelines for Public Health Units'.
- Dugbaza, T. *et al.* (2012) *National best practice guidelines for data linkage activities relating to Aboriginal and Torres Strait Islander people*. Australian Institute of Health and Welfare and Australian Bureau of Statistics.
- Jampajinpa Patrick, S. W. and Jakamarra, M. (2011) 'Warlpiri Skin Names'.
- Lovett, R. *et al.* (2020) 'Knowledge and power: the tale of Aboriginal and Torres Strait Islander data', *Australian Aboriginal Studies*, 2, pp. 3–7.
- Lowitja Institute for the Close The Gap Campaign Steering Committee (2021) *Close The Gap Campaign Report 2021.*
- *Pertussis (whooping cough)* (2019) *Australian Immunisation Handbook*. Available at: https://immunisationhandbook.health.gov.au/vaccine-preventable-diseases/pertussis-whooping-cough (Accessed: 24 February 2020).
- Shin, W. and Song, J. (2021) 'What our survey found about effective COVID-19 communications in Asian Australian communities', *Melbourne Asia Review*, 5. doi: 10.37839/MAR2652-550X5.16.
- University of Melbourne Indigenous Studies (2017) *Indigenous Data Sovereignty Symposium 2017 (IDDSS17) Panel 01 - What is Indigenous data sovereignty? (Video)*. Available at: https://vimeo.com/243600584 (Accessed: 4 March 2021).

Questions?

Please take 5 minutes to give us feedback! Link to feedback survey in chat box

https://datalibrary-rc.health.wa.gov.au/surveys/?s=MEPRP7WDHD

Following are some other slides that we can probably leave out unless we're really stuck for enough material

You were particularly interested in the number of other children in the household, and who has been vaccinated. You obtain the following history.

(Video clip of somebody pretending to be a family member talking about the people in the household)

Activity: With this information, draw a family tree

Another aside: An example from the Hunter New England Public Health Unit working with First Nations communities in outbreaks

(Pertussis cluster - let's park this one … it's too complex)

We find out that another child at the same school has also been diagnosed with pertussis

- This child is 3 years older than our first case
- The definition of a school outbreak is 2 or more cases in the same class

So is this an outbreak?

- Actually need more information! In schools in remote communities, it is common for multiple year levels to be combined in the same class
- In our case … YES, the two children are in the same class

Back to pertussis!

Media:

The local media has found out and wants a story on this case - what do you tell them?

(What do you do about a pertussis outbreak in a remote school? - Let's also park this one, the guidelines basically tell you to talk to specialists!

- Check guidelines
- How do you communicate with the families of all other children in the class?

Summary of the teaching day evaluation to the first year MAE cohort – March 2021

Table 1. Summary of evaluation of individual sessions showing responses of strongly agree and agree*
(Response options were: strongly agree, agree, neither agree or disagree, disagree, strongly disagree)

	Lesson 1 – AMR and HAI N=20		**Lesson 2 – COVID-19 vaccines N=18**		**Lesson 3 – REDCap N=13**		**Lesson 4 – First Nations and CALD N=13**	
	Strongly agree (%)	**Agree (%)**	**Strongly agree (%)**	**Agree (%)**	**Strongly agree (%)**	**Agree (%)**	**Strongly agree (%)**	**Agree (%)**
The facilitators were prepared and organised	30	60	40	56	92	8	83	17
The learning objectives were outlined at the beginning of the session	65	30	44	50	77	23	75	25
The content presented was relevant to my knowledge and understanding of epidemiology and public health	45	45	56	39	92	8	67	33
I feel motivated to learn more about this subject area after the session	40	40	56	39	77	23	42	58
The facilitator's teaching methods and aids were appropriate and effective to my learning	50	40	33	50	85	15	75	25
The facilitators provided opportunities to ask questions and participate in further discussion	50	45	44	50	77	23	42	58
At the end of the session, the learning objectives were met	35	55	50	44	77	23	75	25
Overall, I am very satisfied with the session	40	50	61	33	85	15	75	25
The facilitators listened to me and respected my previous experiences in this area#							42	17

* Some totals are more than 100% as numbers were rounded up
# This statement was only included into the evaluation for lesson 4

Spatial Epidemiology: More than just maps

Lessons from the field – Parts A and B – Anny Huang

Background

In our epidemiological analyses, we are often encouraged to describe our findings in terms of time, place and person. The description of place often involves using maps. But maps are more than pretty visual aids for data presentation. There are statistical analyses that can only be done when the dimension of location is taken into account. These can involve some very complex regressions (obviously you're not expected to do this by the end of this session)! Maps can also be incredibly political. I've personally known epidemiologists who have been interrogated by police and threatened with jail for the maps that they have made!

An apology: I had wanted to give a tutorial on using QGIS during this LFF, but unfortunately I had trouble with getting permission to install this on my work laptop. I suspect that some of you might also have that difficulty with your work devices too. I am very happy to teach on this in the future, if we can figure out how to make it work logistically!

Learning objectives

At the end of the session you should be able to:

- Appreciation for some of the benefits and limitations of maps
- Understand some general mapping / spatial terms
- Appreciate some of the similarities in describing spatial and non-spatial data
- Have a very general awareness of some of the statistical analyses that can be done with spatial data

Lesson overview

Before the online teaching session, please complete the exercises associated with Part A and Part B of this lesson.

Resources

1) Elliot P and Wartenberg D (2004) "Spatial Epidemiology: Current Approaches and Future Challenges", *Environmental Health Perspectives* 112(9): 998-1006. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1247193/

Sorry that this article is pretty old now, and there are so few resources! There are resources, but they are ones you have to pay for, and not freely available online. I hope you guys know that I am not intentionally trying to be unhelpful.

Most of what I know about spatial epidemiology are what I learned during courses, and a few different projects where I've had to use these skills. So what I am teaching you is really "from the field", although some of it is from fields beyond the MAE!

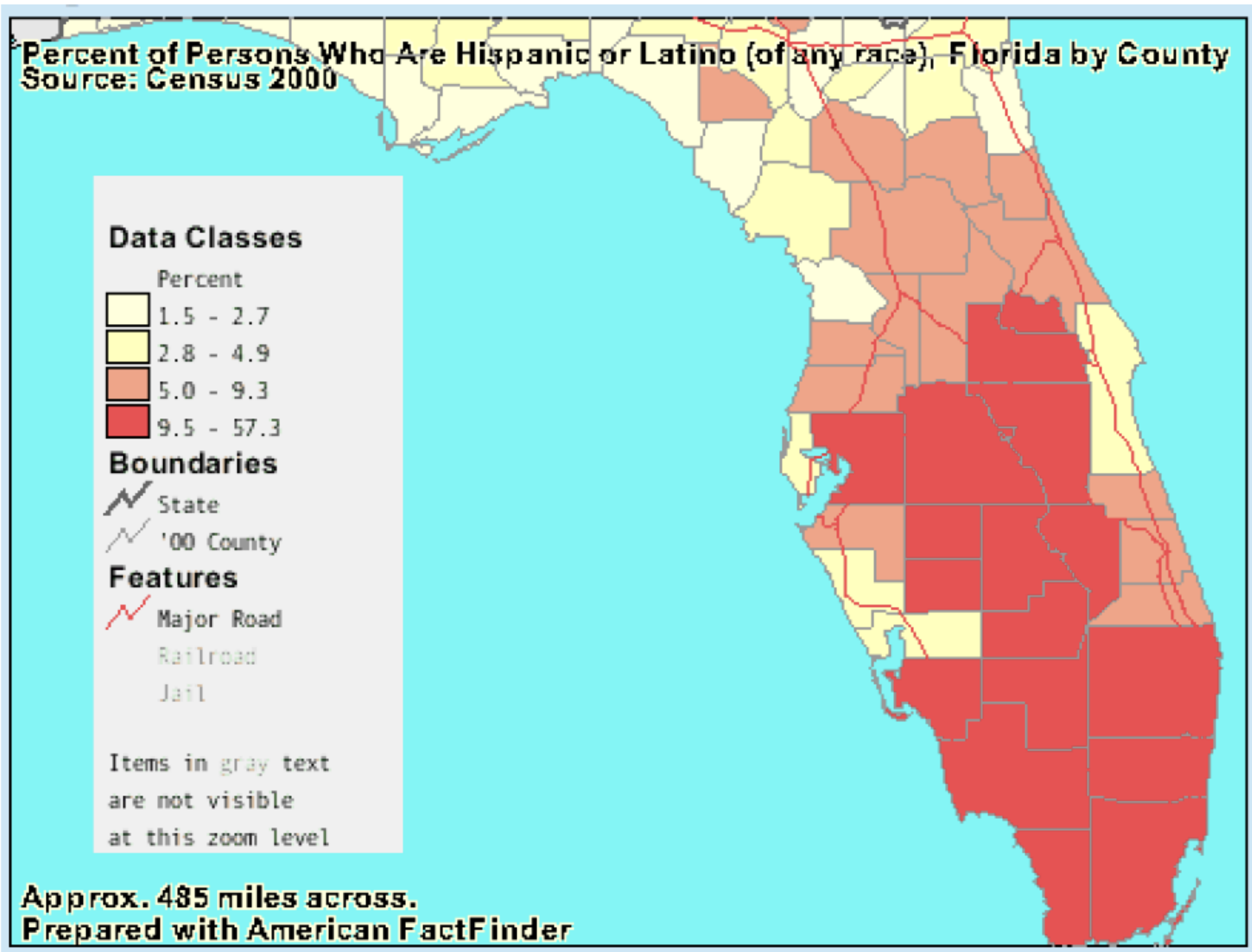
Please complete Part A and B in your own time and bring your answers to the online teaching session.

Feel free to contact me via email at yuanfei.huang@health.nsw.gov.au or via phone on 0431537257 you need to discuss anything beforehand.

Part A: Thinking about maps

I'll talk more about mapping concepts during my presentation, but here is just an example to start you thinking. Take a look at this map and answer the questions below.

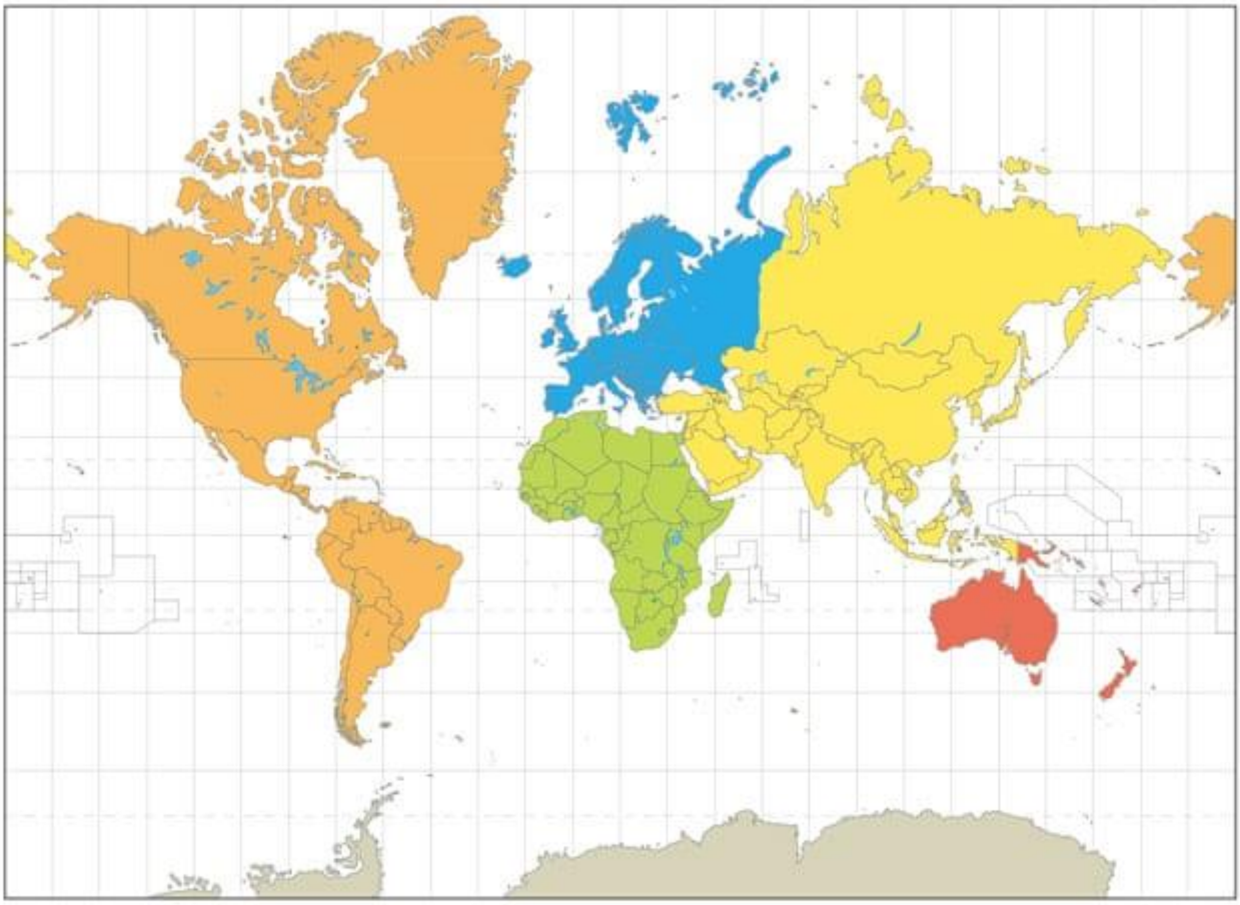
Map 1: Latino populations in Florida



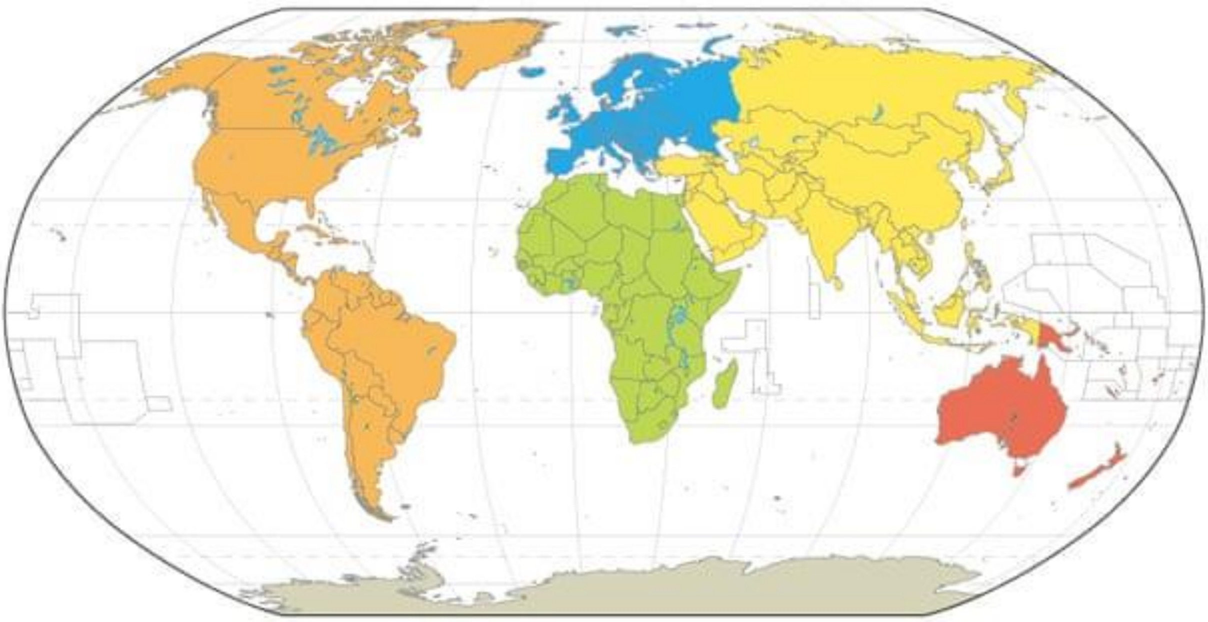
Questions: What do you like about this map? What don't you like about this map? What is this map trying to say?

Now let's think about map projections. Here are 2 maps of the world drawn using the most common map projections. Have a look at both maps and answer the questions below Map 3.

Map 2: Map of the world in Mercator projection



Map 3: Map of the world in Robinson projection



Questions: Which map are you more used to? Which map do you like more? Which map is more accurate? Which map is more useful for your projects?

Part B: Some concepts in spatial statistics (univariate)

Point locations:

Here are some data from the NSW Arbovirus Surveillance and Mosquito Monitoring Program in the 2020/2021 season. To begin with, there is no spatial information attached. It is just like any other non-spatial dataset that you might work with.

Table 1: Mosquito counts in NSW ASMMP coastal sites, week ending 22 May 2021

Location	Mosquito count
Ballina	41
Bellingen	NC
Byron Bay	NC
Casino	NC
Coffs Harbour	NC
Gosford	35
Kempsey	16
Lake Cathie	13
Mullumbimby	NC
Nambucca	NC
Narooma	0
Port Macquarie	9
South West Rocks	19
Tweed Heads	5
Wyong	4
Yamba	31

Key: NC = No collection

Question: What are some ways to describe these data?

We now obtain the following geographical information, which we've appended to our dataset. (Joining datasets is a crucial skill when you're working with GIS software! Remind me to show this to you if I do end up demonstrating GIS stuff to you one day.)

Table 2: Mosquito counts in NSW ASMMP coastal sites, week ending 22 May 2021 – with geographical coordinates

Location	Mosquito count	Latitude	Longitude
Ballina	41	-28.9	153.5629
Bellingen	NC	-30.4835	152.898
Byron Bay	NC	-28.7	153.5334
Casino	NC	-28.8667	152.7324
Coffs Harbour	NC	-30.3	153.1094
Gosford	35	-33.3208	151.2336
Kempsey	16	-31.0605	152.8482
Lake Cathie	13	-31.547	152.836
Mullumbimby	NC	-28.514	153.497
Nambucca	NC	-30.6665	152.7324
Narooma	0	-36.242	150.108
Port Macquarie	9	-31.38	152.9
South West Rocks	19	-30.8842	153.0403
Tweed Heads	5	-28.3541	153.3447
Wyong	4	-33.282	151.418
Yamba	31	-29.4332	153.3406

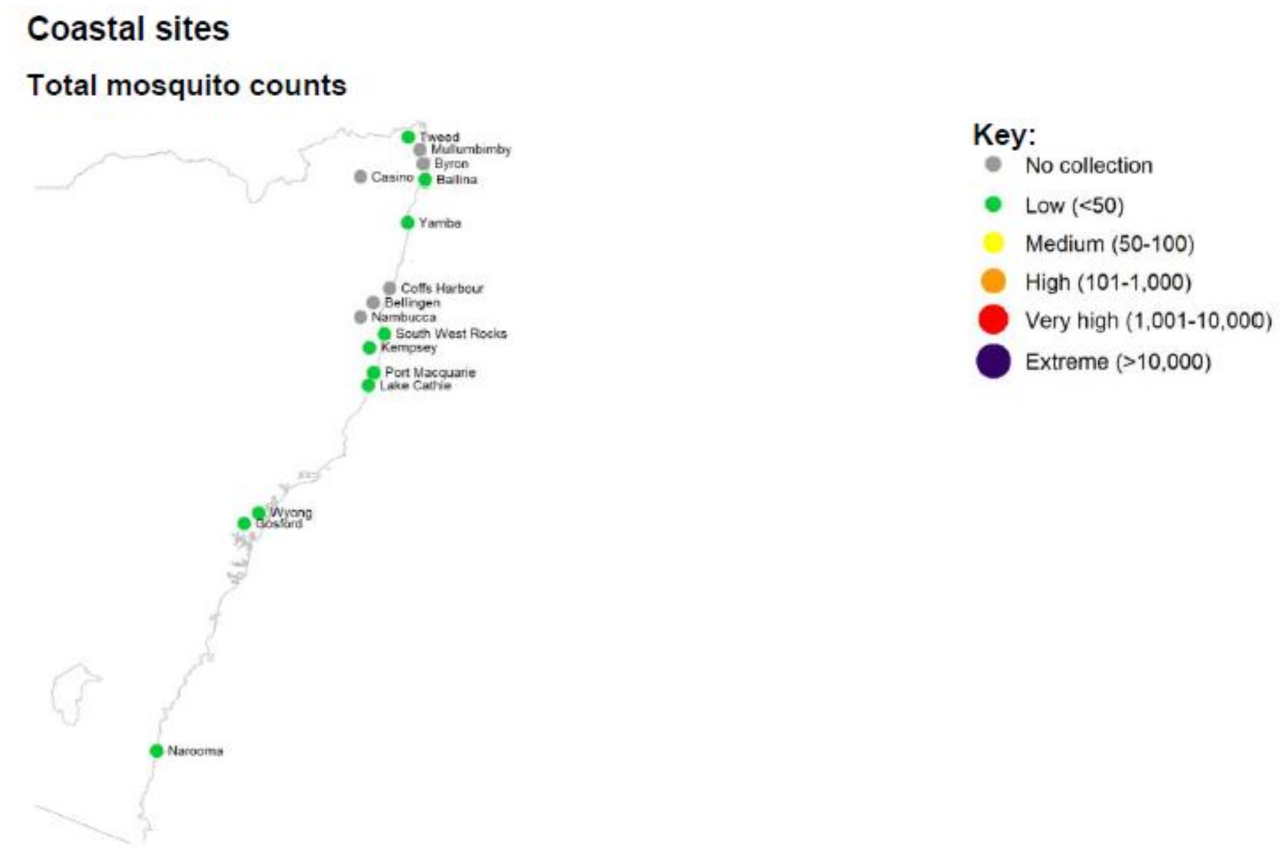
Key: NC = No collection

Now that you have this information, you consider making a map.

Question: Why might it be useful to make maps? How might maps help you?

Question: What kinds of things do you want to think about before you draw a map? (Sorry, this question is quite vague, but list everything that comes to mind!)

Map 4: Mosquito counts in NSW ASMMP coastal sites, week ending 22 May 2021



We now have our map! Now we want to describe the data on the map. Let's begin with univariate spatial statistics. This means only describing the points on the map in terms of their geographical location.

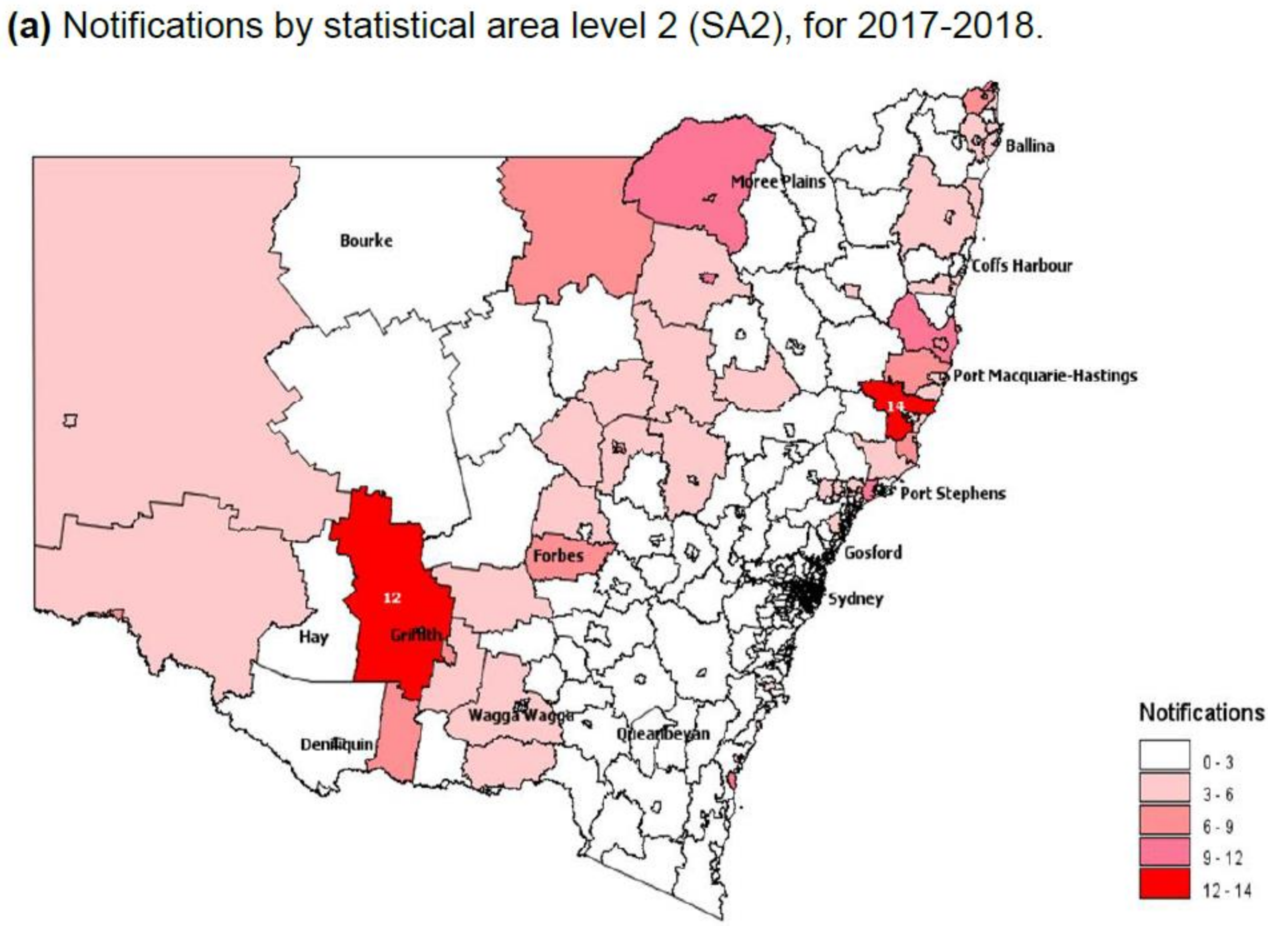
Question: How do you describe the data on this map?

Bonus questions: Why would we have trouble determining how far the furthest (and nearest) points are from each other? What do we need to do with these data? *Do not worry if you do not know the answer now. I will explain this in our teaching session. I've just included this question here in case you want to refer back to it in the future.*

Areas:

Besides points on a map, you might also want to look at entire areas. Here is another map from the NSW Arbovirus Surveillance and Mosquito Monitoring Program, from a few years ago.

Map 5: Human Ross River notification counts by Local Government Area



Let's describe this map using univariate spatial statistics again. To remind you, this means only describing the points on the map in terms of their geographical features.

Questions: How would you describe this map? What are some statistics that you can use?

Questions: What are some ways that this map is misleading? And what are some ways to fix them (in an ideal world, assuming that you might have all the data that you need)?

Part C: More complicated spatial analyses

This will come in our online teaching session! (Unfortunately it will probably be quite brief given that our time is limited.)

A journey through space

Lesson From the (geo-coded) Field

Anny Huang

July 2021

1

Lesson outline

- Acknowledgment of country
- Overview of maps
- Some common spatial statistics
- More detailed spatial analyses

2

Maps: an overview

3

Maps

- A map is a simplified, symbolic representation of space
- Different ways of classifying maps:
  - ICSM categories:
    - General Reference
    - Topographic
    - Thematic
    - Navigation Charts
    - Cadastral Maps and Plans
- Geocoding: The process of converting a description of a location to coordinates on a map

4

"All maps lie. Even the best maps distort the truth."
- Justina Chen Headley

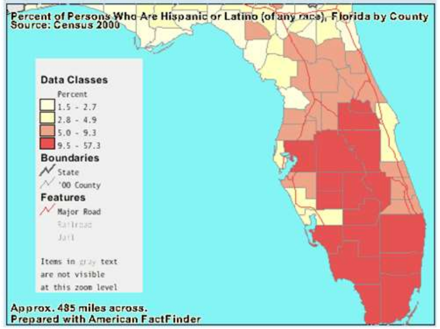
5

Question set 1

What do you like about this map?

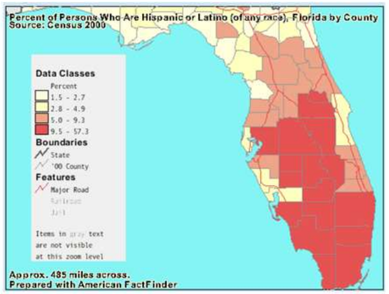
What don't you like about this map?

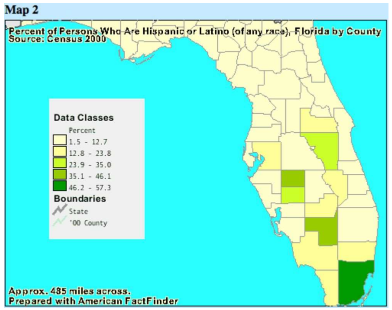
What is this map trying to say?



6

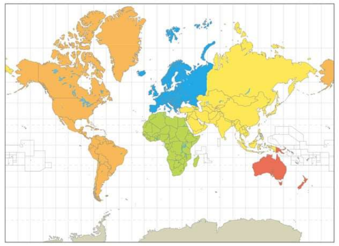
The alternative

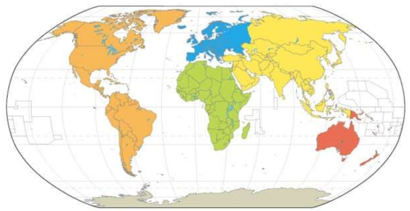




7

Question set 2





Which map are you more used to?
Which map do you like more?

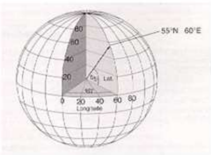
Which map is more accurate?
Which map is more useful for your projects?

8

How do you locate something?

2 kinds of coordinate systems used in mapping:

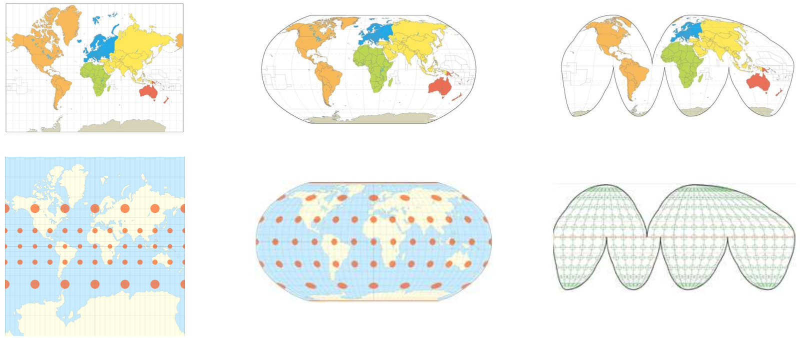
- Geographic coordinate systems (GCS):
  - Latitude and longitude
  - Units: degrees, minutes, seconds
  - Measuring angles
  - Location taken from the centre of the earth, extended out to the curved surface
- Projected coordinate systems (PCS):
  - Units: kilometres, miles
  - Measuring distances
  - Projections are mathematical processes that convert 3-dimensional models of the globe to 2-dimensional views
  - The process of projection involves converting angles to distances



9

Projections (1)

Every projection has distortions



10

Projections (2)

Choose the projection with the least distortion

- This depends on the geographical area you are working in
- Geocentric Datum of Australia 2020 (GDA2020):
  - Replaces the Geocentric Datum of Australia 1994 because we moved 1.8m!
- North American Datum 1983 (NAD1983): for USA and Canada
- Lambert-93 (RGF93): for France
- Universal Transverse Mercator (UTM):
  - Countries without their own projected coordinate system
  - Working across several countries
  - NOT Cambodia!

11

"A map is a medium. It conveys a message: a message that is truncated and distorted, by necessity, by accident, or on purpose."
– Prof Bertrand Lefebvre, EHESP

12

Some common spatial statistics

13

Question set 3

Here are some data from the NSW Arbovirus Surveillance and Mosquito Monitoring Program in the 2020/2021 season.

What are some ways to describe these data?

Location	Mosquito count
Ballina	41
Bellingen	NC
Byron Bay	NC
Casino	NC
Coffs Harbour	NC
Gosford	35
Kempsey	16
Lake Cathie	13
Mullumbimby	NC
Nambucca	NC
Narooma	0
Port Macquarie	9
South West Rocks	19
Tweed Heads	5
Wyong	4
Yamba	31

Key: NC = No collection

14

Some basic univariate, non-spatial statistics

What are some ways to describe these data?

- Counts and proportions
  - For example: number of sites that did not do collection, number of sites with <20 mosquitoes
- Averages:
  - Mean
  - Median
- Measures of spread
  - Range
  - (Inter-quartile range)

Location	Mosquito count
Ballina	41
Bellingen	NC
Byron Bay	NC
Casino	NC
Coffs Harbour	NC
Gosford	35
Kempsey	16
Lake Cathie	13
Mullumbimby	NC
Nambucca	NC
Narooma	0
Port Macquarie	9
South West Rocks	19
Tweed Heads	5
Wyong	4
Yamba	31

Key: NC = No collection

15

Question set 4

We now obtain the following geographical information, which we've appended to our dataset.

Now that you have this information, you consider making a map.

Why might it be useful to make maps? How might maps help you?

Location	Mosquito count	Latitude	Longitude
Ballina	41	-28.9	153.5629
Bellingen	NC	-30.4835	152.898
Byron Bay	NC	-28.7	153.5334
Casino	NC	-28.8667	152.7324
Coffs Harbour	NC	-30.3	153.1094
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Mullumbimby	NC	-28.514	153.497
Nambucca	NC	-30.6665	152.7324
Narooma	0	-36.242	150.108
Port Macquarie	9	-31.38	152.9
South West Rocks	19	-30.8842	153.0403
Tweed Heads	5	-28.3541	153.3447
Wyong	4	-33.282	151.418
Yamba	31	-29.4332	153.3406

Key: NC = No collection

16

How are maps helpful?

- To show where things are
- To help you navigate
- To show spatial relationships
- To identify clusters and gaps
- To define boundaries
- To help you get a point across visually
- To identify spatial changes over time
- To help measure exposures
- To model and make predictions that involve spatial information

17

Question set 5

What kinds of things do you want to think about before you draw a map?

List everything that comes to mind!

18

General mapping considerations

- Purpose and audience
- Web and/or print
- Scale and size
- Simplification
- Type(s) of data
- Map boundaries
- Coordinate system
- Stylistic considerations: colours, symbols, fonts, legends
- The message that you want to convey

19

Tools for mapping (1)

Software:

- OpenStreetMap
- Google MyMaps
- QGIS
- ArcGIS
- Microsoft Excel
- R
- Open Source Geospatial Python

File types:

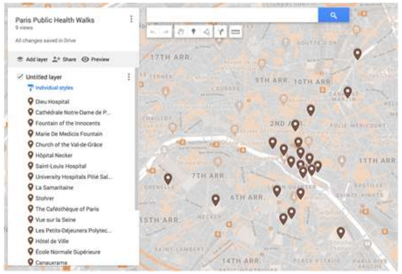
- Shapefiles (.shp)
  - Usually accompanied by other files that are essential for reading the shapefile properly:
    - .dbf, .sbx, .shx, .prj, .shp.xml
    - Do not separate these files! Download them and store them together!
- R files, such as .R, .Rdata
- Spreadsheets: .csv, .xlsx
- Image files: .png, .svg, .jpg etc

20

Tools for mapping (2)

OpenStreetMap

Google MyMaps



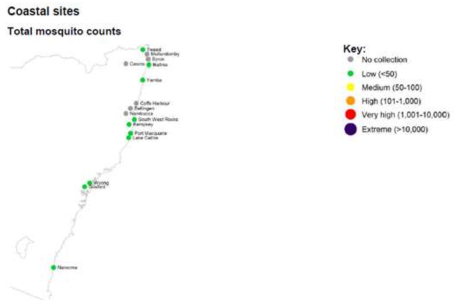
The debate: QGIS vs ArcGIS

21

Question set 6

How do you describe the data on this map?

What are some spatial statistics that you can use?



22

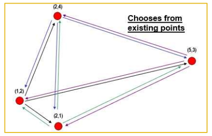
Points

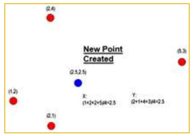
- Associated with an identification and a location
- Can have attributes
- Basic statistical summaries:
  - Counts and proportions
    - Number of points
    - Number / percentage of points with a particular characteristic
  - Averages:
    - Central Feature
    - Mean Centre
    - Median Centre
  - Measures of spread
    - Nearest and furthest distances between 2 points
    - Average distance between points
    - Standard Distance Deviation (SDD)

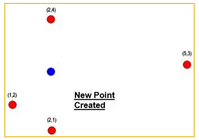
23

Averaging Points

- Central Feature:
  - The specific point that has the shortest total distance to all other points
- Mean Centre:
  - The mean x and y coordinate of the map
- Median Centre:
  - The location on the map that is the shortest distance from all points







24

Question set 7 (bonus)

Why would we have trouble determining how far the furthest (and nearest) points are from each other?

What do we need to do with these data?

25

Question set 7 (bonus)

Why would we have trouble determining how far the furthest (and nearest) points are from each other?

We're using a geographical coordinate system, which cannot measure distances.

What do we need to do with these data?

We need to project the data. The best way is to choose a projected coordinate system and tell the computer to do this for you!

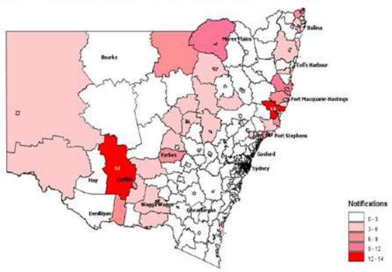
26

Question set 8

How would you describe this map?

What are some statistics that you can use?

(a) Notifications by statistical area level 2 (SA2), for 2017-2018.



27

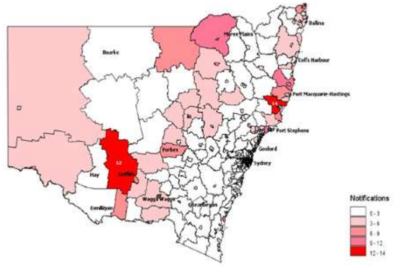
Areas (Polygons)

- Can also have attributes
- Basic statistical summaries:
  - Counts and proportions
    - Number of areas
    - Number / percentage of areas with a particular characteristic
  - Averages:
    - Mean area (size)
    - Median area (size)
    - Mean / median number of neighbouring areas
  - Measures of spread
    - Range of area sizes
    - Standard deviation of area sizes

28

Question set 9

(a) Notifications by statistical area level 2 (SA2), for 2017-2018.



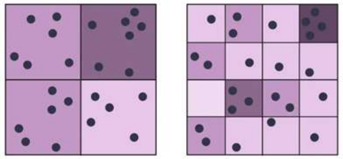
What are some ways that this map is misleading?

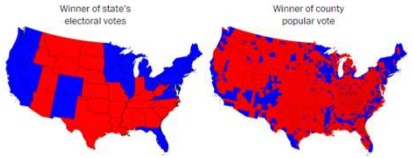
What are some ways to fix them(in an ideal world, assuming that you might have all the data that you need)?

29

Mapping: Some additional considerations

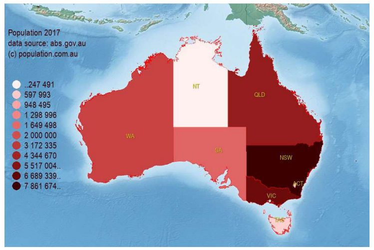
- Edge effects
- Visual confusion and bias
- Modifiable areal unit problem (MAUP)

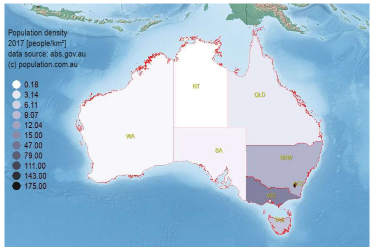




30

Density



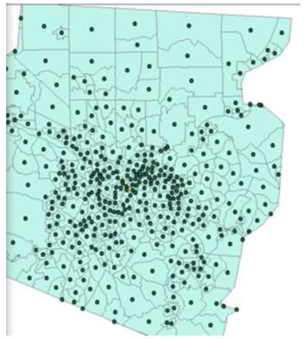


Density = Count / Area
Very useful when comparing areas of varying sizes

31

Areas converted to points: centroids

- Easy to do on GIS software
- Some reasons to do this:
  - May be less visually confusing to analyse
  - Can then perform analyses on centroids the same way as points



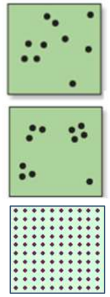
32

More detailed spatial analyses

33

Nearest Neighbour Index / Ratio (NNI / NNR)

- A statistical test that can be performed on point data
- Tells you how evenly spread out your points are
- Null hypothesis: that the distribution of the points are random
  - Gives a 2-tailed p value
- Random distribution of points:
  - NNI = 1
  - p value > 0.05
- More clumped than random:
  - NNI > 1
  - p value < 0.05
- More evenly dispersed than random:
  - NNI < 1
  - p value < 0.05



34

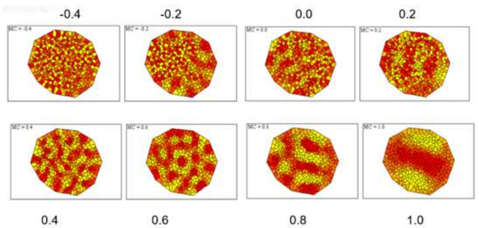
Cluster analysis

- "Hotspot analysis"
- Global and local statistics
- Moran's I score (Moran's index):
  - A measure AND test of spatial autocorrelation (p value available)
  - Score from -1 to 1
  - Null hypothesis: That the spatial distribution of the attribute is completely random (Moran's I score of 0)
  - Only works with projected coordinate systems
  - Does NOT tell you whether a specific subgroup is clustering
  - Many fancy configurations are possible!
  - Both global and local Moran's I scores can be calculated

35

More about Moran's I scores

- Global Moran's I score
  - Overall patterning of features that are similar to each other



- Local Moran's I score
  - For an individual point or area, how similar are the features surrounding it?

36

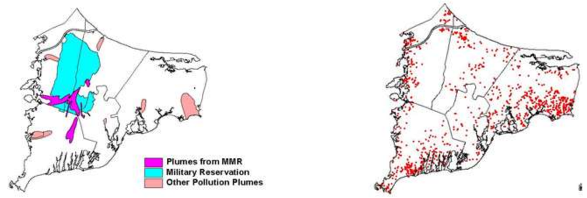
Regressions, modelling and spatial studies

- Spatial autocorrelation:
  - Violates the independence assumption of a "normal" linear/logistic regression
  - Simultaneous autoregressive regression (SAR)
- Can also incorporate time: time series spatial analyses
- Accounting for spatial confounding
- Modelling of hypothetical scenarios:
  - Generalised additive models (GAM)
- Spatial epidemiological studies

37

Example: Case control study in Massachusetts (1)

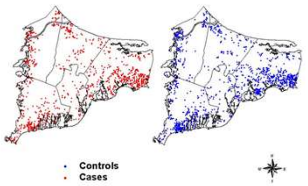
- Study to determine whether chemicals discharged into the water supply from army base was responsible for high incidence of breast cancer in the Cape Cod area, Massachusetts
- Retrospective case control study involving cases with breast cancer, looking back at exposures over 20 years

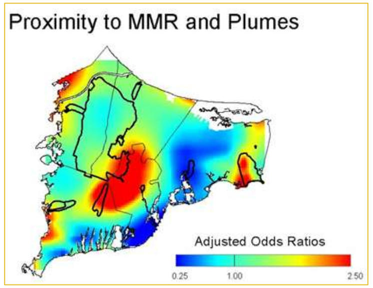


38

Example: Case control study in Massachusetts (2)

- Spatial confounding: more people lived along the coast
- Final model:
  - Adjustment for other confounders
  - Odds ratios modelled with GAM
  - Odds ratios mapped
  - Overlaid with additional exposure information



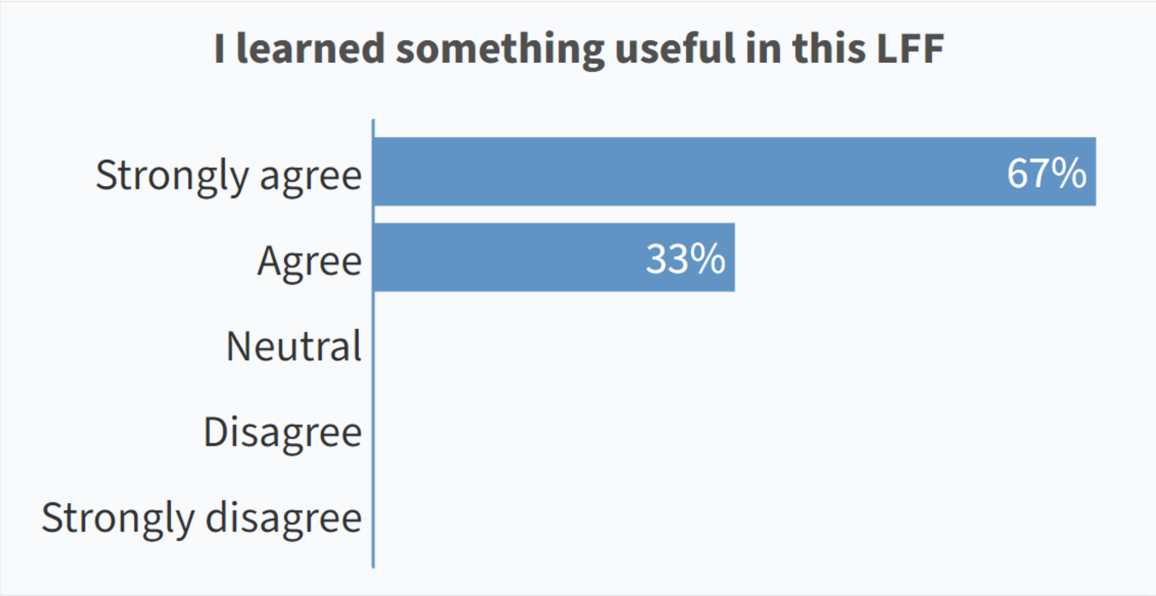


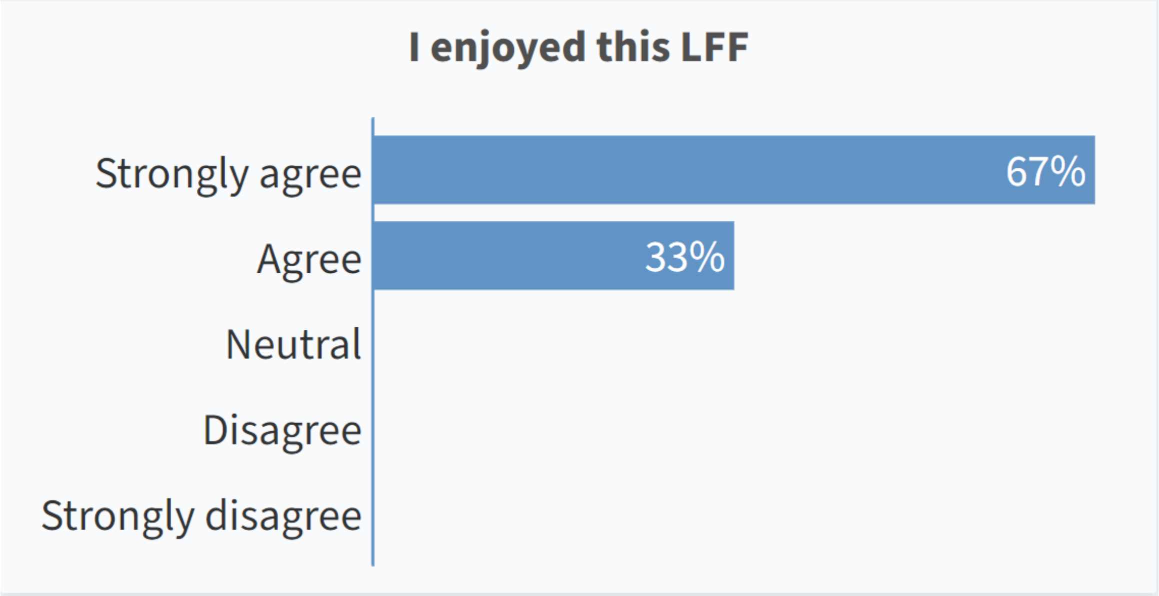
39

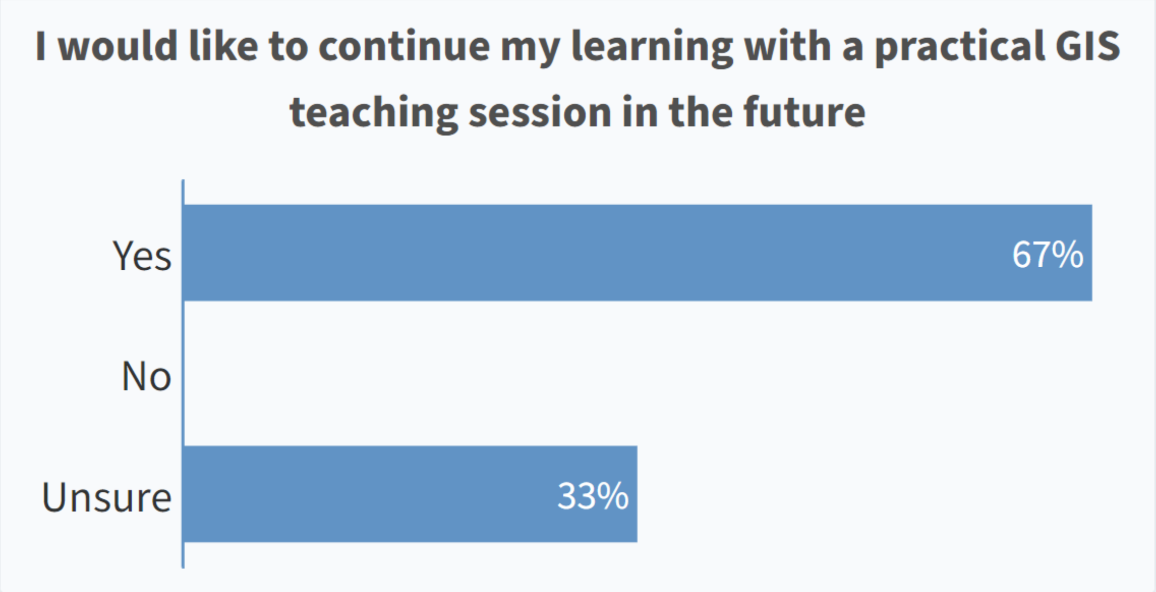
Questions?

Evaluate me! https://pollev.com/annyhuang820

40







Any additional comments? (Optional)

" Thanks Anny, very interesting session. "

" , "

The very honest guide to working with GPs

Anny Huang, November 2021
All views here are my own

1

Part 1

Who is a GP in Australia?

2

Let's work through a flowchart …

Are you a doctor who fits into one of these categories?

↓

	Option A	Option B	Option C	Option D	Option E	Option F	Option G
Passed RACGP exams	x						x
Passed ACRRM exams		x					x
Currently a member of RACGP			x				x
Currently a member of ACRRM				x			x
Recognised by AHPRA as a specialist GP					x		x
Currently working in primary health						x	x

↓

Congratulations! You are a GP!

3

Where do GPs work?

- GP clinics
- Aboriginal and Torres Strait Islander health facilities
- Other clinics
- Aged care facilities
- Home of the patient
- Home of the GP
- Hospitals: public and private
- Government and LHD
- Academia and other research institutions
- Workplaces
- Makeshift spaces – sometimes outdoors
- Antarctica

4

Who do GPs answer to?

- AHPRA
  - Australian Health Practitioner Regulation Agency
  - Recent specialist classification for GPs
  - Practitioner numbers
  - Complaints, warnings, other disciplinary actions all reported to AHPRA
- Medicare
  - Who can bill for which services
  - Who can order which tests
  - Provider numbers: 1 per practice
- PBS
  - Pharmaceutical Benefits Scheme
  - Who can prescribe which medications, at what quantities
  - Prescriber numbers: 1 per doctor
- Commonwealth and State laws

5

What are some additional organisations that a GP could join?

- RACGP
  - Royal Australian College of General Practitioners
  - Not all GPs are with RACGP!
  - You can train with RACGP and then decline future membership
- ACRRM
  - Australian College of Rural and Remote Medicine
  - Not all GPs are with ACRRM: can also train with ACRRM and then leave
- AMA
  - Australian Medical Association
  - Not all doctors are with AMA
  - Low AMA membership among GPs

6

Who else might be helpful to GPs?

- PHN
  - Primary Health Networks
- MDOs
  - Medical Indemnity Organisations
- NPS
  - National Prescriber Service
- PHUs
  - Public Health Units
- Community pharmacists
- Aboriginal Liaison Officers at public hospitals
- Liaison Nurses / Nurse Coordinators at public hospital services
- TIS
  - Telephone interpreting service

7

How are GPs trained (initially)?

- The 2 colleges SET the curriculum, but do NOT necessarily administer the training
  - RACGP
    - 3 year program
    - All training through RTOs
  - ACRRM
    - 4 year program
    - Only administer the self-funded training stream
    - Other training through RTOs / RVTS scheme
  - Both colleges administer their own exams
- Regional Training Organisations (RTOs)
  - 11 organisations
  - Select candidates after a central intake assessment
  - Once you are with an RTO, you are a registrar
  - Organise registrar placements at training practices
  - Liaise with supervisors and training practices
  - Organise additional training sessions

8

What additional certification could a GP have?

- Mental health
- Paediatrics
- Anaesthetics
- Obstetrics
- Sexual health
- Travel medicine
- Drugs and alcohol
- Emergency medicine
- Dermatology
- And many other specialties!

9

Part 2

How do things work at a GP practice?

10

How are GP practices organised?

- Solo GP practice
- Group GP practice
  - Different ways of pooling money
  - Different ways of recording and sharing information
  - Additional level of organisation in large corporate practices
- ACCHOs

11

Who else might you find at a general practice?

- Practice Manager:
  - Important but under-utilised resource
  - Level of training is variable
- Nurse (Remote Area Nurses in some settings)
- Receptionist
- Allied health: physio, dietitian, psychologist, podiatrist, diabetes educator etc
- Pathology collector
- Visiting specialists
- Aboriginal Health Worker
- Cleaner
- Other admin / support staff

12

What does a GP do?

Things that you might see:
- Patient consultations
- Immunisations
- Minor surgical procedures
- Paperwork
- Sell commercial health products

Things that you don't see:
- Paperwork
- Phone calls
- Responding to messages from receptionists and other staff
- Phone advice to colleagues
- Teaching and learning
- Responding to business needs

13

What is special about general practice?

- Relationships and trust
- Ability to keep reviewing an evolving clinical situation
- Consideration all kinds of issues within a family unit
- Home visits
- Priority patients
- Time to answer questions and educate patients
- Flexibility to patient needs / situations
- Knowledge of communities

14

What is GP practice software like?

- Most popular software:
  - BestPractice
  - Medical Director
  - (A range of others are available)
- Usual features:
  - A place to write notes
  - A place to record vital signs and measurements
  - A section for diagnostic test results
  - A section for correspondence in/out
  - A place to record preventative activities
  - A method to set reminders
  - A method to bill for services
  - A method for prescribing and keeping track of prescriptions
  - A method for creating pathology / radiology requests
  - A method to keep track of the waiting room
  - A method to receive messages
  - A method to create documents like medical certificates, referral letters, Centrelink forms, management plans
- Integration:
  - Using products from "secure messaging brokers":
    - Argus (a Telstra product)
    - HealthLink
    - Medical Objects
  - With a range of external organisations:
    - MyHealthRecord
    - Public hospitals (discharge summaries):
      - Different LHDs have different "brokers"
    - Some private hospitals
    - Pathology laboratories
    - Medical imaging / other diagnostic providers
    - Private specialists

Northern Sydney	Argus	1. Emergency 2. Baseline (Inpatient) 3. Geriatric 4. Spinal
Western Sydney	HealthLink	1. Emergency 2. eDischarge - Generic 3. eDischarge - Geriatric 4. eDischarge - Gastroenterology 5. eDischarge - Neurology 6. eDischarge - Respiratory

15

So, you go and see a GP. Who pays?

- Medicare
- WorkCover
- TAC
- Patient's own pocket
- Private health insurance
- Employers
- Regional Training Organisations

16

How does Medicare pay GPs?

- MBS item numbers
  - Everything for each individual patient is billed against a Medicare item number
- Incentive payments
  - Vaccination Provider Information Payments
    - Up to $6 per completed course of childhood immunisations
  - PIPs (Practice Incentive Payments)
    - For the entire practice, for certain activities or after certain KPIs are met
    - Only accredited practices are eligible
    - Examples:
      - Teaching payment for supervising a medical student

IN THE SURGERY		
Item no		
3	$17.75	(Level A) Brief
23	$38.75	(Level B) Standard < 20 mins
36	$75.05	(Level C) Long 20-40 mins
44	$110.50	(Level D) Prolonged ≥ 40 mins

69380

Genotypic testing for HIV antiretroviral resistance in a patient with confirmed HIV infection if the patient's viral load is greater than 1,000 copies per ml at any of the following times:

(a) at presentation; or

(b) before antiretroviral therapy: or

(c) when treatment with combination antiretroviral agents fails;

maximum of 2 tests in a 12 month period

Fee: $770.30 **Benefit:** 75% = $577.75 85% = $682.40

← Previous - Item 69379 Next - Item 69381 →

17

What are GPs NOT paid for?

- Phone calls
  - Without the patient being present at the time
  - Special provisions for COVID-19: currently very limited
- Paperwork
  - Without the patient being present at the time
- Anything else where the patient is not present at the time
  - For example, "Oh, would you mind printing out the X-ray request form for my son? He came to see you yesterday but lost the piece of paper."
- (Follow-up appointments on the same day: have to be justified with a note to Medicare)
- Services provided only by the practice nurse
- Educational / CPD activities
- Any "process improvement" activities for the practice
  - Including all the time getting paperwork ready for accreditation!

18

How are general practices accredited?

- OPTIONAL! Reasons to do this include:
  - To obtain feedback and to know that you are providing safe care
  - Increased patient trust: good for the business
  - Able to access PIP (Practice Incentive Payments) from Medicare
  - Cheaper insurance
- Standards set out by the National General Practice Accreditation Scheme
  - Developed and updated by the Australian Commission on Safety and Quality in Health Care in collaboration with the RACGP
- Actual accreditation process is undertaken by 5 approved commercial organisations (accreditation agencies):
  - ACHS
  - AGPAL
  - Global-Mark
  - IHCAC
  - QPA
- You CANNOT find a complete and publicly available list of accredited practices

19

Part 3

What are the main channels for communication and education?

20

How do GPs keep their knowledge up to date?

What materials are available?
- Reading
- Online education modules
- Talks and webinars
- Skills workshops
- CPR refresher courses

Who provides these materials?
- Colleges (RACGP/ACRRM)
- "Free" providers:
  - Primary Health Networks
  - NPS (National Prescriber Service)
  - Not-for-profit organisations
  - Pharmaceutical companies
  - WebMD
  - State and Commonwealth governments (specific cases)
  - LHDs and Public hospitals (specific cases)
- "Commercial" providers:
  - AusDoc
  - HowToTreat
  - dpLearning
  - Australian Health Industry Group
  - UpToDate
  - St John's Ambulance
  - Private hospitals and clinics

21

What resources do GPs use day-to-day?

- Resources embedded in practice software
- RACGP guidelines
- Therapeutic Guidelines (eTG)
- Australian Medicines Handbook / MIMS
- Australian Immunisation Handbook
- DermNet NZ
- Australian STI Management Guidelines
- Royal Children's Hospital paediatric guidelines
- RCPA Manual
- Other GP colleagues
- Doctors on call at local hospitals
- HealthPathways

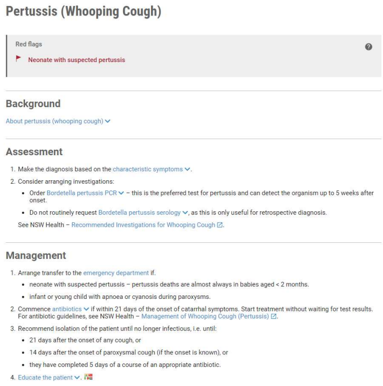
22

What are these HealthPathways?

- Local GP guidelines
  - Developed by local GPs, specialists and other health staff
  - Local service and referral information
- Model used in 40-50 regions in 3 countries:
  - Original site (with the most complete set of pathways): Canterbury, New Zealand
  - Network of Healthpathways regions in NSW: some regions may self-nominate to be "lead sites" for statewide pathways
- Covers all of NSW, but different regions are organised differently
  - Western Sydney: mostly a Primary Health Network project with LHD involvement
  - South Western Sydney: joint funding from PHN and LHD
  - Western NSW: Also a Primary Health Network project that incorporates both WNSWLHD and FWLHD
  - Sydney and South Eastern Sydney: 1 PHN (CESPHN) but **two** Healthpathways sites, 1 for each LHD
- Access managed differently for each region
  - Western Sydney: 1 single username and password for all primary health staff
- Set format for pathways so that GPs can find information they need quickly
  - Critical information comes first! Then exceptions. Then "the usual".
  - Use of dropdowns so that "optional extra" information can be minimised
- Some regional Healthpathways sites are integrated with patient information sites
  - For example: Healthy Western Sydney

23

What does HealthPathways look like?


Pertussis (Whooping Cough)

Red flags

Neonate with suspected pertussis

Background

About pertussis (whooping cough)

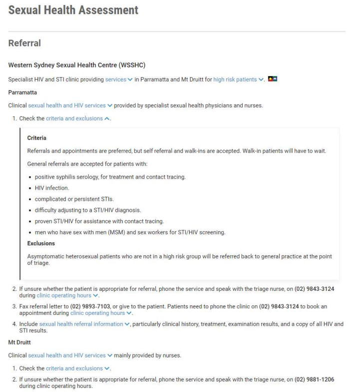
Assessment

1. Make the diagnosis based on the characteristic symptoms.
2. Consider arranging investigations:
   - Order Bordetella pertussis PCR – this is the preferred test for pertussis and can detect the organism up to 5 weeks after onset.
   - Do not routinely request Bordetella pertussis serology, as this is only useful for retrospective diagnosis.

   See NSW Health – Recommended Investigations for Whooping Cough.

Management

1. Arrange transfer to the emergency department if.
   - neonate with suspected pertussis – pertussis deaths are almost always in babies aged < 2 months.
   - infant or young child with apnoea or cyanosis during paroxysms.
2. Commence antibiotics if within 21 days of the onset of catarrhal symptoms. Start treatment without waiting for test results. For antibiotic guidelines, see NSW Health – Management of Whooping Cough (Pertussis).
3. Recommend isolation of the patient until no longer infectious, i.e. until:
   - 21 days after the onset of any cough, or
   - 14 days after the onset of paroxysmal cough (if the onset is known), or
   - they have completed 5 days of a course of an appropriate antibiotic.
4. Educate the patient.


Sexual Health Assessment

Referral

Western Sydney Sexual Health Centre (WSSHC)

Specialist HIV and STI clinic providing services in Parramatta and Mt Druitt for high risk patients.

Parramatta

Clinical sexual health and HIV services provided by specialist sexual health physicians and nurses.

1. Check the criteria and exclusions.

   Criteria

   Referrals and appointments are preferred, but self referral and walk-ins are accepted. Walk-in patients will have to wait.

   General referrals are accepted for patients with:
   - positive syphilis serology, for treatment and contact tracing.
   - HIV infection.
   - complicated or persistent STIs.
   - difficulty adjusting to a STI/HIV diagnosis.
   - proven STI/HIV for assistance with contact tracing.
   - men who have sex with men (MSM) and sex workers for STI/HIV screening.

   Exclusions

   Asymptomatic heterosexual patients who are not in a high risk group will be referred back to general practice at the point of triage.
2. If unsure whether the patient is appropriate for referral, phone the service and speak with the triage nurse, on **(02) 9843-3124** during clinic operating hours.
3. Fax referral letter to **(02) 9893-7103**, or give to the patient. Patients need to phone the clinic on **(02) 9843-3124** to book an appointment during clinic operating hours.
4. Include sexual health referral information, particularly clinical history, treatment, examination results, and a copy of all HIV and STI results.

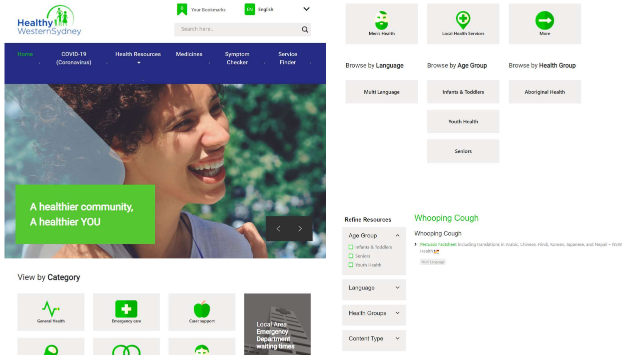
Mt Druitt

Clinical sexual health and HIV services mainly provided by nurses.

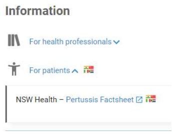
1. Check the criteria and exclusions.
2. If unsure whether the patient is appropriate for referral, phone the service and speak with the triage nurse, on **(02) 9881-1206** during clinic operating hours.

24

How about Healthy Western Sydney?



Corresponding section of HealthPathways:



25

How do you send out mass communications to GPs?

- None of the methods are very good!
- Best for reaching as many GPs as possible about all issues:
  - Through PHNs and their own channels
    - Some PHNs **do** fax/email each clinic quite regularly!
    - Includes Healthpathways alerts
- Other ways
  - Through the colleges
  - NSW Health communications
  - Commercial newsletters: AusDoc, HowToTreat
  - Regulatory issues: liaise with AHPRA
  - Social media: Many GP Facebook groups where links to important information can be posted – especially helpful for internationally trained GPs

26

How do you deliver training to GPs?

- Registrars:
  - Through RTOs
  - Through ACRRM
  - Advocating for RACGP and ACRRM to add it to the compulsory training curriculum
- GPs:
  - Through Primary Health Networks
  - Through RACGP and ACRRM

27

How do you get GPs to stop using faxes?

- First of all, let me tell you about the GP's perspective
- Technical / practice support: Primary Health Networks

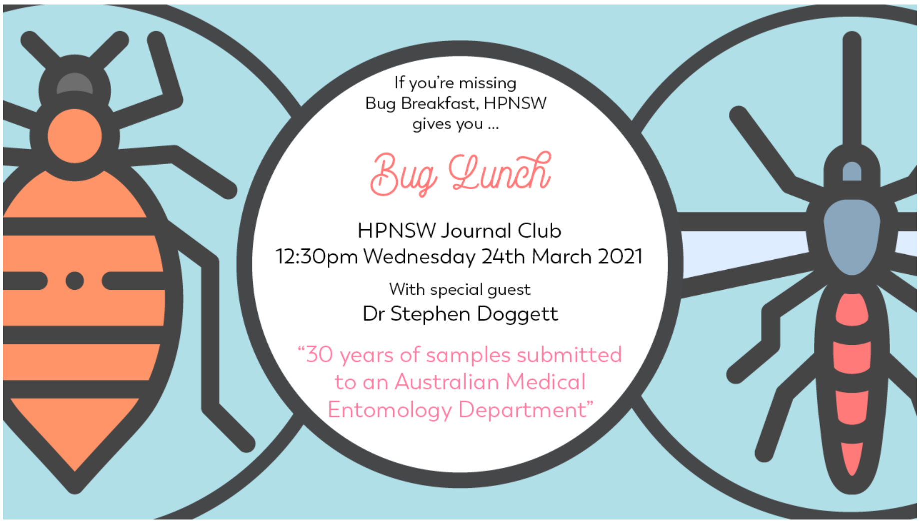
28

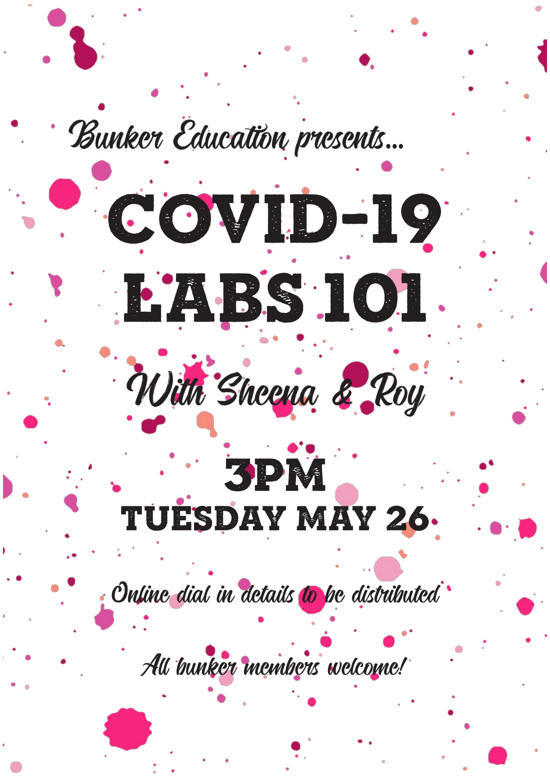
Thanks for listening to me rant

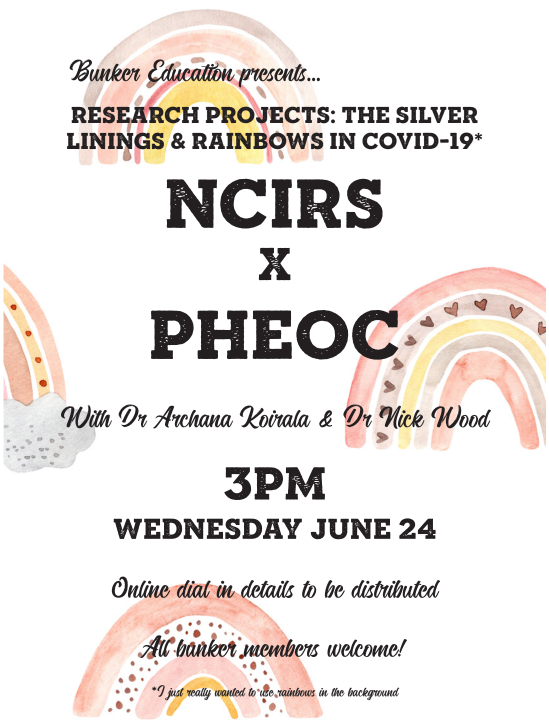
Questions?

29

Graphics design for HPNSW: Some examples







Learning to Count

Epi-logue

Counting Blessings

Acknowledgements

“Epi-logue”: Extended Acknowledgements

I had a conundrum. There are many people I want to thank in this thesis, but I was sure that I didn’t want to make all of them have to read the thesis just to find their names. This QR code was inspired by the pandemic. Please scan with a mobile device to access my MAE thesis acknowledgements page online.