Applied Epidemiology of Communicable Diseases in Queensland

This thesis submitted for the degree of Master of Philosophy in Applied Epidemiology of the 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 text. The work was undertaken from February 2024 to October 2025 as part of the degree Master of Philosophy in Applied Epidemiology, Australian National University. Any contribution made to the research by others, with whom I have worked is explicitly acknowledged in the thesis. I also declare that the intellectual content of this thesis is the product of my own work, except to the extent that assistance from others in the project's design and conception or in style, presentation, or linguistic expression is acknowledged.

Gemma Devlin
October 2025

"The miner was about to give it all up, right at the point when, if he were to examine just one more stone — just one more — he would find his emerald."

— Paulo Coelho, The Alchemist (1988)

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I acknowledge the use of Claude (Anthropic) AI as a learning and editing tool during this research, AI assistance was used to understand statistical methods and R programming concepts. No confidential data, personally identifiable information or research findings were shared when using AI tools. All analysis interpretations and conclusions are my own work, developed under the guidance of my supervisors.

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Abstract

The Population Health Division (formerly Queensland Public Health and Scientific Services) of Queensland houses the Communicable Diseases Branch (CDB) and Public Health Intelligence Branch (PHIB) who are responsible for improving the health of the Queensland population by surveillance, prevention and control of communicable diseases. From February 2024 to December 2025, I completed a 22-month field placement with both branches. Each chapter in this thesis describes a project from this placement, including: an outbreak investigation of campylobacteriosis at a residential aged care facility; evaluation of viral load as a proposed notifiable condition in Queensland through stakeholder interviews, process development and application of selected US Centres for Disease Control Guidelines for Evaluating Surveillance Systems attributes; analysis of recurrent invasive Group A streptococcal disease cases; and description of trends in pertussis surveillance data with a focus on the epidemic year, 2024. Also included are other public health experiences gained during the placement, teaching to my peers and a presentation at a national conference. Together, these projects and experiences fulfil the requirements of the Master of Philosophy (Applied Epidemiology) program at Australian National University.

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List of Abbreviations

ABS	Australian Bureau of Statistics
ACCESS	Australian Collaboration for Coordinated Enhanced Sentinel Surveillance Transmissible Infections and Blood Borne Viruses
AHOD	Australian HIV Observational Database
AIDS	Acquired Immunodeficiency Syndrome
AIR	Australian Immunisation Register
ANU	Australian National University
ArcGIS	Geographic Information System by Esri
ART	Antiretroviral Therapy
ASGS	Australian Statistical Geography Standard
ASHM	Australian Society for HIV, Viral Hepatitis and Sexual Health Medicine
ATAGI	Australian Technical Advisory Group on Immunisation
BBV	Blood-Borne Virus
CBD	Communicable Diseases Branch
CDC	Centers for Disease Control and Prevention
CDNA	Communicable Diseases Network Australia
CHO	Chief Health Officer
CI	Confidence Interval
COVID-19	Corona Virus Disease
DNA	Deoxyribonucleic Acid
DTP	Diphtheria Tetanus Pertussis
Emm-type	M protein gene sequencing system for Group A Streptococcus
ERU	Epidemiology and Research Unit
GAS	Group A Streptococcus
GBD	Global Burden of Disease
GCPHU	Gold Coast Public Health Unit
HCV	Hepatitis C Virus
HHS	Hospital and Health Services
HIV	Human Immunodeficiency Virus
HREC	Human Research Ethics Committee
ICD	International Classification of Diseases
iGAS	Invasive Group A Streptococcal disease

IRR	Incidence Rate Ratio
MAE	Master of Applied Epidemiology
MLST	Multilocus Sequence Typing
NAAT	Nucleic Acid Amplification Test
NCIRS	National Centre for Immunisation Research and Surveillance
NCIRS	National Centre of Immunisation Research and Surveillance Australia
NNDSS	National Notifiable Diseases Surveillance System
NoCS	Notifiable Conditions System
NSW	New South Wales
OCT	Outbreak Control Team
PBS	Pharmaceutical Benefits Scheme
PCR	Polymerase Chain Reaction
PEHRL	Public and Environmental Health Reference Laboratories
PHIB	Public Health Intelligence Branch
PHU	Public Health Unit
PLWHIV	People living with HIV
QLD	Queensland
QPHASS	Queensland Public Health and Scientific Services
RACF	Residential aged care facility
RNA	Ribonucleic Acid
ST	Sequence Type
STI	Sexually Transmissible Infections
UKHSA	United Kingdom Health Security Agency
UNAIDS	United Nations AIDS
UNSW	University of New South Wales
WGS	Whole Genome Sequencing
WHO	World Health Organization

Chapter 1: Introduction to field placement and summary of experience

MAE Journey

My motivation for applying for the MAE program, came partly from my natural inquisitive nature and partly from a desire to develop a deeper understanding of public health data and translating this into action. As a clinician, we are often busy doing, and while evidence-based practice and quality improvements are ingrained into our practice, we often do not have the time or knowledge to accurately capture, explore, and formally share our insights and observations through research and publications. Working with experienced epidemiologists showed me the importance of understanding data and not just reporting it. With a Bachelors and a Masters degree already under my belt, as well as a young family, I knew that embarking on this intensive program was not going to be easy, and yet, I don't think I would have wanted to do it any other way. Each chapter in this Thesis documents my learning and professional development over the last 18 months, demonstrating the progression from clinician to epidemiologist through outbreak investigation, surveillance evaluation, analytical design, and study conduct.

Field placement

I commenced as an MAE student on 12 February 2024 with the Communicable Diseases Branch (CBD) within the Queensland Department of Health. I feel incredibly grateful to have had this opportunity to study in the MAE and work alongside several colleagues who have also completed the program.

The Queensland Department of Health, like many other health departments, has undertaken significant changes in structure following the COVID-19 pandemic response. In Queensland Health this included a commissioned review with recommendations covering a 10-year road map titled, Queensland Public Health Review, March 2023.[1]

The Communicable Disease Branch is responsible for the prevention and control of communicable diseases in Queensland and sat within the Queensland Public Health and Scientific Services (QPHASS) Division. QPHASS was led by a Deputy-Director General and reported directly to the Director-General for Queensland Health. Towards the end of my placement there was further restructuring, with many branches in QPHASS now a part of a new Population Health Division, which is led by the Chief Health Officer.

My placement worked closely with the Epidemiology and Research Unit (ERU) which sits within the Public Health Intelligence Branch (PHIB). PHIB includes Information and Communication Technology (ICT) and Data Services, Population Health Epidemiology and Economics, Epidemiology and Research Unit, Public Health Portfolio Office, OzFoodNetQLD

and Office of the Executive Director. There are several MAE alumni who work within the branch.

Each epidemiologist is primarily responsible for a portfolio area (depending on staff movements or periods of increased activity). The main portfolios are vaccine preventable diseases, tuberculosis and rheumatic heart disease, mosquito-borne diseases, HIV, Blood borne Virus/ Sexually Transmitted Infections (BBVSTI) and acute respiratory infections. The OzFoodNetQLD epidemiologists are responsible for surveillance of food-borne diseases and are part of a national network.[2] Through my projects I was able to work with teams in both Public Health Intelligence Branch (PHIB) and the Communicable Diseases Branch, in particular the BBVSTI and Immunisation teams.

Field projects

A brief description of each project and other competencies is provided below; a summary of MAE competencies and corresponding Chapters is listed in Table 1.1.

1. **Investigation of an acute public health problem or threat**

Chapter 2: Outbreak investigation of campylobacteriosis at a residential aged care facility in Queensland 2024 and review of previous *Campylobacter* spp. outbreak investigations in this setting.

I was part of the team investigating an outbreak of campylobacteriosis at a residential aged care facility, where six cases were identified, no source was confirmed through environmental or food testing. This project also included a review of all outbreak investigations involving *Campylobacter* spp. in residential aged care facilities in Queensland from 2005–2024.

2. **Analysis of a public health dataset**

Chapter 3: Pertussis on the Rise: Descriptive Epidemiological Analysis, Queensland 2024.

I conducted a comprehensive analysis of all pertussis notifications in Queensland from 1991 when pertussis became notifiable in Queensland to 31 December 2024. The project focused on 2024, the epidemic year, and compared it to previous epidemic years, describing notification trends, age–specific notification rates, geographic distribution and vaccination status patterns as well as laboratory testing trends.

3. **Establish or valuate a surveillance or other health information system**

Chapter 4: Making HIV viral load testing a notifiable condition: assessing a proposed new surveillance system.

I evaluated the feasibility of introducing HIV viral load as a notifiable condition in Queensland. The project involved scoping the current guidelines, strategic plans and elimination goals as well as current surveillance systems. The evaluation was conducted through application of the CDC Guidelines for Evaluating Surveillance Systems to assess key attributes including simplicity, sensitivity, representativeness and acceptability. A key focus of the evaluation was acceptability, which was explored through semi-structured stakeholder interviews with representatives from clinicians, laboratory personnel, public health staff, advocacy groups and peers.

4. **Design and conduct an epidemiological study**

Chapter 5: Epidemiology of recurrent invasive Group A Streptococcal disease, Queensland 2006 to 2024.

I designed and conducted an epidemiological study to describe patterns of recurrent invasive Group A Streptococcal disease in Queensland. The study used data from 2005 (when iGAS became notifiable in Queensland) to 2024 and describes the epidemiology by person, place and time of iGAS and recurrent iGAS in Queensland over this period. For this study I used Cox proportional hazards modelling to provide hazard rations and survival curves to quantify the risk of recurrence.

Other competencies

1. **Literature review**

Chapter 5: Epidemiology of recurrent invasive Group A Streptococcal disease, Queensland 2006 to 2024.

Whilst literature reviews were conducted for all projects, as per the requirements of the MAE program this process was formally documented in the design of an epidemiological study project. The literature review used per reviewed databases and relevant clinical guidelines and policy documents to identify literature related to iGAS and iGAS recurrence from a global and local Australian context.

2. **Lay summary**

Chapter 4: Making HIV viral load testing a notifiable condition: assessing a proposed new surveillance system

I developed a participant feedback information sheet for stakeholders who participated in the semi-structured interviews.

3. **Conference presentation**

Chapter 3: Pertussis on the Rise: Descriptive Epidemiological Analysis, Queensland 2024.

I presented findings from the analysis of pertussis notifications in Queensland at the Communicable Diseases and Immunisation Conference, Adelaide 2025. Findings from this project were also presented at the Queensland Public Health and TB Nurses face to face meeting Brisbane in 2025.

4. **Peer-reviewed publication**

These chapters have been prepared as an advanced draft for a peer reviewed publication:
Chapter 3: Pertussis on the Rise: Descriptive Epidemiological Analysis, Queensland 2024.

Chapter 5: Epidemiology of recurrent invasive Group A Streptococcal disease, Queensland 2006 to 2024.

5. **Teaching field epidemiology**

Chapter 6: Teaching activities.

Coursework

I completed the following coursework during the program:

- POPH8916: Outbreak Investigation
- POPH8917: Public Health Surveillance
- POPH8913: Analysis of Public Health Data
- POPH8915: Research Design and Methods
- POPH8914: Issues in Applied Epidemiology

Additional field placement activities

- I visited the Queensland Public Health and Scientific Services - Forensic and Scientific Services (FSS) public health laboratory at Coopers Plains, Brisbane and the Central Laboratory at Pathology Queensland, Herston, Brisbane on Thursday 18 and Friday 19 April 2024, respectively.
- Foundations and intermediate geospatial mapping courses using ARCGIS Pro.
- Attendance of weekly notifications meetings within QPHASS and monthly statewide epidemiology meetings.
- Collaboration with the National Centre of Immunisation Research and Surveillance Australia (NCIRS) on a pertussis project where I was responsible for collating and aggregating Queensland data.

- Attendance of the Communicable Diseases and Immunisation Conference Brisbane 11–13th June 2024.
- Prepared and submitted a clinician alert for pertussis in August in the form of a letter to the editor to the Medical Journal of Australia in August 2024.
- Co-authored a manuscript accepted for publication describing the epidemiology of an ongoing outbreak of Tuberculosis in Queensland.
- Attendance at the HIV&AIDS and Australian Sexual and Reproductive Health joint Conference Adelaide 15–18 September 2025.
- Reviewed Queensland invasive meningococcal disease notifications data (1990–2025) with focus on the period prior and post the introduction of the funded meningococcal B vaccination program in Queensland and contributed epidemiological insights and figures for an education session.

Table 1.1: Summary of MAE program requirements

Requirements	Chapter				
	2	3	4	5	6
Data Analysis		✓			
Acute public health problem / outbreak	✓				
Evaluate surveillance system			✓		
Epidemiological study				✓	
Literature review				✓	
Lay summary			✓		
Conference presentation		✓			
Teaching activities					✓
Peer-reviewed publication		✓		✓	

References

1. Weeramanthri T, Spencer S, Mackie A. Queensland Public Health Review: Final Report. Brisbane (QLD): Queensland Health Steering Committee; 2023 Mar.

2. Australian Government Department of Health and Aged Care. OzFoodNet network [Internet]. Australian Government Department of Health and Aged Care. Australian Government Department of Health and Aged Care; 2023 [cited 2024 Apr 2]. Available from: https://www.health.gov.au/our-work/ozfoodnet-network

Chapter 2: Outbreak investigation of campylobacteriosis at a residential aged care facility in Queensland 2024 and review of previous *Campylobacter* spp. outbreak investigations in this setting

Prologue

Background

In October 2024, the Communicable Diseases Branch was made aware of a *Campylobacter* spp. cluster in an aged care facility. I was invited to participate in an outbreak investigation by the local public health unit as the outbreak control team (OCT) was being assembled. The OCT was being stood up following the notification of one confirmed and two symptomatic associated cases of campylobacteriosis in an aged care facility. The OCT consisted of local representatives from the public health unit from the nursing, environmental health, epidemiology, and medical streams, as well OzFoodNet Queensland and laboratory experts. I was invited to attend the meeting and provide the main epidemiological support for the outbreak investigation. My initial task was to collate the food histories from case questionnaires following site visit and provide the epidemiological summaries for subsequent meetings. I attended the facility for a site visit with the environmental team and helped conduct interviews for the catering staff, clinical managers and grounds and maintenance staff. I also assisted in the collection of the environmental swabs and their delivery to the laboratory. At the conclusion of the outbreak, I summarised the outbreak on behalf of the public health unit in the Queensland Health Notifications System (NoCS) and completed the OzFoodNet final outbreak report.

Lessons learned

This was my first experience in providing epidemiological support to an outbreak investigation. It provided me the opportunity to undertake a field inspection and assess the facility location, site layout and possible resident movements around the facility. This proved to be useful when providing the epidemiological summaries and consideration of possible transmission pathways. Providing the epidemiological summaries to the outbreak response team during the multi-disciplinary meeting gave me experience in presenting concise and clear summaries for an outbreak situation. As there was only a small number of confirmed cases the outbreak investigation utilised descriptive case series to generate exposure hypothesis. Had there been a higher number of cases detected this information could have been used for a case-control study to statistically test for risk factors.

Public health impact

Campylobacter spp. is the most common cause of gastrointestinal disease nationally and is known to be present in the environment in birds and poultry as well as raw meat products. While most cases recover, there is growing literature about longer term health effects

following infection. Gastrointestinal outbreaks in aged care facilities with a large cohort of susceptible people can cause a significant burden on individuals, the workplace and health system requiring prompt investigation and action. It can be difficult to identify a transmission pathway or food source for *Campylobacter* spp. outbreaks due to the nature of the organism.

This outbreak report follows the steps to the investigation and containment of a gastrointestinal outbreak in an aged care facility. Reviewing historical outbreaks of *Campylobacter* spp. in aged care facilities in Queensland helps contextualise this outbreak and describe the broader public health problem. It also highlights the complexity of an outbreak investigation and response where the transmission pathway cannot be confirmed, though the organism is known to be present on food and in the environment, drawing attention to further public health interventions to reduce the burden of campylobacteriosis, in aged care facilities and more widely in the community.

MAE competencies

This chapter met the following MAE competencies:

- Investigation of an acute public health event

Acknowledgments

Thanks to the Gold Coast Public Health Unit (GCPHU) team who invited me to become part of the outbreak control team for this investigation. I would like to thank the environmental health staff for allowing me to attend the site visit and interviews with them and Fiona May, epidemiology team leader at GCPHU, for her support. I would also like to acknowledge the OzFoodNetQLD team Russell Stafford, Robert Bell and Cameron Moffatt for sharing their vast expertise in *Campylobacter* spp. and related outbreaks.

Abstract

Background

To investigate an outbreak of campylobacteriosis in a residential aged care facility in Gold Coast Hospital and Health Service area, Queensland, in October 2024 and describe historical outbreaks of campylobacteriosis in residential aged care facilities in Queensland January 2005–December 2024.

Methods

We undertook a case series study of the outbreak in October 2024 using case interviews and food histories in addition to food and environmental sampling from the residential aged care facility. Notifications of campylobacteriosis in Queensland and nationally 1991–2024 were reviewed. Historical outbreaks of campylobacteriosis in residential aged care facilities in Queensland were described using aggregated summaries from OzFoodNet Queensland records.

Results

Five cases (four confirmed, one probable) were identified from the outbreak investigation at an aged care facility. Three of the five completed questionnaires and four provided food histories. A vehicle of transmission was unable to be determined. Queensland rates of campylobacteriosis are increasing in 2014 the five-year median (2010–2014) was 109 (per 100, 000 people per year) increasing to 158 in 2019 (2015–2019) and again to 174 in 2024 (2020–2024), a trend that has also been observed nationally. There have been eight outbreaks of Campylobacteriosis in residential aged care facilities in Queensland in the period 2005–2024. In all outbreaks no food vehicle was confirmed through laboratory testing of food samples, though through case interviews four were suspected to be foodborne.

Conclusion

No clear transmission pathway could be confirmed in this outbreak investigation. A review of eight previous outbreaks of campylobacteriosis in Queensland residential aged care facilities between 2005–2024 also found no source of infection. *Campylobacter* spp. are known to be in the food supply and increasing case numbers are attributed in part to the rising consumption of chicken. Consideration should be given to how consumers, industry, business and government can collectively reduce the individual and population health burden of *Campylobacter* spp.

Background

Campylobacter spp. species are bacteria that cause campylobacteriosis , a diarrheal disease in humans.[1] Though over 50 species have been identified, the most associated with human illness are *C. jejuni* and *C. coli.*[1,2] It is one of the main causes of human gastroenteritis globally, amplified in the intestines of warm-blooded mammals, it can be found in chicken, wild birds and livestock (pigs, sheep, cattle), as well as domestic pets such as dogs and cats[1,3] It is transmitted to humans through contact with animals or animal products, though the main route of transmission to humans is believed to be through the consumption of raw or under cooked meat, unpasteurised milk or untreated drinking water.[1,3,4] Person to person transmission via the faecal-oral route can occur.[5] *Campylobacter* spp. infection, the cause of over 95 million foodborne illnesses globally in 2010, has a considerable impact on the global burden of disease with increasing incidence and prevalence in both developed and developing countries.[5–7]

Poultry is believed to be the primary source of foodborne transmission with international studies identifying higher levels of *Campylobacter* spp. on poultry products compared to beef, lamb and pork.[1,3] A 2019 Australian study found *Campylobacter* spp. prevalence on retail chicken meat to be 90%, 84% and 96% in Queensland, New South Wales and Victoria, respectively.[3] The most common species varied by state, however in Queensland *C. jejuni* was prominent.[3] The bacterial load present on chicken meat varied by product. Higher levels of bacterial load were observed on whole bird samples compared with the drumstick, Maryland and wing samples.[3] Other studies have detected the presence of more than one strain in broiler flocks and on meat samples.[8–10] The various stages of farm to plate production may explain the diversity of strains present, with a number of opportunities for contamination including on the farm, slaughterhouse, processing plant or in food preparation.

The symptoms of campylobacteriosis usually begin two to five days following exposure though may be up to 10 days.[1] Those affected present with diarrhoea, nausea, vomiting, fever, and headache, with symptoms generally lasting three to six days.[1] Most cases are self-limiting, however, acute complications such as bacteraemia, hepatitis, pancreatitis or miscarriage can occur.[1,5] Longer lasting complications after infection have been reported and include irritable bowel syndrome, reactive arthritis, and Guillain-Barré syndrome.[1,5] Severe outcomes such as death are rare, but occur more commonly in the elderly, infants and those who are immunocompromised.[1,3,4,11] The virulence of each strain and their potential to cause disease in humans is still being explored. Molecular studies have indicated the presence of antimicrobial resistance in some strains.[12,13]

Campylobacteriosis is a notifiable condition in all Australian states and territories and is one of the most commonly notified conditions, with 38,714 notifications nationally in 2024.[14] In Queensland there were 9,021 notifications in 2024, with a crude incidence rate of 161 cases per 100,000 per year.[15] Generally cases occur sporadically, and outbreaks in Australia are considered uncommon.[4] However, it has been identified that there may be underreporting of campylobacteriosis with an estimated 10 community cases in Australia for every case notified.[3,5,16–18] Globally, reported outbreaks have been associated with consumption of raw milk, undercooked chicken liver and pâté, and contact with pet store puppies.[19–21] Foodborne outbreaks in Australia have been linked to food vehicles including raw peas, cheese, chicken liver pâté, custard, tuna salad and cucumber, many of which were associated with cross contamination.[22] The burden of *Campylobacter* spp. in Australia nationally is estimated to be approximately US$110 million annually.[23]

In Australia, residential aged care facilities have been identified as a common setting of reported campylobacteriosis outbreaks.[4] A 2020 review of *Campylobacter* spp. related outbreaks from 2001 to 2016 reported one quarter (22/84) of outbreak-associated cases occurred in aged care facilities.[4] This was often without identification of mode or vehicle of transmission.[4] This degree of representation may be due to well established guidelines for reporting gastroenteritis in aged care facilities.[4,24]

Campylobacter spp. are sensitive to stressors in the environment such as temperature, availability of water and oxygen.[22,25] The bacteria will usually grow at 30–45°C and, under moist conditions, may survive in temperatures as low as 4°C.[22] *Campylobacter* spp. bacteria are usually inactivated by heat when cooking and the process of pasteurisation and do not survive on dry surfaces with varying degrees of oxygen tolerance.[22,25] The isolation of *Campylobacter* spp. in the environment or from food items during an outbreak is difficult and outbreak investigations often rely on descriptive epidemiological methods as the primary source of intelligence.[4]

On 8 October 2024 the Gold Coast Public Health Unit (GCPHU) was notified via email from an aged care facility of a single case of campylobacteriosis in a resident, and another two symptomatic residents with tests pending. Queensland public health legislation and Department of Health, Disability and Ageing's resources such as *Outbreak coordinator's handbook gastroenteritis kit for aged care* outline that notification must be made where there are two or more associated cases of gastroenteritis.[26] Following the notification, an outbreak control team was assembled to undertake further investigation.

Methods

We undertook a case series investigation of campylobacteriosis associated with the same aged care facility in the period 2 October 2024 to 23 October 2024 in Queensland. Descriptive analysis of the outbreak was performed using variables for case demographics, including age, sex, block of residence, case type (staff/resident), food histories (as described below), clinical symptom type, symptom onset, duration of symptoms, hospitalisation, and laboratory test type and results. Food history data were taken using Queensland Health's *Campylobacter* spp. hypothesis generating questionnaire.

Notification case counts and rates per 100,000 per year between 1990–2024 for Queensland and Australia were extracted from the National Notifiable Disease Surveillance System (rates reported by the National Notifiable Disease Surveillance System using Australian Bureau of Statistics population data[27]).

Notifications from the Queensland Notifiable Conditions System (NoCS) were extracted for Gold Coast Hospital and Health Service for the period 1 January 2023 to 31 December 2024 to compare number of notifications by epidemiological week.

An aggregated summary of *Campylobacter* spp. outbreaks in aged care facilities for the period 1 January 2005 to 31 December 2024 (from OzFoodNet Queensland/Public Health Intelligence Branch) was reviewed to describe number of outbreaks by year, outbreak length in days (calculated by date of onset of first case to date of onset of last case), demographics, clinical symptoms and food and environmental findings to identify possible transmission pathways.

Case Definitions

Case definitions for the outbreak were developed using the Communicable Disease Network Australia national guidelines and in consultation with the outbreak control team, including laboratory team members.[14]

Outbreak cases were identified as having an onset of symptoms between 2 October (onset symptoms of first case) and 23 October as below:

Confirmed case: Resident or staff member of the residential aged care facility (RACF) with isolation of *Campylobacter* spp. OR nucleic acid amplification test (NAAT) detection of *Campylobacter* spp.

Probable case: Resident or staff member of the RACF with clinically compatible symptoms of campylobacteriosis without laboratory evidence (e.g. does not meet exclusion criteria identification of another pathogen or no attendance to RACF over possible exposure period or confirmation criteria, as described in *confirmed case*).

Case interviews and food histories

Case interviews including food histories were undertaken using menu records and face-to-face interviews with catering staff (who have access to the menu selections of residents) and three confirmed cases. Food items for the five days prior to onset of symptoms were collated and reviewed for commonly consumed food items. Demographics of cases were recorded. Information regarding health history was provided by clinical staff and confirmed with the case where able.

The outbreak was declared over when there were no further cases seven days after the symptom onset of the last case, with no further cases detected. The incubation period for *Campylobacter* spp. is typically two to five days but can range from one to ten days.

Environmental assessment

Interviews with catering staff about practices and procedures in the kitchen, when serving food as well as identifying wholesale providers were conducted. The grounds person was also interviewed regarding water used, gardens and wild bird activity at the facility.

Environmental swabs were taken from the kitchen and food preparation area. No food samples were taken at the initial environmental health visit. Samples of the raw chicken received from the same wholesale provider were taken on a subsequent visit to assess the *Campylobacter* spp. present and if there was any match with the isolates from the cases.

Animals

The facility staff and resident cases were asked during the interviews if there were any animals that visited the facility.

Laboratory testing

Faecal samples from probable cases were sent by the facility to a private pathology service for testing by NAAT-PCR and then to the Queensland Health Public and Environmental Health Reference Laboratories (PEHRL) for isolation of *Campylobacter* spp. and whole

genome sequencing where isolated. Food samples collected were sent to PEHRL for isolation and whole genome sequencing.

Infection control measures in outbreak response

The local public health team discussed infection control and prevention guidelines with the facility.

Ethics

The investigation was carried out under the provisions of the Queensland Public Health Act *2005* and the study approved by Australian National University Human Research Ethics Committee in accordance with the waiver HREC 2019/200 [28].

Results

Demographics

There were five cases in this *Campylobacter* spp. outbreak at the residential aged care facility, four confirmed cases and one probable case (Table 2.1). The median age of all cases was 83 years, with one male and four females. All confirmed cases were residents of the facility. The probable case was a staff member who had clinical symptoms during the outbreak period, who met the inclusion criteria due to attendance of the facility during the period however there was no sample available for laboratory testing.

Table 2.1: Demographics of cases in *Campylobacter* spp. outbreak investigation in an aged care facility, 2024 in Queensland.

Status	**N (%)**	
Residents		4 (80%)
Staff		1* (20%)
Total		**5 (100%)**
Age		
Residents	Median (years)	87
	Range (years)	79–94
Staff	Age group (years)	30–40
Sex	**N (%)**	
Male		1 (20%)
Female		4 (80%)
Total		**5 (100%)**
Location of residence*	**N (%)**	
Block 1		1 (25%)
Block 2		2 (50%)
Block 3		1 (25%)
Total		**4 (100%)**

*Probable case, **resident cases only

The onset of symptoms for the first case identified was on 2 October and the last case on 16 October 2024 (**Table 2.2**). The facility has six different blocks that house residents. Resident cases were identified in three of six areas, only one area had two cases, and two other blocks had one each (Table 2.1). The outbreak was declared over on 23 October, seven days after symptom onset of last identified case, with no further cases detected.

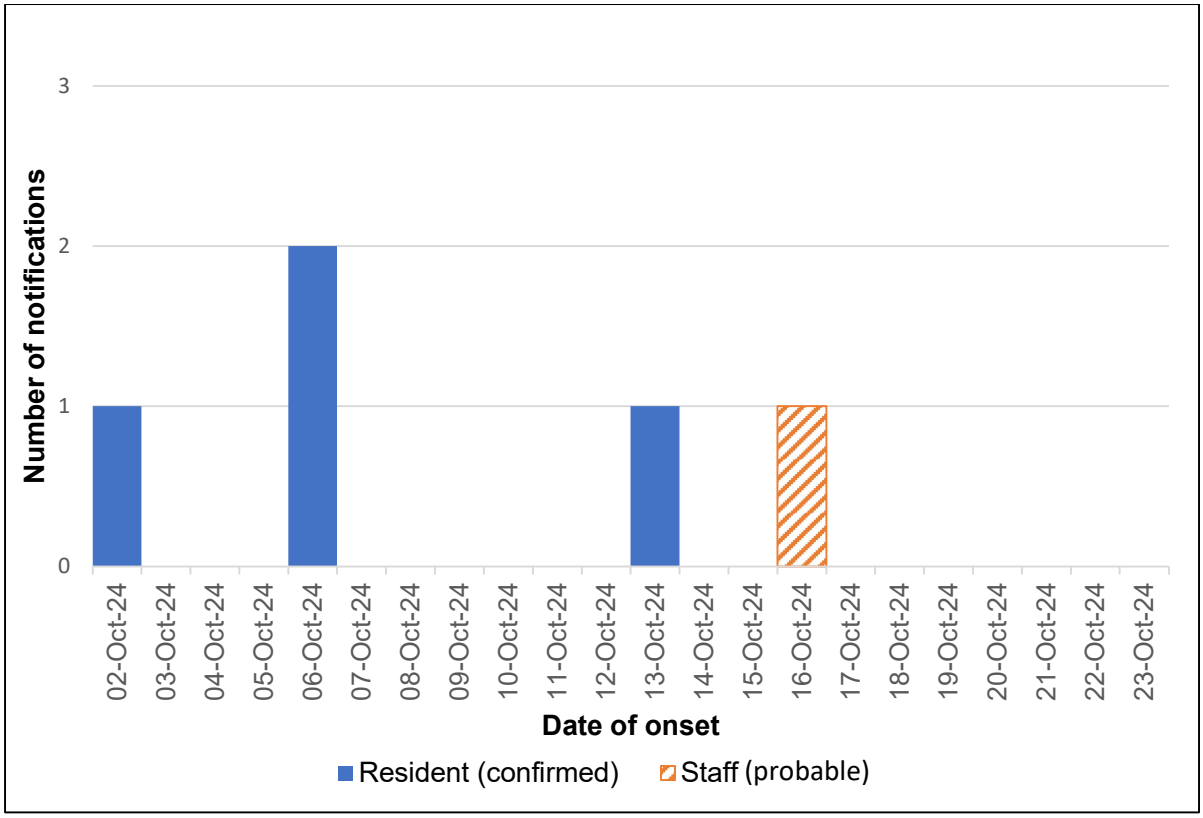

Table 2.2: Cases by onset date for outbreak of *Campylobacter* spp. in a residential aged care facility, 2024

Hospitalisations

There were no hospitalisations associated with this outbreak. One case attended the emergency department for symptoms however was discharged the same day.

Food histories

All four confirmed cases reported consuming chicken-containing meals in the five days prior Commonly reported food items from available food histories are presented (**Table 2.3**). All four confirmed cases report consuming chicken dishes in the five days prior to onset of symptoms. Other common foods eaten by two or three of the cases were eggs, sandwiches, fish and chips and roast pork. Most cases consumed food prepared by the RACF kitchen, however, two cases live independently in the facility and were able to access other foods. No food history was available for the probable case.

Table 2.3: Food items identified by confirmed cases before symptom onset in the outbreak investigation, *Campylobacter* spp. in an aged care facility, 2024

Food items*	Case 1	Case 2	Case 3	Case 4
Chicken	●	●	●	●
Eggs	●	●	●	
Cheese sandwich	●	●	●	
Fish and Chips		●	●	●
Roast pork			●	●

**Food items shown were not necessarily consumed on the same day or as part of the same meal*

Environmental health

Environmental health officers reported kitchen practices at the facility were satisfactory. Environmental health team members provided additional recommendations to the catering staff regarding storage, cleaning and separating preparation areas.

The aged care facility is situated alongside a canal, with water birds, including ducks, known to be present at the facility. At the site visit, the ground staff reported that there were areas where residents routinely feed the birds. However, no cases reported direct contact with birds or bird droppings. Staff at the facility confirmed that there have been no pet therapy visits at the facility for six months.

The local public health team discussed infection control and prevention guidelines with the facility staff and all cases reported to be appropriately isolated. A line list of symptomatic residents and staff was maintained by the facility in accordance with outbreak response procedures.

Laboratory findings

Laboratory confirmation was available for four of five cases, two of the four were detected by NAAT-PCR only and the other two were detected by PCR and *C. jejun* was isolated. No testing was performed on the probable case. *Campylobacter* spp. was not detected on food samples collected from the facility on 17 October 2024 (pork, sausage, vegetables, gravy, pasta, pre-cooked chicken). *Campylobacter* spp. was detected on food samples of raw chicken collected on 22 October 2024 (n=3).

Whole genome sequencing showed the two patient isolates belonging to different sequence types from each other (ST-190 and ST-50), while food isolates (n=3) belonged to a third sequence type (ST-48) indicating no close genomic similarity between the case and food isolates or shared sequence type among patient isolates (**Table 2.4**)

Table 2.4). While the number of case and food isolates available was limited, this suggested that the sampled chicken was not the source and that multiple strains were involved in the outbreak.

Table 2.4: Genotypic results of samples where C. *jejuni* was isolated in outbreak investigation

Sample type	MLST-ST (multilocus sequence typing - sequence type)
Clinical (Case 1)	190
Clinical (Case 4)	50
Food (chicken)	48

Campylobacteriosis in Queensland

The notification rate for *Campylobacter* spp. in Queensland (**Table 2.5**) has steadily increased over the period 1991–2005 from 93 per 100,000 persons per year to 165 per 100,000 persons per year, though is slightly lower than the peak year, 2021 (181 per 100,000 persons per year). The notification rate nationally has followed a similar trend. The introduction of culture independent diagnostic testing using multiplex PCR in Queensland laboratories from late 2013 onwards resulted in increased detection of *Campylobacter* spp..[29] A Queensland study examining the period 2010–2014 found that among specimens by both PCR and culture, 36% of *Campylobacter* spp. positive stools were PCR positive only, with no isolate available.[29] This has implications for outbreak investigations and WGS because fewer notified cases have isolates available for analysis.

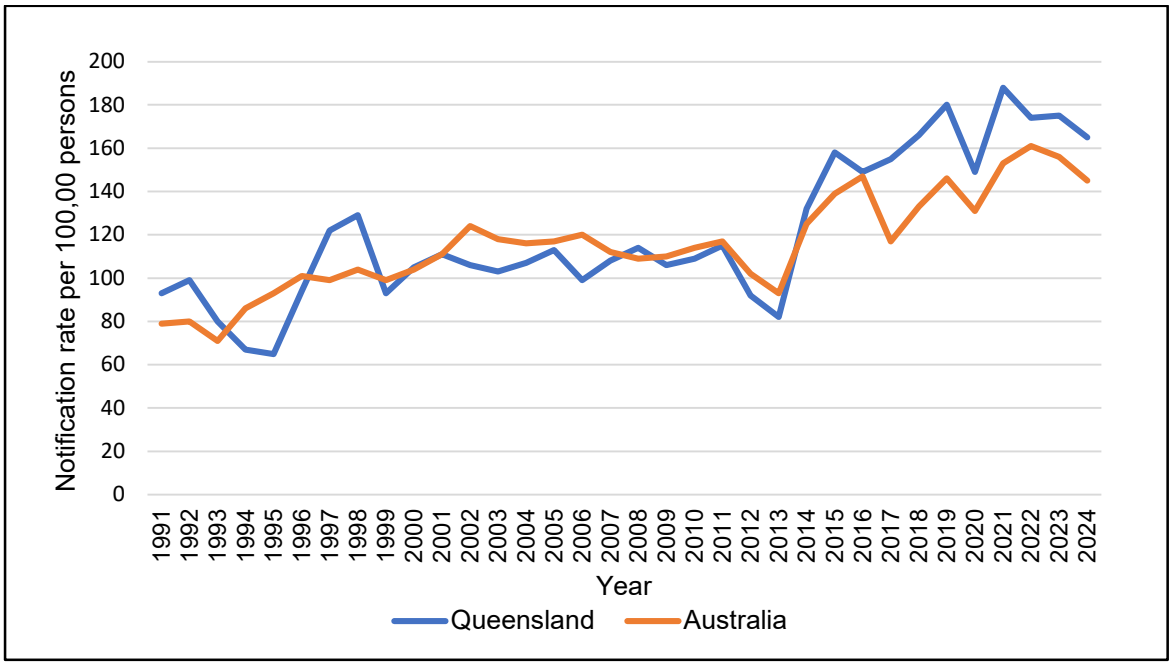

Table 2.5: Incidence rate of *Campylobacter* spp. notifications by year in Queensland and Australia1991–2024

Table 2.6 demonstrates that there was a slight trend upwards in the two weekly average number of *Campylobacter* spp. notifications in the Gold Coast Hospital and Health Service in epidemiological week 34 to week 38 (8.5 to 18), but less than the 2 weekly average numbers in the first half of 2024 and follows a similar trend for the same period in 2023.

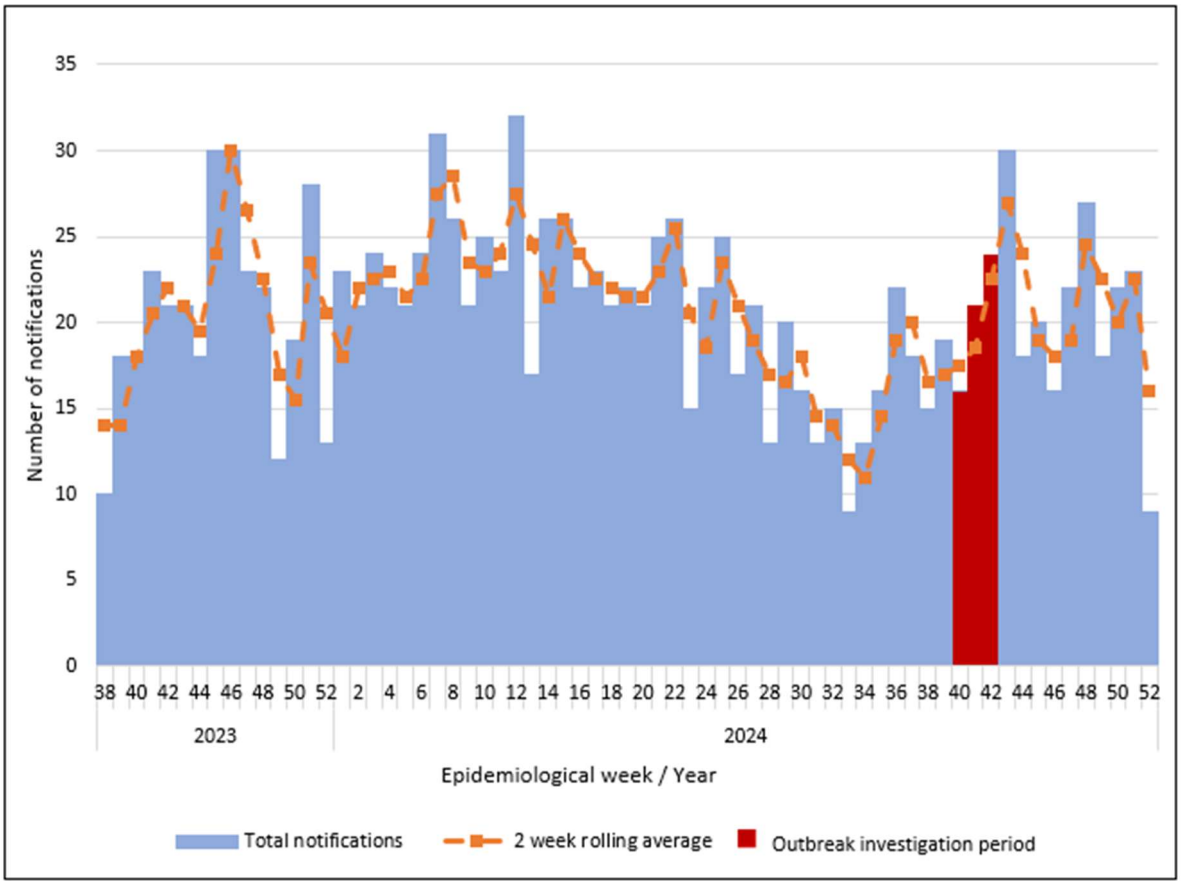

Table 2.6: Number of *Campylobacter* spp. notifications by epidemiological week / year and two-week rolling average for Gold Coast Hospital and Health Service week 38 2023–week 52 2024

Campylobacter spp. outbreaks in Residential Aged Care Facilities in Queensland 2005–2024

In the period 2005 to 2024 there have been eight outbreaks of *Campylobacter* spp. reported in aged care facilities in Queensland. Most years had either none or one outbreak of *Campylobacter* spp. reported across this period, except 2010 when three outbreaks occurred. Outbreak duration ranged from 1–12 days with a median of 7 days. The total number of cases in these outbreaks combined was 75 cases. The median number of cases in each outbreak was 8.5 (range 3–23 cases). The median number of laboratory-confirmed

cases in each was 3.5, range 1–9 cases. The median age of cases for each outbreak where recorded ranged from 81–94 years (missing=4). The percentage of females affected ranged from 70–100%. Of the symptoms featured in reported outbreaks, diarrhoea was recorded for all, none reported bloody diarrhoea. In two of the eight outbreaks, symptoms of fever, nausea, abdominal pain, and vomiting in addition to diarrhoea, were features. Of the 75 cases in all outbreaks combined, 1 case died and 2 cases were hospitalised.

In four of the eight outbreaks, foodborne transmission was suspected, while for the remainder the mode of transmission was unknown. No food vehicle was identified via laboratory testing of food samples (where taken, n=4). Summaries of the outbreak investigations indicated that in four outbreaks chicken was consumed prior to onset (period not defined in aggregated summary). The remaining four outbreaks did not report any commonly identified foods. Three outbreaks report possible cross contamination risks via benchtops, washing of raw chicken or blenders used to puree food for residents. There was no identification of *Campylobacter* spp. in environmental testing where swabs were taken from locations including kitchen benches and food preparation areas (5 of 8). Four of the eight also reported either animals onsite or having animals (pet therapy) visit the facility. A summary of possible transmission pathways identified in the outbreak investigations described above is provided in Table 2.7**: Possible transmission pathways identified in *Campylobacter* spp. outbreak investigations in residential aged care facilities 2005–2024 in Queensland.**.

Table 2.7: Possible transmission pathways identified in *Campylobacter* spp. outbreak investigations in residential aged care facilities 2005–2024 in Queensland.

Possible transmission pathways identified*	Outbreak investigations n=8	(%)
Chicken consumption	4	50
Cross contamination	3	38
Animals onsite	4	50

*More than one possible transmission pathway identified in some outbreaks

Discussion

In this case series and outbreak investigation of *Campylobacter* spp. cases in an urban aged-care facility in Queensland we were unable to identify the source or mode of transmission. Failing to find a mode of transmission is not uncommon with *Campylobacter* spp. outbreaks, and is consistent with previous outbreaks in aged care facilities in Queensland and nationally.[4]

Environmental testing in the kitchen and food preparation areas in the outbreak yielded negative results. This is also a feature of the previous eight outbreaks in RACFs reported in Queensland. This is unsurprising due to the nature of the pathogen. *Campylobacter* spp. is readily inactivated by heat, do not survive on dry surfaces, have poor oxygen tolerance and have potentially longer incubation periods (up to 10 days), while outbreak investigations typically rely on descriptive evidence.[4,22]

Food samples of raw chicken taken from a delivery from the supplier after the outbreak had commenced isolated *Campylobacter* spp. When these isolates were sequenced, the MLST-ST (ST 48) showed no similarity to the *Campylobacter* spp. isolates from the two outbreak cases (Case 1 and Case 4). These food isolates were not genomically similar to the patient isolates, and the two patient isolates were also not the same sequence type as each other. Whilst both cases consumed common high risk food items in the days preceding onset, their symptom onset was 11 days apart. The small number of isolates and knowledge that food items can be colonised with more than one *Campylobacter* spp. sequence type make the interpretation of whole genome sequencing in this and similar outbreaks challenging. Even in larger outbreaks, this complexity persists, an Australian university outbreak of 56 confirmed cases linked to chicken liver pate, identified two distinct *C. jejuni* strains among cases and *C. coli* in the leftover pate, with negative environmental swabs of the kitchen area, demonstrating the diversity that can exist within a single food item.[30] Interrogation of the PubMLST database indicates that ST-48 has been associated with sporadic and outbreak human cases, chicken meat or offal and chicken and cattle globally, ST-50 with sporadic and outbreak cases, chicken meat or offal, beef/lamb/offal, cattle, chicken, cow's milk and potable drinking water, wild birds, and broiler environments globally, and ST-190 with human sporadic cases, chicken meat/offal, sheep faeces, cattle faeces, and broiler environments in the United Kingdom, New Zealand, Israel and Australia.[31] Nevertheless, sequencing information in outbreaks with higher numbers may assist in understanding the complex nature of transmission as it has in other food-borne diseases such as salmonellosis.[32]

The pattern of cases implies that transmission is likely to be intermittent rather than point source, with one main cluster toward the start of the outbreak (3 confirmed cases). As with all outbreaks, there may be some mild or asymptomatic cases that were missed, and some positive cases may be due to the presence of long-term colonisation in humans.[33–35] Further research into carriage in the aged care setting may be of value when interpreting outbreak data and planning responses and risk assessments in this setting.

In Australia, consumption of chicken meat and contact with domestic animals (dogs and chickens) are identified as risk factors for *Campylobacter spp*. infection with proton pump inhibitor use also associated with an increased risk .[23] All cases in the outbreak investigation consumed chicken, though this was across different days, and different deliveries from the same supplier. A recent Australian case-control study involving 571 cases and 586 controls recruited over three different regions, incorporated epidemiology and genomic sequencing and modelling to identify risk factors.[17,23] The study found that eating cooked chicken in the seven days prior to illness accounted for 30% of the cases.[17,23] A limitation of this outbreak investigation is that individual-level information on medication use, including proton pump inhibitors or relevant medical history that may increase susceptibility to infection was not collected. This information was also not available for the aggregated Queensland aged care outbreak summary data. Thus, assessment of the contribution of these variables to this outbreak is limited.

Aged care facilities combine several factors that potentially increase the risk of *Campylobacter* spp. clusters. Centralised food preparation may lead to multiple residents and staff being exposed over a short period of time, as the preparation of large volumes of food in one location creates multiple opportunities for cross-contamination (for example, through ingredients, equipment and staff handling). This may make it more difficult to identify a potential food source in an outbreak. Exposure to individual pets or pet therapy and comfort animals may also be a factor. Contact with animals was not identified to be a factor in this outbreak. The concept of animal assisted interventions has emerged as a popular adjunctive intervention in holistic patient care.[36,37] Though transmission of diseases may occur from animal to human directly or indirectly person-to person by shared contact with animals (e.g. petting by multiple individuals), risks for this setting have not been extensively studied. The Australasian College of Infection Prevention and Control provides recommendations for animal therapy in health care facilities, including making attempts to reduce exposure in vulnerable people, ensuring the availability of handwashing stations and the recording of animal visits for contact tracing purposes.[37,38]

The proportion of females was higher than males in the outbreak described and in the *Campylobacter* spp. outbreaks in RACFs in Queensland dataset. This is in contrast to a study of national data for seven countries which showed that in all age groups incidence rates are consistently higher in males.[39] This may be explained by the Australian Institute of Health and Wellbeing data that show the number of women ≥65 years in permanent residential aged care is double the number of men.[40]

In enteric (and other disease) surveillance, hospitalisation and death are indicators of disease severity. There were no hospitalisations in this outbreak. Hospitalisation rates vary globally, possibly impacted by surveillance, access to care and, estimates of underreporting.[41] An Australian study undertaken by Moffatt et al. linking campylobacteriosis hospital discharge data to surveillance data in the Australian Capital Territory reported a 14% hospitalisation rate for campylobacteriosis in the period 2004–2013.[41] It was also reported that only 52% of hospitalised cases had the correct International Classification of Diseases (ICD) coding, with similar findings observed in the US and Sweden [41]. Moreover, Moffatt et al. identified that incomplete surveillance records highlight the limitations in using either of these data collection points as an indicator for morbidity.[41] This suggests that using hospitalisations as a measure of morbidity may not be representative. Other long-term complications such as inflammatory bowel disease, Guillain Barré syndrome and, reactive arthritis have also been associated with campylobacteriosis .[42–44] These outcomes are not captured in routine enteric surveillance but may contribute to health burden and healthcare associated costs.

Australia's consumption of chicken has increased over the last 30 years, and Australia is one of the top 10 chicken consumers globally.[45] While *Campylobacter* spp. can be colonised in other foods of animal origin such as beef or pork, differences in processing techniques have been attributed to the lower prevalence on these compared with poultry meat.[18] Many public health interventions related to foodborne illness are targeted at improved hygiene practices and regulations at the end of the supply chain where food is prepared, such as food handlers and individuals. While these are important public health considerations, accountability for food safety should be shared between consumers, businesses, industry, and government. Directing all interventions at retailers and individual consumers may not be effective in reducing risk and subsequent cases when products, particularly poultry meat, are known to be contaminated with *Campylobacter* spp.

New Zealand introduced regulations progressively over 2005–2007 relating to the farming and processing of poultry in response to a significant and sustained increase in campylobacteriosis cases from 1980–2005.[46] The interventions focus on farm biosecurity, strict cleaning and disinfection of farm and transport equipment and, mandatory microbiological testing at processing plants. This resulted in the human *Campylobacter* spp. notification rate halving between 2006–2020. The notification rate of campylobacteriosis in New Zealand fell from over 380 cases per 100,000 persons in 2006 to 116 cases per 100,000 in 2023. Reducing foodborne illness related to *Campylobacter* spp. has been recognised as a priority in Australia's Foodborne Illness Reduction Strategy (2018–2021).[47]

As part of this strategy, a Campylobacter attribution study was completed and new poultry production hygiene criteria were implemented.[48] The features or outcomes of this are not available, however a small downward trend in the incidence campylobacteriosis between 2022 to 2024 has been observed, although the significance of this remains uncertain

In this outbreak we were unable to determine the mode of transmission. While foodborne transmission is reported to be the most common mode of acquisition for *Campylobacter spp*., isolation of the pathogen in food or the environment during outbreaks is difficult due to the nature of the organism. This is a feature of most campylobacteriosis outbreaks in aged care settings. Future areas of research identified for this cohort may include carriage and asymptomatic infection, the use of animal therapy and longer-term health complications and their impact on quality of life and the health system. Conversely, more is known about the presence of *Campylobacter* spp. on raw poultry products. As seen in New Zealand, stringent implementation of poultry production and processing controls can be effective in dramatically reducing community-wide risk. The impact of recent implementation of control mechanisms as part of Australia's Foodborne Illness Reduction Strategy should be closely monitored. Given the high levels of both chicken consumption in Australia and rates of campylobacteriosis in our community, there is considerable scope for reducing disease.

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Chapter 3: Pertussis on the Rise: Descriptive Epidemiological Analysis, Queensland 2024

Prologue

Background

During 2024 there was a rising trend of pertussis cases. Early in the year, approximately April, my supervisor mentioned that this would be an interesting topic for a project. At this time the rise in cases was predominantly in South East Queensland. With my field supervisor's direction an early output of this project was to write a clinical alert about rising pertussis rates in the form of a letter to the editor in the Medical Journal of Australia.

As I worked through this project, pertussis cases continued to rise, concluding 2024 with the highest number of annual cases since modern surveillance commenced in Queensland. There were several interesting aspects to this analysis: case counts and rates; location; vaccination coverage; laboratory testing; and hospitalisation data. The outbreak was described relative to the previous peak in 2011, and the median was used as the summary measure, because pertussis notifications were unusually low during the COVID-19 pandemic period and would have disproportionately reduced the mean. Through this work, I also had the opportunity to collaborate with the National Centre for Immunisation and Research Surveillance (NCIRS) on a national pertussis surveillance project.

My role

For this project I reviewed the relevant literature and developed the research protocol in consultation with my supervisors. I prepared and coordinated the ethics, governance approvals, and relevant data requests (and subsequent amendments). I performed the data cleaning and data analysis, developing the Stata commands for analysis and equivalent R code for analysis and mapping by locations (Hospital and Health Service area). I extracted and analysed the public laboratory testing data from the Pathology Queensland's database, AUSLAB, and reviewed previous publications for comparison. Finally, I prepared the chapter as a draft manuscript in line with author requirements for a research article from the journal Vaccine.

MAE Competencies

This chapter met the following MAE competencies:

- Analysis of a public health dataset
- Advanced draft for peer reviewed publication

- Conference presentation (**Appendix 1 : Conference presentation**)

Lessons learned

This study enabled me to review topics such as vaccine impact, priority age groups and vaccination coverage. There were similar trends in rising pertussis cases occurring in the United Kingdom and Europe; this gave me the opportunity consider international similarities and differences. I gained invaluable experience in developing the research protocol for submission to the Human Research Ethics Committee (HREC), applying for a waiver of consent, ethics submission and subsequent amendments.

I increased my proficiency in both Stata and R considerably during this project. Initially writing the Stata do file then translating this to an R script. I found that the process (for both Stata and R) was greatly improved as my level of understanding of the data, data analysis and epidemiological concepts progressed through the program. This highlighted to me that the statistical program is the tool but having the concepts and understanding to apply them are key. I believe this is an important lesson for me to remember when teaching epidemiology practices and using tools such as R or Stata.

I had experience in developing an important clinical message quickly within the guidelines of a medical journal using publicly available data. Knowledge of the process of submission was gained through this letter to the editor and later through the preparing a manuscript in line with author guidelines. I had the opportunity to present my findings at the Communicable Disease and Immunisation Conference in Adelaide, June 2025 in a vaccine preventable diseases session.

Public health impact

As pertussis had a huge resurgence in 2024, both in Australia and internationally, this data analysis contributes to our understanding the increase in this condition in Queensland. The descriptive epidemiology provides important insights to policy makers for informing health promotion activities particularly around vaccine coverage for maternal pertussis vaccination and confirmation that the childhood and adolescent boosters have important roles in disease control. With knowledge of waning immunity related to acellular vaccines, the project also generates further discussion about pertussis containing vaccines and future vaccine research.

The impact of the COVID-19 pandemic restrictions on pertussis cases in 2020–2022 is evident. As with many respiratory conditions, the non-pharmaceutical interventions likely affected the transmission of pertussis during this time. This project highlights the epidemiology in the period following this disruption of transmission. My outcomes also demonstrate the impact of laboratory testing on disease surveillance activities and the value of acknowledging this when considering public health interventions. These lessons should extend to improving our understanding of future pertussis epidemics. In addition, presentation of this this project at a national public health conference allowed me to disseminate findings widely and discuss trends with other public health professionals.

Finally, the epidemiological findings in this project support contemporary public health response to pertussis in Australia; with maternal immunisation, infants younger than six months of age remained protected despite record case numbers and that school-aged children likely drove transmission. Improving education and coverage around the maternal pertussis vaccine remain key to minimising serious outcome for outcomes in infants, the most venlernable population.

Acknowledgements

I would like firstly to acknowledge the contributions of all the public health unit and public health laboratory staff who followed up and processed testing for the record number of pertussis cases in 2024. The enhanced surveillance information and laboratory testing data provided a more complete understanding of this condition and dataset. I would also like to acknowledge Mohana Rajmokan, Advanced Epidemiologist with the Epidemiology and Research Unit in Queensland Health: her quiet and continued guidance and support through this (and several other vaccine preventable disease related projects) was invaluable. Thank you to my supervisors Emma Field, who pushed me when I needed, and Stephen Lambert who shared his vast knowledge and experience in vaccine preventable diseases.

Intended Journal

Prepared in accordance with the author guidelines for an original research article for *Vaccine*.

Title

Pertussis on the Rise: Descriptive Epidemiological Analysis, Queensland 2024

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Word Count

Abstract: 275 (limit 300)
Main body: 3748 (limit 5000)
Tables/ Figures: 7 (limit 10)

Abstract

Background

A dramatic rise in pertussis cases was observed globally in 2023–2024. Using surveillance data, we describe the epidemiology of pertussis in Queensland in 2024 and identify those most at risk to inform public health action for management and prevention.

Methods

We extracted pertussis notifications of Queensland residents from 1991 to 2024, inclusive. Case counts and rates in 2024, overall and in specific age-groups, were compared with the 10-year median incidence rates (2014–2023) and 2011 (previous annual peak). Infants aged <6 months were analysed by maternal vaccination status. Queensland public laboratory testing data were extracted, with test type, result and age group explored for trends.

Results

The total number of notified pertussis cases for 2024 in Queensland, 14,957, was almost 11 times higher than the 10-year median (1,372 cases/year). Age-specific incidence rates in 2024 were observed to peak at age 11 years (2,113/100,000 persons/year). The incidence rate for infants aged <6 months was 53% and 62% lower than the 5–9 year and 10–14-year-old age groups, respectively. Maternal vaccination was given in pregnancy for 50% of notified cases aged <6 months. Laboratory testing trends showed increased testing overall in 2024 compared to previous years.

Conclusion

We found total and age-group specific notification rates aligned with what is known about pertussis in the vaccine era, the vaccination schedule and waning immunity. Despite unprecedented case numbers overall in 2024, rates in infants were lower than older children and adolescents, and similar when compared with rates in the previous peak year 2011. The protective benefit of maternal vaccination for infants aged <6 months and of the adolescent booster reinforce the value of interventions to increase the pertussis vaccination coverage.

Keywords: *Bordetella pertussis*, maternal immunisation, vaccine- preventable disease, disease surveillance, Queensland, Australia.

Background

Pertussis, commonly known as whooping cough, a respiratory infection caused by the bacterium *Bordetella pertussis* remains an important public health concern.[1] Infection often clinically presents as a prolonged cough, gradually becoming paroxysmal, characterised by a 'whoop', a high-pitched inspiratory stridor and post-tussive vomiting. Transmitted person-to-person via respiratory droplets, it is highly infectious.[1] Infants younger than six months of age are at greatest risk of severe infection and account for the majority of hospitalisations and deaths.[1–3] Humans are the only reservoir for *Bordetella pertussis* with adults and adolescents often the source of infection for infants.[3] Immunity following natural infection or vaccination is not lifelong, with frequent disease outbreaks and epidemics occurring in highly vaccinated populations.[2] In Australia, epidemics are usually observed every 3–4 years.[1]

Although pertussis epidemics have occurred regularly over time, the resurgence of pertussis notifications in recent years is believed to be partially attributed to waning antibodies associated with acellular vaccines, producing gaps in immunity for particular age cohorts.[2,4] Prior to the acellular vaccine, whole cell vaccines were widely used. Both whole-cell and acellular vaccines have contributed to reduced morbidity and mortality. However, there was reported variability in effectiveness and increased adverse reactions associated with the whole cell vaccine when compared to the acellular vaccine.[2,5,6] This resulted in many developed countries adopting the acellular vaccine into their funded programs.[2,5,6] Observational studies have shown reduced protection against subsequent pertussis infection in children who received acellular vaccines as their primary course in childhood, making these individuals more susceptible to infection in adolescence and later in life.[5]

Australian infants younger than one year of age receive a primary course of acellular pertussis vaccine at two, four and six months.[1] This is followed by funded booster doses at 18 months (introduced in 2016), four years, and 12–13 years (equivalent to school year seven).[1] To protect infants too young to be immunised, pertussis vaccination in pregnancy has been recommended in Australia since March 2015, following similar programs in the United Kingdom and United States.[1,7,8] In Queensland, a pertussis vaccination was introduced for administration in the third trimester of pregnancy from 2014, prior to this (2009–2012) pertussis vaccination was funded for parents and caregivers of children <6 months under a cocoon strategy.[9]

Vaccination during pregnancy induces an immune response for the mother resulting in transference of anti-*B. pertussis* antibodies across the placenta and via the breast milk.[1,10] The vaccine is safe and if given early in the third trimester is highly effective in reducing the rate of pertussis infection, hospitalisation and mortality for infants up to <2–3 months of age (vaccine effectiveness 69–90%).[1,10,11] A large Australian cohort study consisting of 279,418 mother-infant pairs demonstrated a lower risk of pertussis infection up to 8 months of age when vaccine was administered around 28–32 weeks gestation.[11] The current Australian recommendation is for vaccination in pregnancy to occur between 20–32 weeks gestation.[1] There has been some concern that reduced boosting of anti-*B. pertussis* antibody concentrations during the child's primary course may be observed in infants whose mothers received vaccine during pregnancy, referred to as "blunting" or "interference".[10,11] This effect does not appear to be clinically meaningful and has not been shown to significantly increase risk of disease before the 18-month booster.[10,11]

During the global COVID-19 pandemic many jurisdictions observed fewer notifications of infectious diseases, including respiratory diseases.[12,13] This reduction has been attributed to a range of factors: public health interventions implemented to stop the spread of COVID-19, changes in health seeking behaviours and changes in testing capacity and surveillance during this time.[3,14] The COVID-19 pandemic and related public health interventions also brought to light the influence of social media, misinformation, vaccine hesitancy, autonomy and government distrust.[2] While vaccine hesitancy and misinformation existed in the pre-COVID-19 era for vaccines such as for polio and measles, mumps and rubella, it was observed that many people turned to social media platforms for vaccine information during the pandemic, creating both opportunities and challanges.[14–16]

A steady rise in pertussis cases, a global public health concern, was observed nationally towards the end of 2023 and notification rates increased more rapidly in 2024. The rise nationally started with a substantial increase in notifications in New South Wales and Queensland and later, Victoria. Similar trends were also seen globally in the United Kingdom, Europe and the United States.[17–19] For this investigation we used pertussis notification and laboratory testing data to gain insights into the current pertussis epidemiology in Queensland with a focus on 2024, the most recent epidemic year.

Methods

This is a case series study of all confirmed and probable pertussis cases as per the Communicable Diseases Network Australia (CDNA) case definition in Queensland from 1 January 2024 to 31 December 2024.[3] Queensland notification data from the Queensland Notifiable Conditions System (NoCS) since 1 January 1991 were used for comparative analysis. Pathology Queensland AUSLAB laboratory testing data, covering public laboratories around the state, were extracted for 2024 and used to review location, age, test type, number of total tests, and results to report testing numbers and calculate PCR test positivity overall and by age group. This was validated with publicly available information from private pathology provider Sullivan and Nicolaides' online infectious disease reports for pertussis.[20] Sullivan and Nicolaides operate private laboratories in Queensland and northern New South Wales with 20 of the 22 total laboratories (including the central laboratory) located in Queensland.[21]

Vaccination coverage was obtained through published data from the Australian Government Department of Health, Disability and Aging, the National Centre for Immunisation Research and Surveillance (NCIRS) and Queensland Health. The estimated residential population values were obtained from the Queensland Health Statistical Services Branch (derived from Australian Bureau of Statistics estimates ASGS2021 edition 3) to calculate population specific rates for age, First Nations status and Hospital and Health Services (HHS). The variables sex, date of birth, First Nations status, location (Hospital and Health Service), episode date, died of condition, outcome, hospitalised, maternal vaccination status, maternal vaccination date, case vaccination dose number, case vaccination dose date and case notes were extracted from NoCS. The variables for age (weeks, months and years) were created using date of birth and episode date and vaccination date (case and/or maternal) and episode date were used the variable for time between vaccination and episode of pertussis

Queensland pertussis case counts, proportions, and incidence rates over the period 1 January 2024 to 31 December 2024 were calculated and analysed by age, age group, sex, First Nations status, Hospital and Health Service area, confirmation type, vaccination status of cases including maternal vaccination status, hospitalisation, and outcome. Case numbers and incidence rates from 2011 (previous highest annual case count) were used to calculate incidence rate ratios (IRRs) by location (Hospital and Health Service area) and age group using aggregated age groups for older cohorts and expanded younger age groups to capture finer distinctions and vaccine timing impact. The 10 year (2014–2023) median incidence

rates were used for comparison, noting 2020–2022 were COVID-19 pandemic years resulting in significantly fewer notifications over this period. Analysis, figures and summary tables were generated using R (version 4.4.1).

This study was approved by the Metro South Human Research and Ethics Committee (HREC/2024/QMS/109840) and Australian National University Human Research and Ethics Committee (H/2025/0053).

Results

There were 14,957 notifications of pertussis in Queensland in 2024. Females accounted for 52% (7,700) of cases and 78% (11,707) were in non-First Nations people. Demographics for sex, age group and First Nations status are presented in **Table 3.1.**

Table 3.1: Demographics of pertussis notifications in Queensland, 2024.

Demographics	N	N (%)
Sex	14,925*	
Female		7,700 (52%)
Male		7,225 (48%)
Age Group (years)	14,957	
<1		305 (2%)
1–4		1,073 (7%)
5–9		3,486 (23%)
10–14		4,605 (31%)
15–19		1,557 (10%)
20–39		1,580 (11%)
40–64		1,741 (12%)
65+ years		610 (4%)
First Nations status	12,882*	
First Nations		1,175 (9%)
Non-First Nations		11,707 (91%)

*Missing: sex = 32, First Nations status = 2,075. Percentages were calculated using non-missing denominator for each demographic variable.

Most cases of pertussis (75%, 11,174/14,957) were notified in south east Queensland. In 2024, all Hospital and Health services (HHS) observed an increase in annual incidence compared to the HHS-specific 10-year median. When compared with 2011, the previous

peak year, changes in HHS annual incidence rate varied across the state. A summary of incidence rates for 2011, 2024, 10-year median and 2011/2024 IRR (95% CIs) by HHS is provided in **Table 3.2**.

Table 3.2: Summary of pertussis notifications, annual incidence rates for 2011, 2024, 10-year mean and incidence rate ratio (IRR) by Hospital and Health Service in Queensland.

Hospital and Health Service	2011 notifications (N)	2011 incidence rate*	2024 notifications (N)	2024 incidence rate*	10-Year median incidence rate* 2014–2023	IRR 2011/2024 (95% CI)
Cairns and Hinterland	725	305.1	697	258.0	13.6	0.84 (0.72–1.00)
Central Queensland	402	190.5	362	156.7	21.3	0.83 (0.67–1.02)
Central West	16	129.3	14	130.5	19.0	1.01 (0.79–1.29)
Darling Downs	832	311.7	1,330	445.1	32.7	1.42 (1.23–1.64)
Gold Coast	726	137.3	2,313	337.3	24.6	2.47 (2.02–3.01)
Mackay	278	162.0	271	142.9	16.4	0.88 (0.70–1.10)
Metro North	1,788	201.0	2,591	232.7	23.7	1.15 (0.96–1.39)
Metro South	1,916	185.6	2,931	230.1	20.6	1.24 (1.02–1.50)
North West	14	43.9	39	138.7	8.2	3.08 (2.19–4.33)
South West	58	219.8	60	246.4	24.4	1.12 (0.93–1.34)
Sunshine Coast	946	259.1	1,684	351.8	29.5	1.35 (1.15–1.59)
Torres and Cape	58	235.1	151	577.9	95.4	2.46 (2.11–2.86)
Townsville	221	96.3	874	353.1	14.3	3.65 (2.92–4.58)
West Moreton	592	243.2	1,087	325.3	28.6	1.33 (1.13–1.57)
Wide Bay	412	200.2	553	231.6	10.3	1.15 (0.95–1.39)

* incidence rate per 100,000 persons per year

Annual pertussis notifications by year 1991–2024 in Queensland are presented in **Figure 3.1**. The highest number of notifications were observed in 2011 and 2024, against a backdrop of fluctuating annual notification numbers that peak every 3-4 years. Prior to 2024, the years with the highest activity and largest case numbers were recorded in 2011 (8,985) and 2010 (8,300).

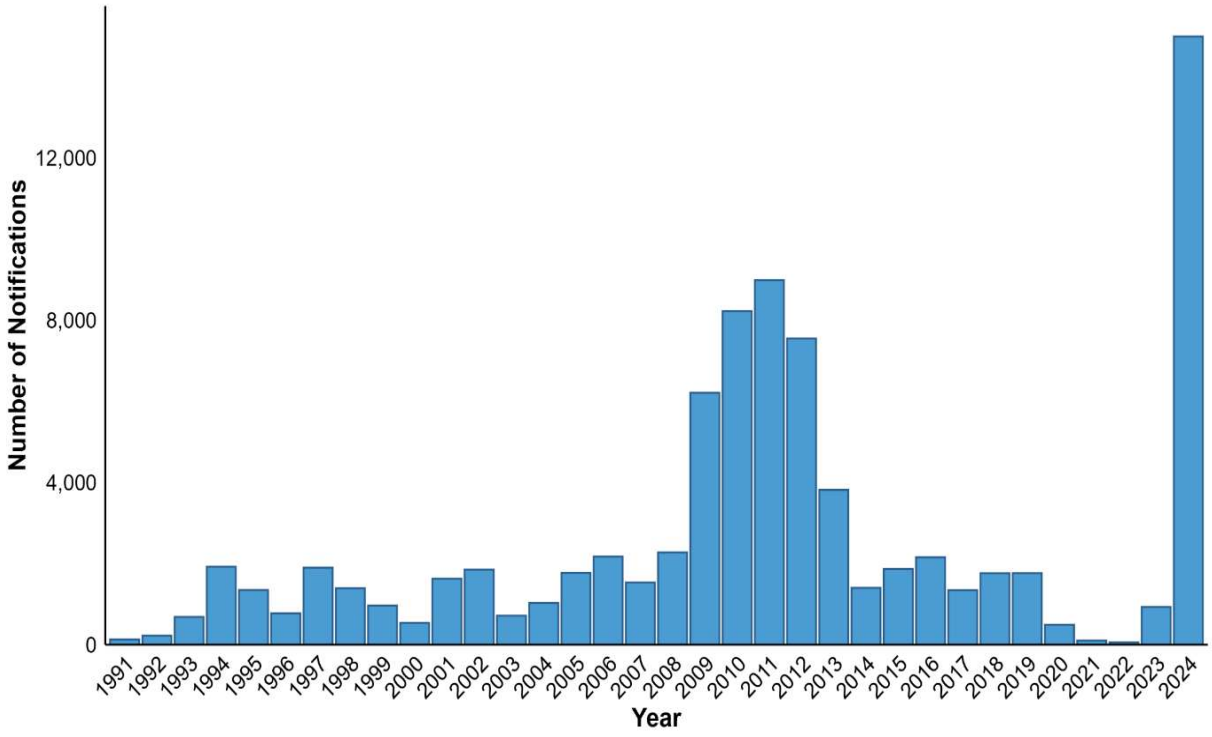

Figure 3.1: Queensland notifications of pertussis by year 1991 to 2024

The age specific incident rates for 2024, 2011 and 10-year median are demonstrated in **Figure 3.2**. Age-specific incidence rates were observed to be the highest across primary school aged children and young adolescents in 2011, 2024 and in the 10-year median peaking at 11 years of age in 2024 (n=1507) and 8 years of age in 2011 (n=325). There is a pronounced drop in the incidence rate at around 11–12 years in 2024, also observed in 2011, though more noticeable in 2024 due to higher case numbers. Rates are relatively stable between 20–85+ years of age in 2024.

Incidence rate ratios (IRR) for condensed age-groups, comparing the incidence rates in 2011 with 2024 are shown in **Figure 3.3**. The age-groups < 6 months (0.93, CI 0.75–1.17) and ≥20

years (0.60, CI 0.57–0.62) observed a decrease in incidence in 2024 compared with 2011, while an increase was noted in all other age groups. Incidence rates in the age groups 5–9 (1,039 per 100, 000 persons per year) and 10–14 years (1,287 per 100, 000 persons per year) were double that of any other age groups in 2024, though when compared with 2011, the highest increase between these two periods was observed in the 15–19-year age group (4.28, CI 3.80–4.83). The overall IRR from 2011 to 2024 was 1.37 (CI 1.33–1.40) .

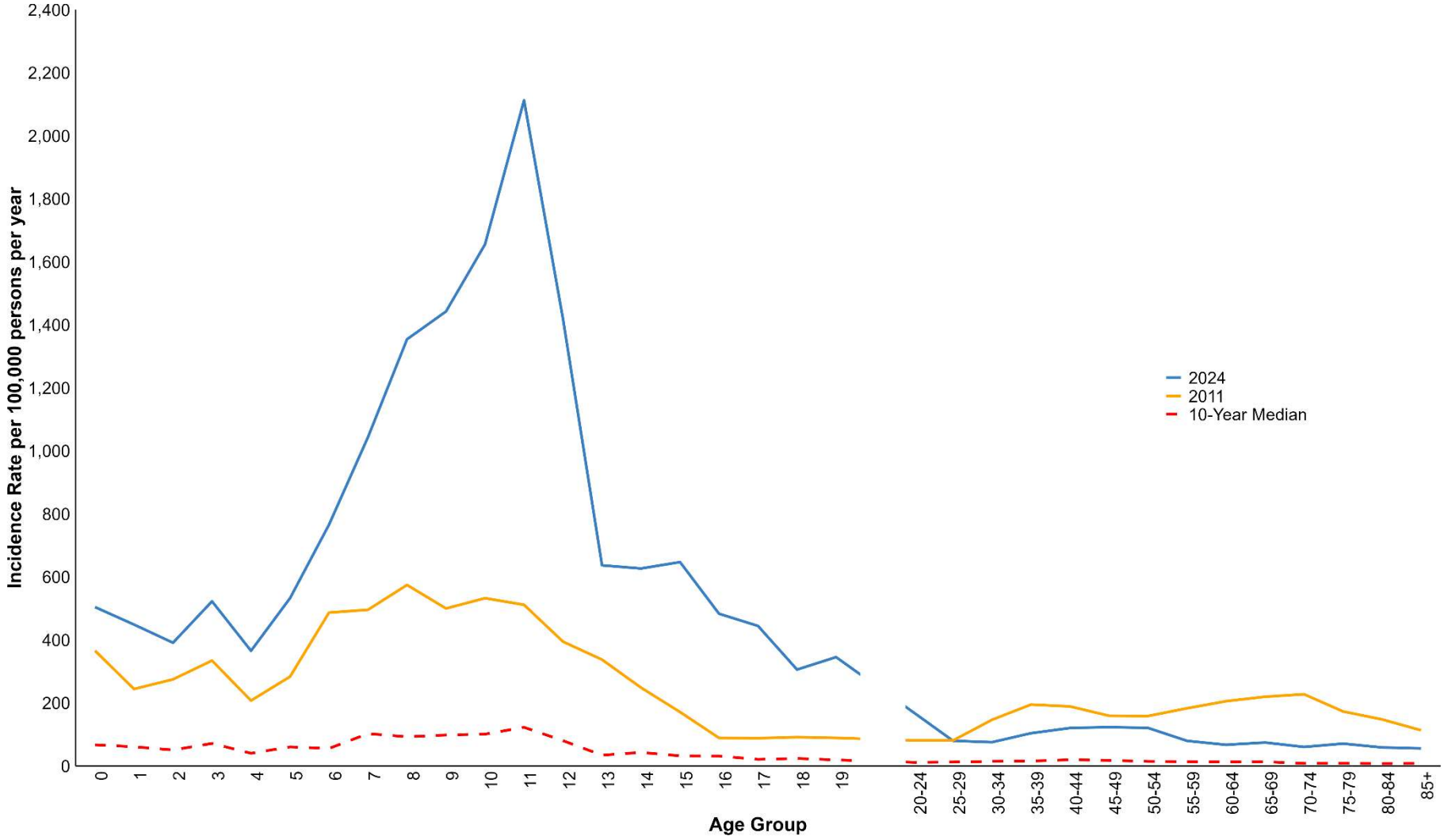

Figure 3.2 : Queensland age-specific pertussis incidence rate for 2024-, 2011- and 10-year median (2012–2023) presented by age in single years (0–19 years), 5-year age groups (20–85+) years.

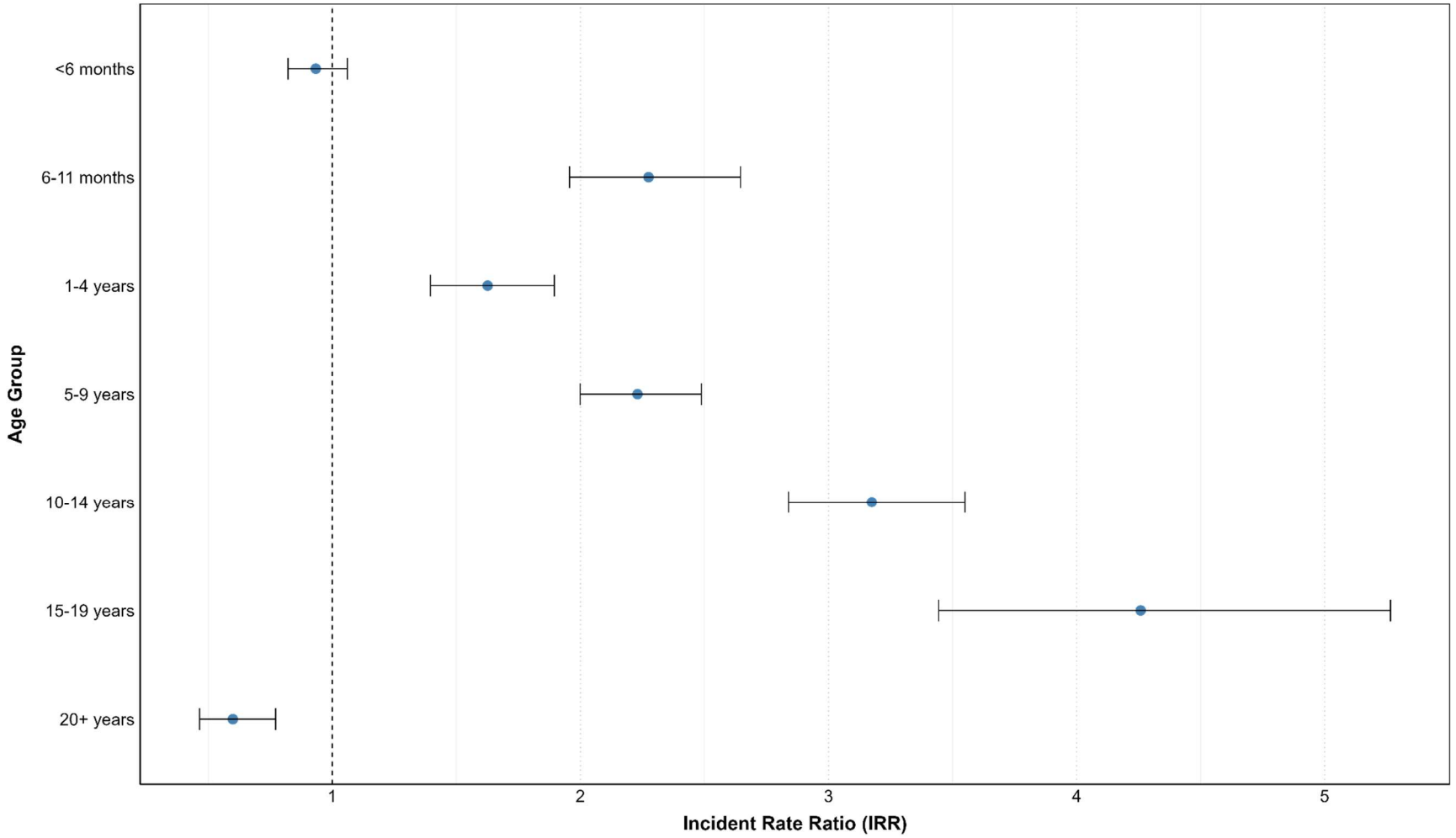

Figure 3.3: Incidence rate ratio with 95% confidence intervals for pertussis notification comparing 2024 to 2011 by age group in Queensland

There were two deaths in 2024 where pertussis was recorded as a contributing factor, one case aged <6 months (case fatality <6 months: 0.72%) and the other ≥65 years (case fatality ≥65 years: 0.16%). The overall case fatality for pertussis in Queensland for 2024 was 0.01%.

Of the 14,957 cases, a pertussis vaccination date was recorded in 8,135 (54%) and not recorded in 6,851 (46%) cases. A comparison of age distributions showed that cases with vaccination recorded were younger (mean age 10.8 years) compared to those without this vaccination recorded (mean age 28.1 years). Of the cases missing any vaccination dates (6,851), vaccination status was reported as unknown or missing for 80% (5,476), 16% (1,101) were recorded as not vaccinated, 2.6% (178) as age appropriate/complete, 1% (75) as incomplete and 0.3% (21) as not age eligible for vaccination. A summary of national and Queensland vaccination coverage by age group and cohort is presented in **Table 3.3**.

In 2024, for notified cases younger than 6 months and those aged 6–11 months, pertussis vaccine was given during pregnancy for 66 (50%) cases and 104 (62%) cases, respectively. In cases <6 months where mothers received pertussis vaccination during pregnancy, the average age of episode was 3.1 months compared to 2.5 months for cases where no pertussis vaccination had been received during pregnancy ; this comparison was descriptive only. The median time between maternal vaccination date and infant episode of pertussis was 28.4 weeks (IQR: 6.6 weeks). In infants <2 months of age (n=35) comparison by mother’s pertussis vaccination status in pregnancy showed that there were 12 cases (34%) with vaccination compared with 23 cases (66%) without. This comparison was descriptive only.

Table 3.3: National and Queensland pertussis vaccination coverage by age group

Age Group/Population	Location	2020	2023/2024	Change (percentage points)
1 year[22]	National	94.6%	93.3% (2024)	-1.3
	Queensland	94.7%	93.2% (2024)	-1.5
2 years[22]	National	92.6%	92.1% (2024)	-0.5
	Queensland	92.8%	91.4% (2024)	-1.4
5 years[22]	National	95.1%	94.0% (2024)	-1.1
	Queensland	94.7%	92.8% (2024)	-1.9
13 years[23]	Queensland	-	71.5% (2023)	-
15 years[23,24]	National	86.8%	85.5% (2023)	-1.3
	Queensland	84.2%	83.1% (2023)	-1
Pregnancy[25,26]	Queensland	77.2%	70.7% (2023)	-6.5

Note: Coverage estimates are from published external sources and were not derived from surveillance data used in this study.

Laboratory testing

There were 16,786 pertussis tests performed by Pathology Queensland (public laboratory) in 2024, of these 97% (16,203) were PCR tests. In 2024, the proportion of PCR tests across age-groups was between 93–99%, with the highest proportion of serology tests used in older cohorts aged ≥20 years (78%, 446/571). Overall test positivity in 2024 for the public laboratory testing was 6%. When reviewing 2024 by month, an increased amount of testing was observed in the middle of the year, while test positivity was highest in October. Test positivity by year of age (**Figure 3.4**) was highest in older children with 16.6%, 19.6%, and 19.6% positivity for ages 10, 11, and 12 years, respectively.

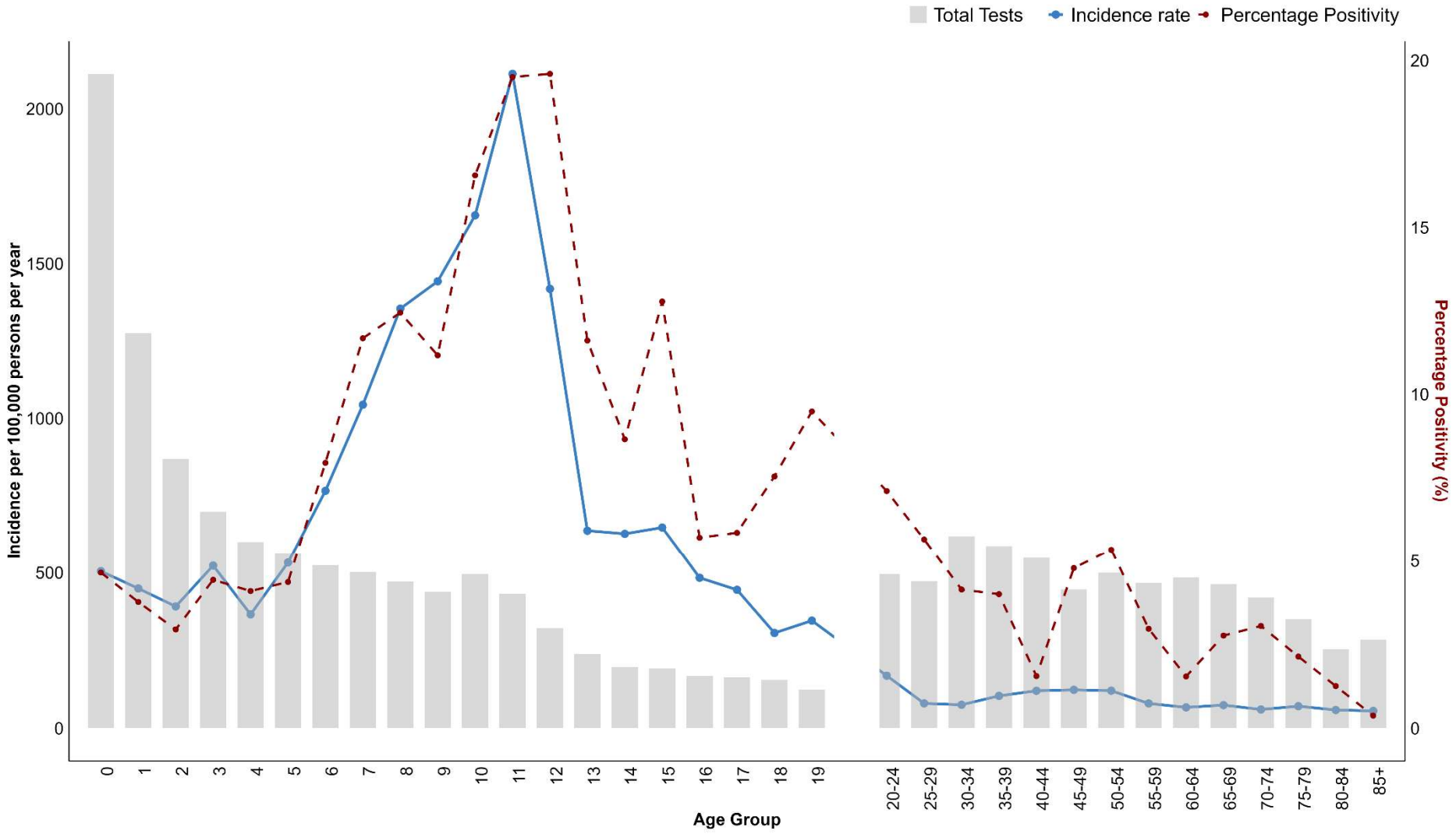

Figure 3.4: Number of PCR tests performed, PCR positivity and incidence rate by age in single years (0–19 years), 5-year age groups (20–85+ years) 2024, in Queensland.

The Pertussis Annual Report 2024 published by private laboratory Sullivan and Nicholas reports that 86% of laboratory diagnosed cases (9,531/11,109) were via PCR test.[20] This represents the highest annual proportion of pertussis diagnosed via PCR between 1999–2024. The total number of PCR tests in 2024 (>150,000) exceeded any other individual year (2004–2024) with all other years having fewer than 50,000 tests performed. The percentage of PCR tests positive for pertussis was higher in the period 2008–2012, the PCR percentage positivity for 2024 was approximately 5%. Comparison by age group and sex showed the highest proportion of positive PCR tests was the 10–14-year age group (~15% for each male and females). The pertussis PCR testing and proportion positive for 2024 shows sustained lower positivity rates mid-year around weeks 26–34 with higher rates at the start and toward the end of the year.

Discussion

Through this analysis of a range of pertussis data, we found the number of pertussis cases notified in Queensland in 2024 (14,957) surpassed the previous annual peak in 2011 (8,985) and was more than 10 times higher than the median annual number of cases per year in the 10 years prior (2014–2023). All HHS areas had higher incidence rates in 2024 than their HHS-specific median (6–24 times higher), while incidence rate ratios comparing 2024 and 2011 showed variation in HHSs across the state. This variation highlights the value of considering local epidemiology alongside of local responses in addition to wider response campaigns.

The distribution of notifications by age is in line with our understanding of waning immunity with studies of previous epidemics indicating immunity can wane in as little as two years following vaccination.[1] The significant decline in notifications after the age of 11–12 years highlights the impact of the dTpa booster vaccination which adolescents receive via the Queensland school-based vaccination program in year 7. These incidence rate trends are mirrored in the public laboratory testing data which similarly show high PCR positivity rates in age 11 and 12 (each 19.6%). These notification and testing data are broadly consistent, both showing the high burden of pertussis in school-aged children and young adolescents. This is important not only for these age groups, but also because they may contribute to transmission to infants, who are most at risk of severe disease. Changes to the timing of the booster may warrant consideration, though due to observed waning immunity, schedule adjustments alone may not provide sustained protection across age groups. Investment in the development of novel vaccines that provide longer lasting protection presents an opportunity for reduced transmission across the lifespan and thus improved disease control.

Current research into live attenuated vaccines has a number of favourable features: intranasal delivery, sustained immunity and a reduction in the potential for asymptomatic transmission by reducing nasal colonisation with *B. pertussis.*[27,28]

The current downward trend in childhood vaccination coverage is of concern. Similar falls in vaccine coverage have been observed post COVID-19 pandemic globally, with the coverage of vaccines for other conditions such as human papilloma virus (HPV) and meningococcal disease also decreasing.[29,30] This pattern of declining vaccination coverage has been acknowledged in the National Immunisation Strategy for Australia 2025–2030, which promotes an increase in uptake of vaccines nationally across all age groups through program governance, community engagement and workforce development.[31] The high rates of pertussis in school aged children and the impact of the dTpa booster for adolescents observed in this study underscore the importance of this strategy alongside vaccine development.

Pertussis vaccination coverage in pregnancy was steadily increasing each year until 2020, since following a downward trend.[26] This is not unique to Queensland, declining pertussis vaccination in pregnancy has also been observed in the United Kingdom where the pertussis maternal vaccination program coverage fell from 74.7% in 2017 to 68.2% in 2024.[17] These declines may be related to pandemic-related disruptions, changes in behaviours, access, equity, and/or lasting distrust of government.[32]

Somewhat reassuringly, despite waning immunity, falls in vaccine coverage and record case numbers in school aged children, those aged <6 months, a key focus of pertussis prevention strategies, represented a small proportion of notified cases in 2024 (<1%), suggesting protection of this vulnerable age group. Incidence rate ratios between 2011 and 2024 were significantly higher in age groups 1–4 years, 5–9 years, 10–14 years and 15–19 years (IRR range 1.64–4.28), while in the <6 months group the IRR was 0.93 (CI 0.75–1.17). Although this decrease was not statistically significant, the relative stability in this age group when contrasted with surging cases among children and adolescents, highlights the impact and importance of the pertussis vaccination during pregnancy. Furthermore, in 2024 where maternal vaccination was given in pregnancy, cases notified in infants <6 months were on average older than cases without maternal vaccination (3.1 months vs 2.5 months). The median time from maternal vaccination date to infant's (<6 months) episode was 28.4 weeks (IQR: 6.6 weeks). This indicates a potential reduction in passive protection for infants around this time, supporting the recommendation for vaccination in pregnancy from 20 weeks gestation. Given the demonstrated effectiveness, the observed decline in maternal

vaccination coverage is concerning. As such, reversing this trend and maintaining high vaccination coverage in pregnancy should be a priority for state and national programs.

Several limitations should be acknowledged. While this study uses notification data from the Queensland surveillance system NoCS, this represents only those tested rather than the whole population of infected individuals. This is a limitation as testing may have been influenced by health seeking behaviours, such as individuals seeking out tests for a persistent cough, clinicians having a lower threshold to test, following the COVID-19 pandemic, easy access to laboratory services, and communications to clinicians and increased media as cases began to rise in 2024. Notably, pertussis epidemics have followed previous respiratory pandemics, such as influenza in 2009.[33]

The laboratory testing data presented are for public laboratories collected from hospital and public health care facilities. There is a potential for bias in the public laboratory data, with over-representation of those attending hospital. It is acknowledged that most pertussis cases are tested in a primary care setting thus testing likely not performed in a public laboratory. As such, those attending hospital may be swayed to young children or those with worse symptoms. Though, private laboratory tends pertaining to PCR testing use, number of tests and age-group specific positivity rates reported in the Sullivan and Nicolaides Pertussis Annual Report 2024 report are similar to the public laboratory data presented.[20]

Dates of vaccination for individuals used for analysis were extracted from the Queensland surveillance system NoCS data, this is manually recorded for each notification, presenting potential for data entry errors or incomplete records. An antenatal indicator field was added to Australian Immunisation Register (AIR) for clinicians to select in March 2025 which if completed, may be useful for future research by allowing data linkage instead of relying on individual case follow up. This however is limited to the completeness of the added field. Gestational age at birth is not available from the surveillance data preventing a more detailed analysis of maternal protection. Additionally, other factors such as the impact of reduced immunogenic boosting from decreased exposure to circulating pertussis during pandemic years, or pathogen-specific changes cannot be determined from surveillance data alone and therefore have not been explored. This study was not able to account for, if any, the impact of *Bordetella parapertussis* on pertussis notifications across the study period. There is currently insufficient evidence to suggest a substantial impact on pertussis epidemiology or warrant a change in public health response.[34]

The resurgence of pertussis in 2024 has led to the highest number of cases notified in a single year in Queensland. While vaccine related waning is observed, the vaccine has likely had an effect in protecting infants during this period, demonstrated by the incidence rates compared with previous periods of high case numbers. Downward trends in vaccination rates for children, adolescents and in pregnancy are flags for action in this area. Historically, pertussis epidemics have occurred in Australia in the context of high childhood vaccine coverage.[1] Therefore, given the currently available vaccines, vaccination in pregnancy is the most impactful intervention for protecting infants too young to be vaccinated. Regardless of which vaccine is used, the global shift in community perception of communicable diseases and public health interventions following the COVID-19 pandemic are important considerations in understanding and acting upon these trends.

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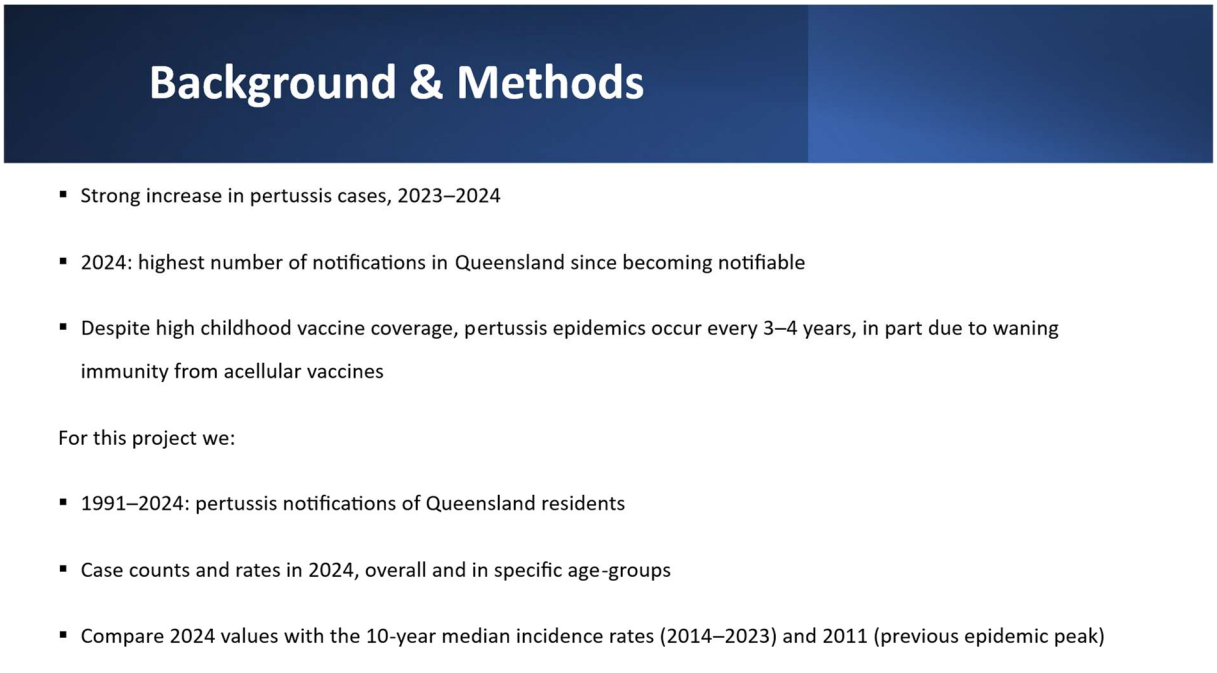
Appendix 1 : Conference presentation

Presented at Communicable Disease and Immunisation Conference in Adelaide, June 2025





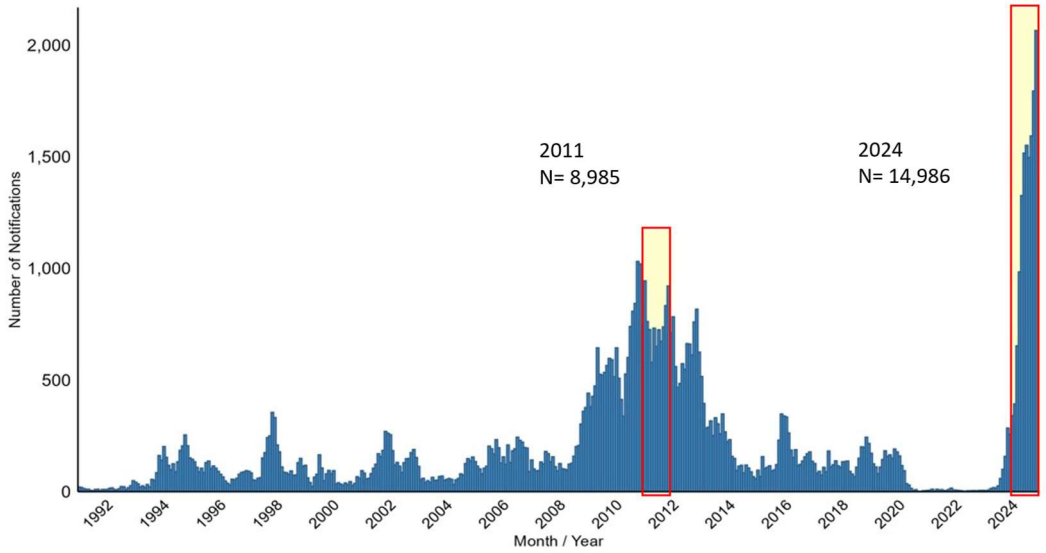


Figure 1 : Notifications of pertussis cases by month and year 1991–2024 in Queensland

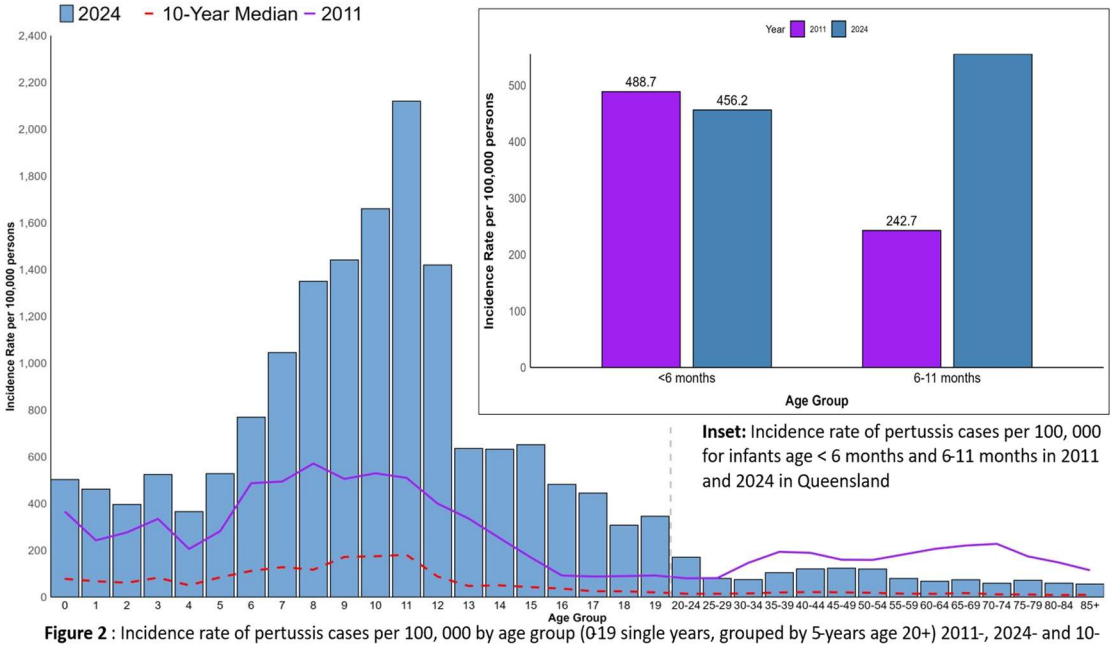


Figure 2 : Incidence rate of pertussis cases per 100, 000 by age group (0-19 single years, grouped by 5-years age 20+) 2011-, 2024- and 10-year median in Queensland

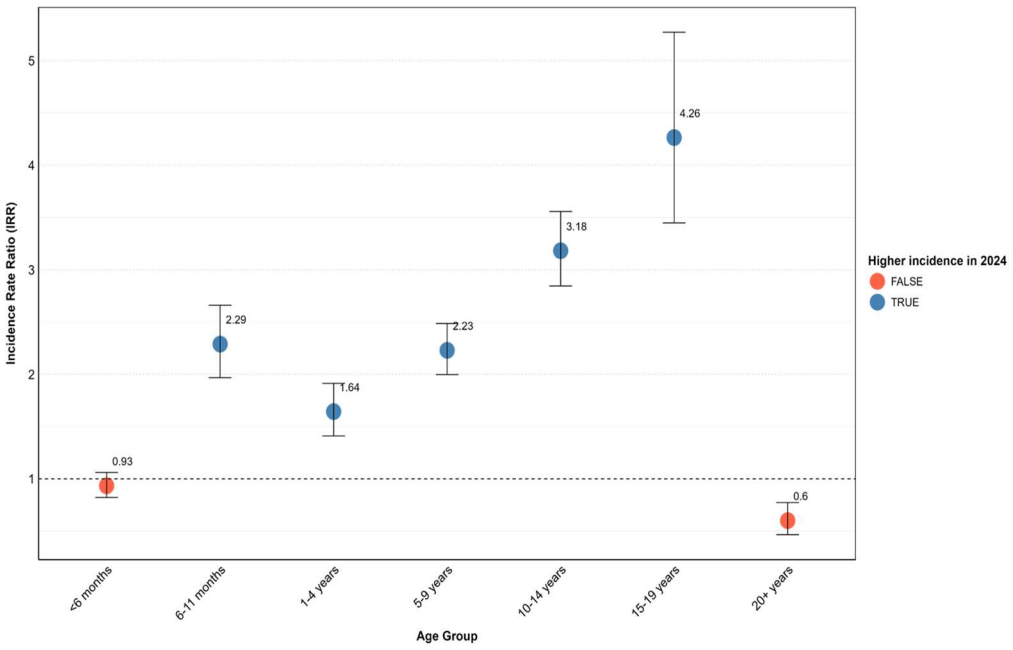


Figure 3: Relative change in incidence rates from 2011 to 2024, in Queensland.

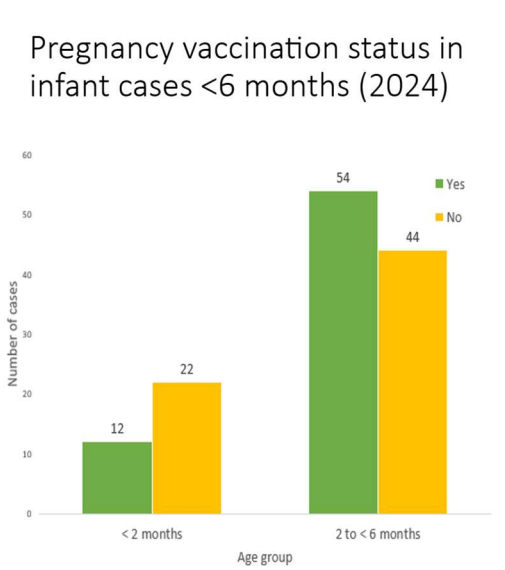
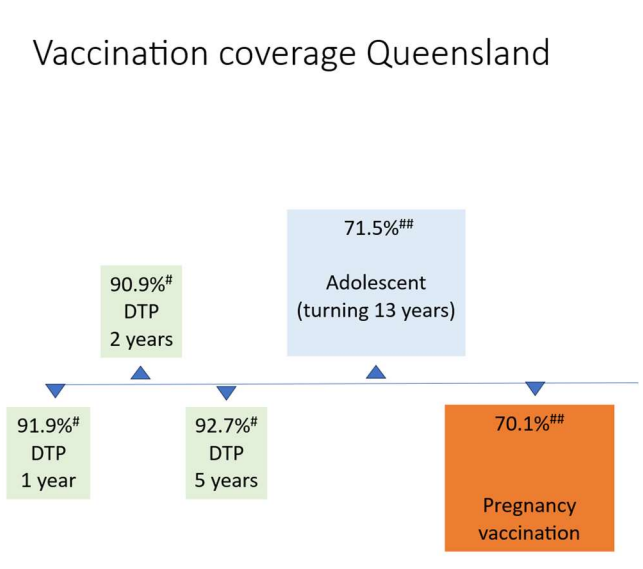


Figure 5: Number of pertussis cases < 2 months and 2 to 6 months by pertussis vaccination in pregnancy status

*missing = 6



#annualised qtly data (Sept. 2024) source: Department of Health, Disability and Aging
2023

Summary

- 2024: highest number of pertussis cases since modern surveillance began (1991)
- Age distribution fits with waning of acellular pertussis vaccine
- Pregnancy vaccination: reduction in proportion of cases in < 6 months despite large increases in most other age groups in 2024
- Queensland overall childhood vaccine coverage ok, less than target 95%
- Focus on increasing vaccination coverage in pregnancy and adolescents now for future epidemics



Image: During presentation at Communicable Disease and Immunisation Conference 2025 in Adelaide.

Chapter 4: Making HIV viral load testing a notifiable condition: assessing a proposed new surveillance system

Prologue

Background

Virtual elimination of HIV is a Sustainable Development Goal that Queensland is working towards. Progress is monitored through care cascades, one of which reports the proportion of people living with HIV (PLWHIV) on treatment and with viral load suppression.

Due to ongoing stigma and discrimination, HIV notification data are handled differently to other notifiable conditions making accurate cascade reporting challenging. A prior clinical audit showed that a significant number of PLWHIV in Queensland receive follow-up with private providers rather than public services. From a public health perspective, this fragmentation of care complicates data collection and limits the ability to inform policy decisions that may impact PLWHIV in Queensland. Also, how this data informs policy decisions that filter back to PLWHIV in Queensland.

A former Master of Philosophy (Applied Epidemiology) student Elenor Kerr developed a prospective surveillance system to monitor time to viral suppression for individuals with new HIV notifications.[1] This project built upon that work but focuses on establishing stakeholder engagement and exploring insights to inform sustainable implementation of cascade surveillance in Queensland.

My role

This project differed from others I completed during the program as it centres around assessing the feasibility of introducing a new surveillance system in Queensland. My role involved first understanding and mapping the current surveillance systems for HIV in Queensland Health and nationally. To do this I spent time with the HIV epidemiologist and HIV public health team within Queensland Health. The early stakeholder insights gained during these consultations were crucial to understanding the current HIV public health activities and developing the proposed surveillance system.

Through this consultation and with the input of my supervisor I was able to identify the main stakeholders to engage. I developed semi-structured stakeholder interview questions and participant information sheets. I conducted six interviews, transcribed these, and reviewed interviews for common themes guided by the aims of the study. I identified which attributes would be most relevant to assess the system in line with the attributes outlined in the

Communicable Diseases Control (CDC) *Updated Guidelines for Evaluating Public Health Surveillance Systems*.[2] I assessed how a proposed surveillance system would or could function. In addition to this I also identified key publicly available data that could be used to evaluate the proposed system. I completed the chapter for my thesis, a lay summary of the project for participating stakeholders and a summary for the Blood Borne Virus/Sexually Transmitted Infections (BBV/STI) team, presented at a team meeting.

MAE competencies

This Chapter met the following MAE competencies:

- Establish or evaluate a surveillance or other health information system
- Lay summary for non-scientific audience (**Appendix 2: Feedback for participating stakeholders**)

Lessons learned

This project provided valuable lessons in understanding surveillance in the context of an incomplete system or a proposed model rather than an evaluation of an existing system. As this was a proposed surveillance system only selected CDC attributes could be assessed. The surveillance system for HIV is complex, in part driven by the stigma and discrimination around the condition. Surveillance is based on capturing data from several sources that piece together to form a larger, albeit incomplete, picture of the epidemiology of HIV in Queensland. Surveillance is also tied strongly to WHO elimination targets. Designing a system to meet elimination targets while maintaining confidentiality to avoid discouraging testing presents a challenge globally. By spending time with and interviewing stakeholders in this area, I was inspired by the passion people had for their work. I gained experience in identifying other data sources to evaluate or describe the surveillance activities.

Public health impact

Queensland Health's commitment to the virtual elimination of HIV transmission by 2030 is reaffirmed in the Queensland HIV Plan 2030. This plan sets priority areas for empowerment, collaboration and partnerships, program integration, and addressing health service needs across the engagement cascade. Whilst viral load results are not notifiable in any other state or territory, this supports surveillance objectives set out in the National HIV Strategy.

Investigating an initiative to make HIV viral load testing notifiable in Queensland was listed as a priority action in the plan (Priority action 5.5). This project proposes a process for incorporating viral load test results into the existing surveillance system for HIV and how this information may be used to provide a more complete understanding of retention and engagement of PLWHIV in Queensland. The project also provides valuable insights into relevant Queensland stakeholder views on viral load testing as a notifiable condition in Queensland.

Acknowledgments

I acknowledge the stakeholders who gave their time to complete the interviews and review transcripts. I take the time to acknowledge the pioneers in HIV and those who have worked to reduce stigma and inform awareness and advocacy for this disease. I acknowledge the HIV public health team who have always welcomed me to spend time with them and knock on their door to ask questions. I thank Damin Si, epidemiologist, who manages the HIV surveillance portfolio in the Epidemiology and Research Unit, for his time and direction he gave me about how the surveillance pieces work together. My supervisors Emma Field and Stephen Lambert, who again provided me with the reassurance and encouragement, helped me conceptualise and shape this project this into its current form.

Abstract

Background

Global elimination targets set by the Joint United Nations Program on HIV/AIDS (UNAIDS), also referred to as the 95-95-95 targets, guide countries to achieve the Sustainable Development goal of ending the HIV/AIDS as a public health threat by 2030. Due to stigma and discrimination of people living with HIV(PLWHIV) and the chronic nature of the condition, the surveillance of HIV and associated health data is complex and differs from most other notifiable conditions. With viral suppressive treatment available to manage HIV, viral load has become an important biological marker for the risk of onward transmission. Thus, viral load testing, requested by treating clinicians, can also act as an indicator of engagement and retention in care. This project explores the practicability, public health benefit and relevant stakeholder insights into making viral load testing a notifiable condition in Queensland.

Methods

A case definition and proposed process for HIV viral load notification was developed through scoping of the current surveillance activities and workflow as well as stakeholder consultation. An evaluation of the proposed surveillance system using the US Centers for Disease Control and Prevention (CDC) Guidelines for Evaluating Surveillance Systems attributes simplicity, sensitivity, representativeness and acceptability was conducted. Six key stakeholders including public health professionals and community representatives were engaged for their insights into viral load as a notifiable condition in Queensland.

Results

The current surveillance HIV workflow was mapped and a case definition and process for viral load notification were developed in line with existing notification procedures.

Evaluation using CDC surveillance attributes demonstrated the following:

- Simplicity: the system could be integrated into the current infrastructure, with an estimated additional 11,333 notifications annually;

- Sensitivity: the proposed system allows real-time reporting and flagging of changes, inclusion of all testing sites and all health providers;

- Representativeness: inclusion of all testing would reduce geographical bias and over representation of cohorts, enabling more equitable interventions; and

- Acceptability: five of six stakeholders felt this information could be useful from a public health perspective, but some raised issues regarding confidentiality and privacy, with some worried notification may lead to more punitive approaches.

Conclusion

To move toward elimination public health data can be used in respectful and safe ways to enable a better understanding of the epidemiology of HIV in Queensland. Viral load testing as an indicator of engagement in care can be collected in a similar process to HIV notifications and could provide valuable insights for models of care, prevention activities and support for people living with HIV. Importantly, any policy changes and public health actions need to consider PLWHIV perspectives through active engagement.

Background

Human immunodeficiency virus (HIV) affects the immune system by targeting and destroying white blood cells.[3] First reported in 1983, HIV rapidly became a pandemic with ongoing transmission in all countries.[3] At the end of 2024, an estimated 40.8 million people were currently living with HIV.[4]

HIV mainly targets CD4 T-lymphocyte helper cells which are important in regulating the body's immune response to pathogens.[5] Weakening of the immune system leaves the body susceptible to certain infections, resulting in a range of clinical manifestations.[5] Untreated, HIV infection will progress to acquired immunodeficiency syndrome (AIDS), a more advanced stage of the disease.[3] There are two types of HIV, HIV-1 and HIV-2, with the former being the most prevalent globally.[6]

Transmission occurs through the exchange of infected body fluids including unprotected sexual contact, maternal to child transmission or contamination of reusable medical or drug injecting equipment.[6] Maternal to child transmission can occur during pregnancy, during childbirth or postpartum through breastfeeding.[7] There are sub-populations identified as higher risk of HIV infection, including gay, bisexual, and other men who have sex with men (GBMSM), sex workers, and drug users. In Australia, male to male sex was the most common risk exposure (63%) identified for HIV notifications in 2023, though this has been declining across the last decade.[8] The WHO Asia-Pacific region reported almost a quarter (23%) of the global number of new HIV infections in 2023.[9]

The HIV response has been impeded by the stigma, marginalisation and, in some circumstances, criminalisation associated with HIV.[10] Enduring public perceptions of HIV transmission and its association with sexual and drug using behaviours can impact HIV prevention approaches.[11,12] It is reported that those at risk are more likely to seek testing in non-threatening, non-judgmental services that are responsive to their individual circumstances.[11] With associations and intersections between sexuality, culture, gender, race, ethnicity, class and identity, HIV-related stigma affects health seeking behaviours and, in turn, the diagnosis of HIV and engagement in care.[11,13]

Although, there is no cure for HIV, significant gains have been made in testing, prevention, and treatment of the disease. Advancements include pre-exposure prophylaxis to prevent

infection in those without infection but risk of exposure, and antiretroviral therapy (ART), aimed to keep the viral load of those infected represent profoundly supressed.[14] Antiretroviral therapy has led to significantly lower morbidity and mortality for those living with HIV.[15] The viral suppression achieved by ART is also important in prevention as it reduces the risk of onward transmission.[15] The World Health Organization (WHO) states that viral suppression is key in improving individual health and preventing both sexual and perinatal transmission.[16] Viral load has been identified as the key predictor of the risk of heterosexual transmission of HIV-1.[17]

The Joint United Nations Program on HIV/AIDS (UNAIDS) have set Fast Track targets to end the AIDS epidemic by 2030.[18] The approaching 2025 targets require diagnosis of 95% of all HIV cases, 95% of those diagnosed receiving antiretroviral treatment, with 95% of those on treatment having viral suppression achieved.[8,19] These are referred to as the 95-95-95 targets of the HIV diagnosis and care cascade. Australia is aiming to virtually eliminate HIV transmission by 2030, with the Australian cities of Adelaide, Brisbane, Melbourne, Sydney, and Perth joining a network of global cities (350+) signing on to the Fast Track Cities Paris Agreement to End HIV epidemic by 2030.[12,20,21]

Surveillance of HIV in Australia

HIV is a nationally notifiable condition in Australia and notifiable in all states and territories.[22] All cases that meet the national case definition (**Table 4.1**) are notified to the local jurisdictional health department by doctors and laboratories in line with local legislative requirements.[6] States and territories report newly diagnosed cases to the National HIV Registry which is held by the University of New South Wales' (UNSW) Kirby Institute and coordinates the national surveillance reporting of HIV and the national epidemiology updates provided to UNAIDS for global reports.[23]

The minimum information collected as part of the notification in each state and territory in Australia are name coded (first two letters of first and last name), sex at birth, date of birth, postcode, country of birth, language spoken at home, First Nations status, date of diagnosis, CD4 cell count at diagnosis, viral load at diagnosis, likely place of acquisition, likely source of exposure, year of arrival in Australia, reason for test, and evidence of newly acquired HIV (diagnosed with HIV with evidence of negative or indeterminate HIV test in the previous 12 months).[23] Due to the confidential and sensitive nature of HIV notifications, legislation in

Queensland and other states and territories only allow the collection of a four letter name code (first two letters of first and last name).[6]

Table 4.1. National case definitions for human immunodeficiency disorder (HIV)[6]

HIV case definition
Both confirmed cases and probable cases should be notified.
Confirmed case requires laboratory definitive evidence only.
Laboratory definitive evidence ≥18 months of age [22] Repeatedly reactive HIV antibody or HIV antigen/antibody combination assay AND at least one of the following: • Positive western blot immunoassay OR • Detection of HIV-1 p24 antigen, confirmed by neutralisation OR • Detection of HIV nucleic acid (RNA or DNA) by an HIV nucleic acid test* **Laboratory definitive evidence <18 months of age**[22] • Detection of HIV-1 p24 antigen, confirmed by neutralisation, on two separate specimens on different days OR • Detection of HIV nucleic acid (RNA or DNA) by an HIV nucleic acid test, on two separate specimens on different days*
Probable case: requires laboratory suggestive evidence
Laboratory suggestive evidence (any age)[22] • Detection of HIV-1 p24 antigen, confirmed by neutralisation^ OR • Detection of HIV nucleic acid (RNA or DNA) by an HIV nucleic acid test*# *HIV nucleic acid testing should be performed on a dedicated specimen not previously used for other testing ^ for those <18 months of age, sample must be from a child >1 month of age # for those <18 months of age, sample cannot be cord blood
Note: Additional information to distinguish newly acquired HIV infection should be collected routinely for surveillance purposes and includes evidence of a negative or indeterminate HIV antibody test and/or a seroconversion illness occurring within the 12 months prior to diagnosis.

The most recent prevalence information of HIV in Australia in 2023 was estimated to be 0.14% (adults ≥15 years), reflecting an estimated 30,010 people living with HIV (PLWHIV) in Australia at that time.[8] There were 722 new notifications (first diagnosis) in Australia during 2023, with 37% of these classified as late diagnoses, based on CD4+ T-cell count.[8] In addition to those first diagnosed within Australia, in 2023 there were 580 HIV cases notified

who were previously diagnosed overseas.[8] Nationally, a downward trend in HIV notifications has been observed over the last decade , with the greatest reduction observed in Australian-born men who have sex with men (MSM).[8] In Queensland, while a decline in new HIV notifications was seen during 2020–2022 during the COVID-19 pandemic period, a return to pre-pandemic notifications (new notifications: 158 and 156) occurred in 2023 and 2024 (**Figure 4.1**).[24] New South Wales and Victoria also reported an increase in annual notifications in 2023, however in these states notifications were still lower than pre-pandemic annual totals.[25,26]

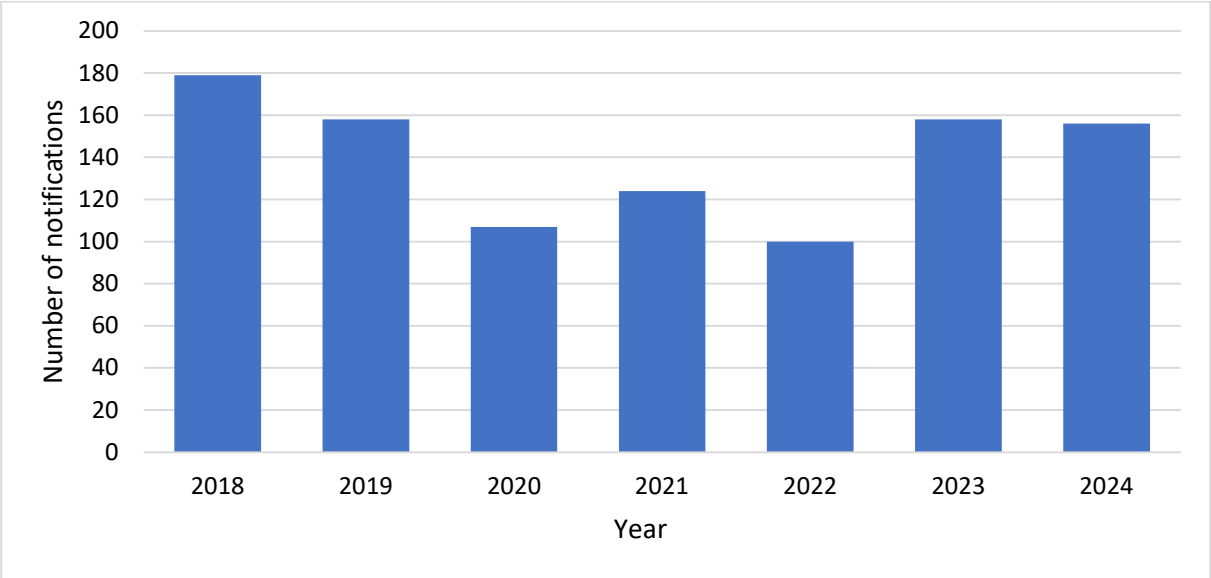


Figure 4.1. Number of new HIV diagnosis 2018–2024 in Queensland[24]

Viral load, used in initial diagnosis and for ongoing monitoring of viral suppression, is considered a key biological risk factor for transmission.[6] The definition for viral load suppression is widely accepted as <200 copies/ml. At this level, HIV remains present, but ART has supressed the virus to a level that prevents onward transmission through sexual contact. Virus suppression to this level also results in long-term health benefits, increased quality of life and life expectancy, for PLWHIV. [6,27] For PLWHIV on a stable suppressive regime, viral load testing is recommended every 3 to 4 months or as clinically indicated (this may be extended to 6 months for some individuals).[28] Shorter intervals may be required in some circumstances such as drug toxicity, simplification of or other changes to regime, virological failure or suboptimal response.[28]

The information for calculating UNAIDS 95-95-95 targets and progression toward elimination is not readily available through routine surveillance.[25] In Australia, the Kirby Institute uses

modelling and estimations from a number of sources guided by a national stakeholder reference group to assess progress.[25] Australia's progress towards the 95-95-95 targets from the Kirby *HIV, viral hepatitis and sexually transmissible infections in Australia annual surveillance report 2024* is presented in **Figure 4.2** . Of the estimated 13% (3,970) of PLWHIV without viral suppression, approximately 59% are estimated as undiagnosed, 23% diagnosed but not in care, 1% in care but not on treatment and 17% on treatment but not surpressed.[8]

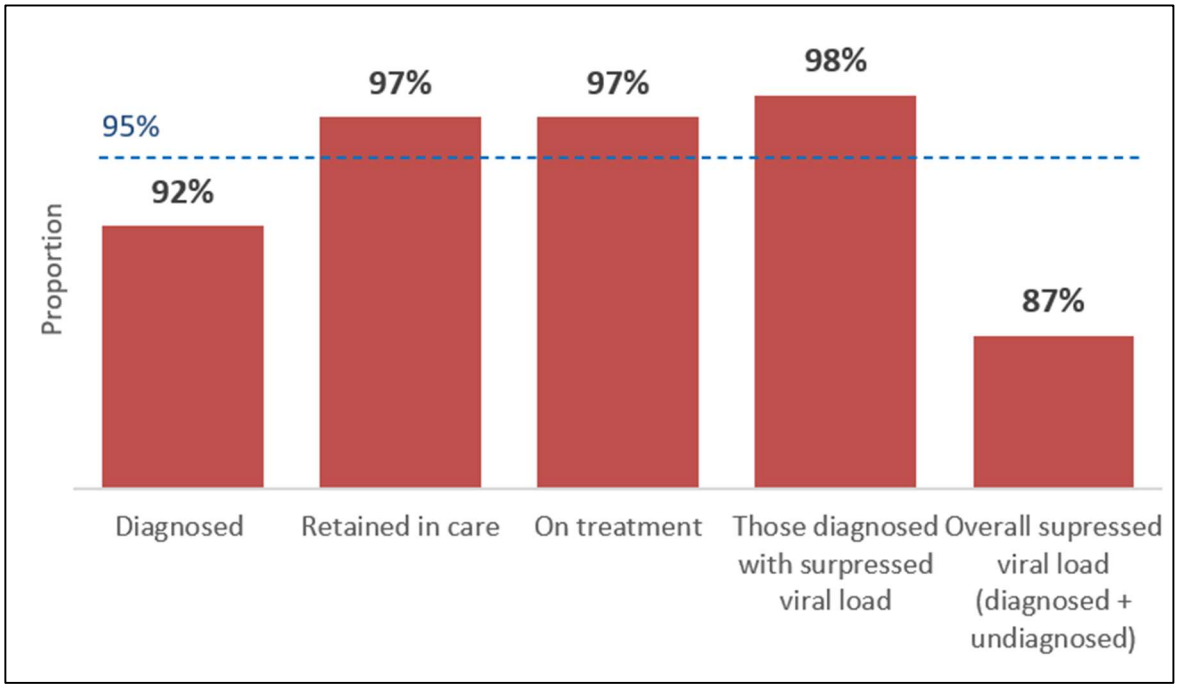


Figure 4.2 :**HIV diagnosis and care cascade estimates for Australia, 2023**[8]

Engagement in care for PLWHIV can be described as a continuum, with those untested or not diagnosed at one end and those fully engaged in care at the other.[29] For PLWHIV, engagement is dynamic and retention in care is as important as initial engagement for individual and public health outcomes.[29] The success of the previous UNAIDS targets 90-90-90, has demonstrated that benchmarks for engagement in care and viral load suppression are important factors in achieving improvements in HIV control on the pathway to elimination.[29,30]

Challenges in HIV surveillance

Due to discrimination, stigma or potential personal or criminal ramifications, maintaining confidentiality has been an important policy to encourage the uptake of testing and

engagement in care, resulting the two-by-two name format.[31] This coding system opens the possibility of duplicate records due to inaccurate, incomplete or by use of other names, including aliases.

In 2024, the Queensland Health HIV public health team conducted an audit of all HIV notifications recorded in the Queensland notifiable conditions database to identify individuals who appeared to be disconnected from care. Part of this assessment included how many did not have viral load testing information updated within the preceding 15-month period. The HIV public health team subsequently followed up this cohort to update information about connection to care, and, where requested, assist them to re-engage into support and care. A key finding from this audit was that 35% of (1,211/3465) that were thought to be potentially not engaged in care, were engaged in care and often had care through private General Practitioners and specialists (S. Greenbank, Communicable Diseases Branch, Queensland Health, personal communication, July 2025). This provided a more up to date picture of Queensland's HIV epidemiology and cascade of care estimates allowing for focused re-engagement strategy.

It is proposed that viral load testing surveillance can be used to strengthen Queensland's progress toward virtual elimination of HIV. While HIV notifications are essential for monitoring new diagnosis, they do not provide a complete picture engagement in care or viral suppression among PLWHIV. Surveillance of viral load testing for PLWHIV at a public health level can signal trends or changes in testing providing the potential for improved clinical practice and a quantitative measurement for policy and decision making. The surveillance for HIV is largely built around modelling and non-identifiable information from sentinel sites, a universal surveillance system also offers more dynamic monitoring of the 95-95-95 elimination targets.

The Australian Government's 2023 HIV Taskforce Report identified several important recommendations for prevention, testing, awareness, decriminalisation, and partnership. The recommendations seek to understand how policy may contribute to stigma and/or conversely be affected by stigma.[12] These recommendations included exploring ways to improve accuracy and timeliness of data for surveillance, with emphasis on measuring progress against the 95-95-95 targets, to promote current science in guiding law and policy reform and further promoting the role of treatment as a prevention in virtual elimination.[12]

Aim and objectives

The aim of this project was to explore the feasibility of a proposed surveillance system to better monitor engagement in care and viral load testing in Queensland. As a notifiable condition, viral load has the potential to improve our understanding of engagement in care and monitor epidemiological trends for HIV. Given that HIV can now be considered chronic condition with effective treatment, engagement in care and viral suppression has important implications for both individual health outcomes and public health response in Queensland, crucial for informing elimination strategies. The objectives were to:

1. Propose a process for how viral load testing surveillance could be incorporated into current surveillance activities for HIV in Queensland; and

2. To assess the acceptability, simplicity, sensitivity, and representativeness of this surveillance system using the proposed process and CDC surveillance evaluation guidelines.

Methods

There were two steps involved in this evaluation in line with the objectives, the first, a scoping review existing systems and proposed system design and the second an assessment of attributes.

Scoping review and system design

To develop a proposed surveillance process for HIV viral load testing, engagement with internal stakeholders in Queensland Health HIV surveillance and HIV public health teams was first undertaken to describe existing HIV surveillance and reporting in Queensland. This involved mapping the existing HIV notification process and scoping reporting requirements and data collection methods, Queensland surveillance reports and national publications, information used in global surveillance reports, Communicable Diseases Network Australia guidelines and methods used HIV estimates and modelling.

Attribute assessment

The proposed surveillance of viral load testing was considered using four attributes of the *CDC Updated Guidelines for Evaluating Public Health Surveillance Systems*; simplicity, sensitivity, representativeness and acceptability as described in

Table 4.2**.** As this was an exploratory study of a proposed new notifiable condition not all attributes were applicable. This evaluation focused on these four attributes based on the feasibility of assessment within the study timeframe and availability of baseline data for meaningful comparison.

Table 4.2: CDC Updated Guidelines for Evaluating Public Health Surveillance Systems attributes and evaluation methods[2]

Attribute	Definition	Method of evaluation
Simplicity	Ease of integration into existing operations	A system map was created comparing current HIV surveillance in Queensland with the proposed HIV viral load surveillance process to identify integration points and shared workflows. Estimated workload by number of tests performed annually (private and public) in Queensland . Counts of viral load tests performed in private laboratories in Queensland in 2024 using available reports for the relevant Medicare Benefits Schedule item number combined with the count of number or viral load tests performed in Pathology Queensland for public pathology.
Sensitivity	Assessment of the extent to which the proposed surveillance system can capture viral load testing data and identify people engaged in care and evaluate its ability to detect changes in epidemiological patterns.	A review of the key characteristics of current surveillance of HIV viral suppression and engagement in care compared with proposed process. The characteristics compared included data sources and capture, population, reporting, location of sentinel sites and number of new HIV notifications in Queensland by Hospital and Health Service area and health service type. Review re-engagement audit: description of outcomes of PLWHIV identified and followed up if possibly not

Attribute	Definition	Method of evaluation
		engaged (no testing on record for 15 months or greater).
Representativeness	The proposed surveillance system data would reflect the true distribution of viral suppression/engagement in care	Methods as described for sensitivity (reported separately)
Acceptability	The proposed surveillance system would be acceptable to the users, including end users and PLWHIV	Relevant insights from review of transcripts of semi structured interviews with stakeholders. Including views on privacy and confidentiality, stigma, workload and resourcing, reliability and coverage and community engagement. This is described further below in *Stakeholder engagement*.

The volume of quantitative viral load testing undertaken in private pathologies in Queensland is described by accessing counts of MBS item numbers for quantitative HIV viral load testing for 2024 from Services Australia. The two item numbers used: 69378: Quantitation of HIV viral RNA load in plasma or serum in the monitoring of a HIV sero-positive patient not on antiretroviral therapy - 1 or more tests and 69381: Quantitation of HIV viral RNA load in plasma or serum in the monitoring of antiretroviral therapy in a HIV sero-positive patient - 1 or more tests on 1 or more specimens. Testing that occurs in public laboratories is state funded and therefore should not be associated with an MBS item number rebate. The aggregated total number of viral load tests performed in public laboratories in Queensland in 2024 was obtained from the Queensland Health Public Health Intelligence Branch.

Stakeholder engagement

Stakeholders included in this assessment were identified as those who are part of the current surveillance of HIV and those who may be impacted by the proposed surveillance system (**Table 4.3**). HIV surveillance in Queensland is centralised in the Department of Health. Stakeholders were identified by discussion with the HIV public health and Blood Borne Viruses and Sexually Transmissible Disease Unit in the Communicable Diseases Branch.

Stakeholders identified were invited to participate in a one-on-one 60-minute semi structured interview. Each stakeholder received a participant information sheet and a copy of the proposed questions at the time of invitation (Appendix 1: Stakeholder participant information sheet and semi structured interview questions). Questions were open ended with an additional question for those involved in policy and reporting. Additional follow-up questions were asked based on the participants responses to gain a further understanding or insight. Interviews were conducted over Microsoft Teams and interviews were recorded and transcribed.

Table 4.3. Stakeholders engaged and their role in HIV surveillance in Queensland

Stakeholder	Role in surveillance
HIV Public Health team	Statewide surveillance Patient support Linking patients to care
Epidemiology and Research Unit	Statewide surveillance Reporting to national HIV Register
HIV reference laboratory Queensland	Testing and reporting for laboratory tests
PLWHIV peer support and advocacy organisation PLWHIV representative	Advocacy, support of people living with HIV Peer support, education, and prevention
Infectious Diseases Physician	Patient care and service provision

Ethics approval for this work was obtained from the Australian National University Human Research Ethics Committee, 2017/909.

Results

Scoping review and system design

In Queensland, the *Public Health Act 2005 (Qld)* provides a legislative framework to support the management of Human Immunodeficiency Virus (HIV) and other controlled notifiable conditions.[32] Sections 70–75 of *Public Health Act 2005 (Qld*) (the Act) allows for the follow up of epidemiological and surveillance information for laboratory and clinician notifications of all HIV cases diagnosed in Queensland as well as those diagnosed interstate or overseas.[32]

Notifications for HIV are reported to the Department of Health HIV Public Health team by the reference laboratory and are manually added to the Notifiable Conditions System (NoCS), using a two-by-two name code though pathology providers collect full names. In addition to this during clinical audits, a list of viral load results for the defined period is accessed through AUSLAB (public laboratory information system) and matched by last name, first name (to coded name) and date of birth with the date last seen, last follow up, provider, CD4+ count and viral load values. These are entered manually by the HIV public health team and a dedicated data services officer. The Queensland surveillance report for HIV is published annually. The report does not include reporting on viral suppression or engagement in care.

As the custodians of the National HIV register, the Kirby Institute publishes the national HIV surveillance report annually. The data for reporting of viral suppression and other clinical factors are collected by the Kirby Institute via deidentified sentinel surveillance (not linked to cases on the National HIV Register) and analysed separately. Data are collected through a number of sources: several sexual health clinics, primary health facilities and laboratories through the Australian Collaboration for Coordinated Enhanced Sentinel Surveillance Transmissible Infections and Blood Borne Viruses (ACCESS), a national surveillance network (established in 2008 extended to include HIV in 2016) and Australian HIV Observational Database (AHOD), an observational cohort study established in 1999.[33,34]

The care cascade is used to estimate the proportion of PLWHIV on treatment with supressed viral load. These values are produced using the proportion of people with viral suppression on the AHOD, along with treatment coverage estimated from combined data from the Pharmaceutical Benefits Scheme (PBS) and non-Medicare eligible access schemes.[23] The underlying principle of treatment as prevention relies on comprehensive ART coverage.[35] A persons initial linkage to and engagement in care becomes an important indicator to measure the success of this elimination strategy success. People living with HIV in Queensland may be engaged in care either through public hospitals, sexual health services and community-based general practitioners or specialists.

The proposed process for viral load notification was designed to use existing infrastructure; notification procedures work flow and data management requirements in place for HIV notifications in Queensland (**Figure 4.3**). Laboratories would notify each viral load test as a separate notifiable condition type, with results matched to existing HIV notifications by name code and date of birth where possible; where no existing notification is identified (such as those with initial diagnosis overseas or interstate), a new record would be created in NoCS.

The broader population of interest is all PLWHIV in Queensland, though the target population for this proposed surveillance system is those diagnosed PLWHIV with reportable viral load tests results.

Key integration points are the secure transfer of results to Queensland Health, the same restriction of access to the HIV public health team, manual entry and matching to name code and date of birth and data storage in the approved notifiable conditions register NoCS.

Case definition

Under the proposed definition, a case would be defined as any individuals who underwent a laboratory-performed viral load test in Queensland. Notifications would include name, date of birth, viral load result, health provider requesting the test, postcode, date and name of laboratory testing performed. Notifications are then recorded in NoCS using the name code.

Data sources

Data for the surveillance process will come from public and private laboratories performing viral load testing in Queensland. It is proposed that when a viral load test is undertaken by request of a clinician, the performing laboratory will notify Queensland Health of the viral load test information as described in the proposed case definition (above).

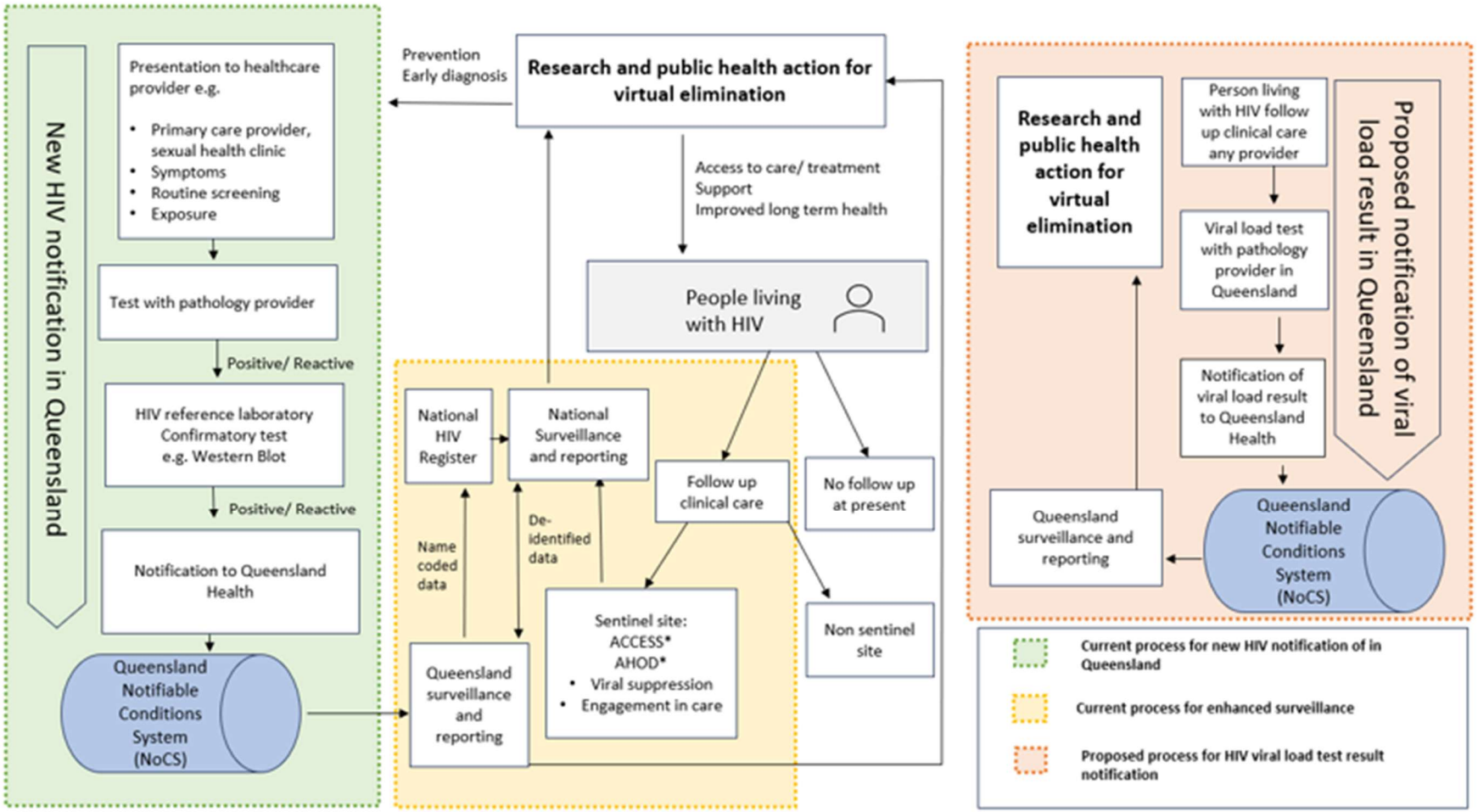


Figure 4.3: **Process flow map of new HIV notification process in Queensland, current process for enhanced surveillance and proposed process for viral load notification**

Attribute assessment

Simplicity

The proposed system fits into the current process for capturing notifiable conditions in the notifiable conditions register (NoCS). With manual entry required, there will be a workload for the data officers. The most appropriate method of secure transfer testing results would also need to be established to maintain the high level of confidentiality as well as agreed data processing time intervals. The estimated number of viral load tests performed in pathology services in Queensland each year is around 11,334 this equates to 217 test results to be entered per week

Sensitivity

Incorporating HIV viral load testing data into public health surveillance should increase the sensitivity of detecting viral suppression and engagement in care, as shown in **Table 4.4**. Currently, the system captures de-identified viral load testing information for those attending sentinel sites. Reliance on sentinel sites (17 of approximately 117 national sites in Queensland) introduces potential gaps in areas of surveillance, such as in geographical areas with traditionally lower incidence rates, or in PLWHIV seeking healthcare from providers other than sentinel sites.

As the health workforce including primary care providers are upskilled in line with policy that aims to increase access to culturally safe care the number of PLWHIV attending sexual health clinics (which provide the source of most of the sentinel surveillance information) may also decrease. In the most recent HIV report attendance to ACCESS sites decreased following the COVID-19 pandemic and recruitment to AHOD was highest between 1999–2000, with 1,245 active participants.[23,36]

Engagement in care estimates using national de-identified data from both sentinel and treatment records potentially reduces the surveillance system’s ability to identify flags or cohorts for engagement. The notification of viral load results in Queensland would provide ongoing and timely detection of treatment failures and care disengagement across healthcare settings. The 2024 clinical audit of PLWHIV in Queensland who may be lost to follow up undertaken by Queensland Health, provides a timely insight into the public health actions that can be implemented with improved case detection for PLWHIV (S. Greenbank, Communicable Diseases Branch, Queensland Health, personal communication, July 2025).

Representativeness

In Queensland 85% of new HIV cases are notified within South East Queensland, though, this may not be reflective of the geographical distribution of all PLWHIV residing in Queensland as it only captures new notifications. The average annual number of new HIV notifications diagnosed in Queensland was 134 (2018–2022). In the recent reengagement audit, there was estimated to be approximately 6,000 PLWHIV in Queensland. Aggregated reporting of national trends provides limited information for individual jurisdictions to evaluate their service or model of care.

Information collected from sentinel sites are critical for periodic national and WHO reporting by providing an indication of progress towards elimination targets. However, the notification of viral load results would provide data that is more reflective of the true epidemiology of HIV across the state. This would allow for more targeted public health responses, quality improvement processes and benchmarking that accurately represents the population and healthcare landscape. A comparative analysis (**Table 4.4**) demonstrates how representativeness could be improved across surveillance components.

Table 4.4. Key characteristics of sentinel based-surveillance system for reporting viral suppression and engagement in care in Australia compared with proposed system in Queensland

Surveillance	Sentinel-based (current)	Proposed	Sensitivity Impact	Representativeness Impact
Data sources	National ACCESS & AHOD sites	All pathology providers in Queensland	More testing sites included	Eliminates participation bias
Data capture	Additional software to be installed for de-identified reporting	As per Queensland's existing process for notifiable conditions into NoCS	Leverages existing infrastructure	Consistency across all providers
Data storage	Aggregated de-identified data held by independent organisation	Data added to NoCS notification in existing anonymity coding (as per existing HIV requirements)	Maintains same data storage as existing for notifiable conditions	Maintains same data storage as existing for notifiable conditions
Population	Sample of people living with HIV in Australia	All people living with HIV having viral load testing in Queensland	Complete population of those having viral load tests	Removes sampling towards participating sites/ individuals
Reporting	Annually Overall national data	Continuous Queensland specific	Real time vs delayed	Captures temporal patterns and trends
Geographic location	Queensland 17 of ~117 sites** 22% of new HIV notifications in 2023 (158/722)	Statewide	No geographical differences for case detection	True geographical distribution for Queensland
	South east Queensland* 10 of ~117 sites ** 85% of new HIV notifications in 2023 (134/158)			

Surveillance	Sentinel-based (current)	Proposed	Sensitivity Impact	Representativeness Impact
Health service type	Sexual Health Services and some specialised GP's	All health care providers requesting viral load testing	Eliminates health care-setting related detection gaps	Represents healthcare use

* South east Queensland: Metro North HHS, Metro South HHS, Gold Coast HHS, Sunshine Coast HHS, West Moreton HHS. **(ACCESS and AHOD combined)

Acceptability

Acceptability for this project is defined as whether viral load notification would be acceptable to the users, including end users and PLWHIV. Queensland Health's acceptability of the proposal is evidenced through its inclusion in strategic planning documents such as the Queensland HIV Plan 2030 and wider commitment to comprehensive data collection and reporting informing service delivery as outlined in the Queensland Sexual Health Framework. However, acceptance remains conditional on wider stakeholder acceptance ensuring implementation does not compromise other priorities such as testing, person-centred care or increase other barriers such as stigma and discrimination.

Stakeholder engagement

Six semi-structured stakeholder interviews were completed. There was consensus across all stakeholders that PLWHIV are the key stakeholders for this change in surveillance methods, reflecting they can only share from their own experience. The following section summarises the perspectives from the stakeholder interviews, organised into key themes relevant to the acceptability and implementation of the proposed surveillance system.

Feedback from stakeholders was mixed for a viral load notification process. While most agreed this indicator has potential public health benefits and referenced the WHO 95-95-95 elimination goals, there was also hesitancy in collecting individual-level information from a privacy perspective. Four of six stakeholders stated that aggregated viral load testing data available at a local level could inform service level planning or interventions and this is not something that can be captured in existing medical software or data systems. Stakeholders expressed uncertainty about Queensland's progress toward elimination goals due to data gaps. An infectious disease physician noted:

> *"It's challenging to know where we are at, where we're heading in terms of those larger goals".*

However, there was not a consensus on this as a stakeholder stated that viral load results, even when aggregated, would not have usefulness to them and was a lower priority compared to other actions, such as diagnosis and testing initiatives.

Three stakeholders strongly supported enhanced surveillance to include viral load. The peer representative stated:

> *"We can get a better picture of how successfully the epidemic has been managed... If we're serious about virtual elimination of HIV, we need to be able to identify where it is. We should be able to say, 'here we are, we've got the stats and we know what the breakdown is' rather than saying 'we don't actually know' when people ask about viral loads in specific populations like people over 60 or culturally diverse communities".*

Privacy and Confidentiality

Concerns regarding privacy and confidentiality were the main issues across all stakeholders however, stakeholders also acknowledged there are no current concerns with confidentiality with the current notification surveillance system (NoCS) to which new HIV cases are notified.

Confidentiality, stigma, discrimination, and criminalisation were dominant concerns identified for those stakeholders working directly with PLWHIV. The support and advocacy stakeholder commented that it could be a slippery slope in surveillance of PLWHIV, and it was important to understand how this information was used by governments in the future stating:

> *"There's a there's a lot of scope for some stigmatisation to happen in that space…it's a slippery slide in terms of criminalisation or other increased surveillance."*

Five of the six stakeholders engaged emphasised the importance of comprehensive community engagement and clear guarantees from government that the data would not be used in a punitive way. The support and advocacy stakeholder highlighted that, for example, individuals may be concerned about reported tests and the potential impact to their immigration status. Stakeholders stressed that maintaining confidentiality is critical to prevent testing deterrence. A peer representative stated

> *"you've only got to have an instance of a breach of confidentiality and that will have a detrimental effect on people... we want to create an environment where people are very confident to be able to go and have tests and they know that there's no repercussions."*

Adding:

> *"We need to put into practice that we're not going to share any of this sensitive information for punitive reasons or legal reasons".*

The support and advocacy stakeholder stressed the importance of communication:

> *"if people didn't understand that heir viral load was being surveilled in a non-identifiable way. I think it would create barriers to actually showing up for treatment".*

Non-punitive changes with strong legislative protections were central conditions to support from two of the six stakeholders. The peer representative emphasised:

> *"The minute data is used punitively, testing will become a barrier, and people won't test if they think they'll be penalised."*

Stakeholders acknowledged the lived experience perspective, a stakeholder involved in clinical care noting:

> *"It's easy for me to say that because I'm not living with HIV... there is mistrust available to people all the time"*

This was a sentiment that was echoed from all stakeholders.

Workload

Increased workload was identified as a secondary concern. Four of the six stakeholders described satisfaction with the structure of HIV surveillance system and management in Queensland and, feel that Queensland would be in a good position to appropriately introduce such viral load surveillance. The stakeholder involved in statewide surveillance noted:

> *"Our data quality is always very good because the HIV surveillance model in Queensland, a more centralised approach HIV public health team centrally managed the data collection and the follow up."*

The support and advocacy stakeholder praised the current system:

> *"How fantastic that you've got a centralised system that is on the pulse with diagnosis and resourcing to enable good diagnosis to people and also having such a close partnership with a peer-based community organisation as well".*

However, increased workload from manual data entry was raised as a concern. The surveillance stakeholder described receiving the viral load results from laboratories and manually entering them as per name code into NoCS as *"inefficient*". On the other hand, the HIV public health team stakeholder felt having all viral loads reported would reduce their administrative workload and improve the ability to focus on other priorities stating:

> *"It would help in our role so much to have that. For us 100%."*

Reliability and coverage

All stakeholders agree viral load testing could be an indicator of engagement in care, more reliable than other methods such as PBS medication dispensing information as a stand-alone indicator. However, the support and advocacy stakeholder cautioned the achievement of viral suppression should not be the indicator of engagement in care, due to commonality of blips or individual level circumstances.

Stakeholders expressed concern about limited visibility of private sector HIV care, particularly if results were only notified by public pathology services. A stakeholder involved in clinical care noted:

> *"There's a lot of care that occurs in the private sector that I just don't have visibility of, so I don't necessarily understand what the results in the private sector look like."*

Adding:

> *"There's a small subset of people that go to private prescribers or GPs to keep their results out of the system".*

This coverage gap raised concerns about creating a two-tiered surveillance system that captures only those accessing public services, potentially skewing data and excluding those with greater privilege and resources who access private care. The support and advocacy stakeholder warned this could leave marginalized communities as the most surveilled, compounding existing stigma and structural disadvantage. Without a complete picture of viral load testing, stakeholders noted the risk of certain sub-groups not being captured appropriately, creating missed opportunities for support and intervention while potentially leading to problematic assumptions that drive interventions increasing surveillance of vulnerable groups.

Community engagement

All stakeholders regardless of where their views sat within the HIV surveillance spectrum underscored the importance of ongoing engagement with the HIV community on any proposed changes. It was suggested that working with peer support and advocacy groups would relieve any possible concerns from the PLWHIV community. It was also highlighted by a stakeholder working directly with PLWHIV that while virtual elimination of HIV is an in important public health milestone, the ongoing needs of PLWHIV also need to be considered.

All stakeholders acknowledged the importance of gaining perspective of people living with HIV. A stakeholder involved in clinical care reflecting:

> *" I'm not living with HIV and when I walk down the street, I don't think people think I have HIV. And that must be quite hard to get away from if you are living with HIV and you've experienced stigma in the past".*

Stakeholders spoke of the importance to acknowledge the diversity of experiences within the HIV community:

> *"You can't disconnect the science and the statistics from the lived experience of the person" and noted that "people with HIV are all completely different, the only thing everyone has in common is the fact that they're HIV positive."*

Discussion

Undetectable viral load is central to the treatment as prevention strategy and provides important information about whether PLWHIV are receiving effective treatment and are

engaged in care, thereby contributing to surveillance of progress towards HIV elimination. Enhanced monitoring within the existing HIV notification structures is valuable because while current surveillance captures new cases, viral load provides timely information and fills gaps in understanding population wide information. While virtual elimination and new case prevention is important so too is the ongoing care and advocacy for PLWHIV. Information gained through the notification of viral load has the potential to provide information on patterns of engagement in care and health system insights. Therefore, to be meaningful, surveillance findings should also flow back to those collecting information and the PLWHIV community in Queensland. It could also highlight what is working well, revealing successful treatment and retention d providing evidence-based improvement to policy applicable across the whole population of PLWHIV.

This evaluation used technical, operational and stakeholder considerations to provide insights to inform policy decisions about implementing a new surveillance system to capture HIV viral load in Queensland. This aligns with Queensland's HIV Plan 2030 and the 2023 National HIV Taskforce Report, both of which support evidence-based decision making to track progress and reach virtual elimination.

The proposed surveillance system has been demonstrated to easily be incorporated into the current HIV surveillance infrastructure and workflows. The acceptability has been explored with initial feedback from most stakeholder groups supportive, however, if it is to be implemented ongoing engagement with these stakeholder groups is important. As identified by all stakeholders, the lived experience, and insights of PLWHIV should be central to any policy in HIV elimination.

The potential increase in representativeness and sensitivity has been demonstrated. This would provide a more complete comprehension of the HIV epidemiology specific to Queensland, a geographically and culturally diverse state. This opens the potential for more effective public health policy planning.

To move towards elimination, public health data should be used in the most effective and appropriate ways. As stigma and discrimination are constant themes identified in this area of public health it is unsurprising that this would be identified as a concern. The importance of weighing public health benefits against individual risk has been identified by all stakeholders. As the proposed system uses the notifiable conditions practices for HIV, it is believed that the risk to privacy is unchanged. As the stigmatisation and discrimination toward PLWHIV

remains a concern, the continuous engagement of PLWHIV at all stages of development is paramount.

Limitations

While this exploratory assessment of feasibility revealed valuable insights, several limitations should be considered alongside the findings. Stakeholder interviews were completed with six stakeholders identified to be most relevant to this study, this may not represent all stakeholders, potentially affecting the generalisability of the feedback provided. Interviews were conducted with individuals identified as representative of their stakeholder groups, though it is acknowledged there may be variation within stakeholder groups, with factors such as age, years of experience, and personal experiences influencing their response. As this was an exploratory study, only one researcher was involved in the interviews, transcription and analysis. If the study were to be scaled multiple researchers to analyse interviews would be recommended to reduce researcher bias.

The estimated number of private pathology tests is taken from the Medicare item code numbers rather than being reported directly from private pathologies. There were differing numbers of sentinel surveillance sites from ACCESS and AHOD reported (ranging from 90–100), the number of sites reported in the 2024 AHOD report and Kirby HIV report were used. Sites that were contributing to both ACCESS and AHOD were only counted once. The study specifically focuses on Queensland, limiting broader applicability.

The following recommendations are made based on this review of system, reporting and stakeholder feedback to move forward with viral load becoming a notifiable condition. This staged approach prioritises community consultation for informed decision making and to maintain trust, as well as establishing clear protocol and data governance, while not disrupting other policy or strategies to support PLWHIV and elimination targets.

Recommendations

1. Ensure PLWHIV peers are involved in future discussions and progress on this topic. This could be done through:

    i. Collective information sessions with key stakeholder groups, potentially supported by an independent facilitator. Taking this approach will allow for the

assessment of acceptability of any proposed changes and foster shared decision-making that could inform broader HIV elimination policy in Queensland. The use of an independent organisation as a facilitator would add objectivity and may help participants feel more comfortable sharing honest feedback.

ii. Establishment of a data governance committee with representation from stakeholder groups with regular (quarterly/biannual) review of how viral load or other relevant data for PLWHIV is being used and managed as intended, to inform broad public health response and progress toward elimination.

2. Develop formal guidelines outlining the case definition and proposed process for viral notification. This should include clear policy of how data will be safely managed.

3. Explore any legal or regulatory amendments that may need to be made to enable viral load as notifiable condition in Queensland.

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Appendix 1: Stakeholder participant information sheet and semi structured interview questions

Participant Information Sheet

Introduction:

You are invited to take part in a discussion exploring the feasibility of making HIV viral load testing a notifiable condition in Queensland. The project is being undertaken as part of the Master Philosophy Applied Epidemiology program (Australian National University) under the supervision of Dr Stephen Lambert Senior Medical Officer at Queensland Health Communicable Diseases Branch. Insights from key stakeholders about how such a policy could impact public health and people living with HIV is an important part of this project.

As we move toward 2030 and virtual elimination targets, it is proposed that a more complete understanding of the engagement in care and viral load testing of people living with HIV in Queensland may be beneficial in reducing onward transmission. The collection of viral load testing information would be of benefit for both public health and the community by providing an indicator for engagement in care, signalling any global trends or changes in viral load testing and providing quantitative measurement for policy and reporting against UNAIDS 95-95-95 targets. This clearer picture may then allow for more targeting messaging or public health interventions to reduce transmission. This in turn may lead to improved engagement and better long-term outcomes for people living with HIV.

At present any testing completed at public health hospitals and associated health facilities are processed through, Pathology Queensland. The results of viral load testing, date and viral load are available to the Department of Health HIV Public health team for reporting for HIV care cascades and other patient engagement initiatives. Any testing undertaken in a private community laboratory is not available. Gaining a better understanding of HIV viral load testing being done in the community would assist the HIV public health understand whether individuals are already engaged in care, and whether, for some individuals further support may be needed to assist them to be maintained in care and on treatment.

Proposed system:

The option to make testing notifiable would allow viral load testing undertaken at a private laboratory to be linked using the relevant confidential process and notification system in Queensland.

Purpose of the Research:

This research seeks to understand stakeholder perspectives on viral load testing becoming a notifiable condition in Queensland. The findings will help to inform policy recommendations and ensure that any changes in reporting balance public health with individual privacy.

Why You Have Been Invited?

You have been identified as a key stakeholder due to your expertise, experience, or involvement in healthcare, policy development, or advocacy for people living with HIV in Queensland.

What Participation Involves

If you agree to participate, you will be invited to a one-on-one interview lasting up to 60 minutes. During this interview, we will discuss your thoughts, concerns, and any insights you may have regarding making viral load testing a notifiable condition.

The interview will be conducted via a virtual platform (Teams)

All information you provide will be kept confidential. No personally identifiable information will be included in the final report.

With your consent, the interview will be audio recorded to ensure accuracy. The recording will be stored securely and destroyed after transcription.

Risks and benefits

There are no foreseen risks associated with participating in this research. The benefit of your participation is contributing to important policy discussions on HIV elimination strategies.

Participation is entirely voluntary

You may withdraw at any point during the interview or decline to answer any question that makes you feel uncomfortable. You have the right to request that any of your contributions be excluded from the final report up until the report is finalised.

How the information will be used

The results will used as a chapter in a thesis of the Master of Philosophy (Applied Epidemiology), to inform policymakers and a summary of the work may also be published in academic journals and/or presented at conferences. No individual identifying information will be shared in any publication or presentation.

Data Protection:

All data collected during the interviews will be stored securely and in accordance with data protection laws. Only the research team will have access to the information.

The project is approved by the Australian National University Human Research Ethics Committee, 2017/909.

Contact Information:

If you have any questions or require further information about the research, you can contact the researchers at:

Gemma Devlin and Stephen Lambert
Gemma.devlin@health.qld.gov.au
Stephen.lambert@health.qld.gov.au

We greatly appreciate your time and insights and thank you for considering participation in this important study.

Stakeholder semi structured interview questions

Introduction:

You are invited to take part in a project exploring the feasibility of making viral load testing a notifiable condition in Queensland. The project is being undertaken as part of the Master Philosophy Applied Epidemiology program (Australian National University). Insights from key stakeholders about how such a policy could impact public health and patient rights is an important part of this project.

Reminders:

- During this interview, we will discuss your thoughts, concerns, and any insights you may have regarding making viral load a notifiable condition.
- With your consent, the interview will be audio recorded to ensure accuracy. The recording will be securely stored and destroyed after transcription.

- All information you provide will be kept confidential. No personally identifiable information will be included in the final report.

- You may withdraw at any point during the interview or decline to answer any question you feel uncomfortable with. You have the right to request that any of your contributions be excluded from the final report up until the report is finalized.

- The results will used as a chapter in a bound volume of the Master of Philosophy Applied Epidemiology published thesis, to inform policymakers and may also be published in academic journals, presented at conferences. No individual identifying information will be shared in any publication or presentation. Results will be presented at organisation/ team level.

Questions

1. Briefly describe your role in HIV policy, service delivery or surveillance in Queensland

2. In your role, how often is HIV viral load testing information used (for example service delivery, reporting, policy)

   Prompts

- *Daily*
- *Weekly*
- *Monthly*
- *Yearly*
- *Not at all*

2 Would surveillance of viral load testing be beneficial to you in your role?
Prompts: What could the benefit be from a public health perspective, why/ why not

3 What is your opinion on viral load testing as an indicator of engagement in care?

4 In your opinion and experience, what are some challenges with viral load testing surveillance, and what could be done to potentially address these (as relevant to your role)?
Prompts:
- accuracy and completeness
- confidentiality
-workload
-system issues
- private lab testing

5 Do you have concerns related to making viral load testing a notifiable condition?

6 Do you have any other comments/feedback on viral load testing surveillance and engagement of care indicators in Queensland?

Additional question for those involved in policy and reporting:

7 Viral suppression and engagement in care are used for reporting on the HIV elimination targets. In your opinion how simple is the current process for this?

Appendix 2: Feedback for participating stakeholders

Background

This project explored whether HIV viral load tests should become notifiable in Queensland - meaning laboratories would be required to report all HIV viral load test result to Queensland Health through the existing pathways they do for HIV now. The goal of this would be to better understand patterns of engagement in care and viral suppression in people living with HIV, and to monitor public health interventions as we progress toward virtual elimination of HIV by 2030. Unltimately, this could help Queensland better support people living with HIV and work toward ending new infections.

What we did

We interviewed six key people including peer representatives, clinicians, surveillance staff, and advocates. We also looked at how current HIV reporting works and whether viral load reporting could integrate into existing systems.

Key findings

Participants brought a range of viewpoints and thoughtful perspectives to these discussions. Most participants agreed viral load reporting could help with monitoring elimination targets and broader public health goals, though some stated that it would have limited use in individual care. Concerns were raised that some population groups aren’t captured in the current system.

Privacy and confidentiality were the main concerns given HIV still carries stigma and discrimination. Overall, participants were satisfied with current HIV notification protections though emphasised on upholding legislative safeguards against misuse of data. Interviewees called for comprehensive community consultation to prevent discouraging people from testing. Concerns were also raised about increased workload though more manual data entry, though a clinician felt more complete reporting would reduce their administrative workload.

Everyone interviewed agreed people living with HIV need to be central to developing any policy decisions, stating “You can't disconnect the science and the statistics from the lived experience of the person"

Regarding the need for broad engagement, people spoke of the importance of acknowledging the diverse HIV community: "people with HIV are all completely different, the only thing everyone has in common is the fact that they're HIV positive."

Next steps

Insights will be provided to the program area, and key findings will inform direction and next steps for future policy development. Thank you for taking the time to share your insights as a key stakeholder in HIV care, surveillance and advocacy in Queensland. All individual participant responses remain confidential.

This project was undertaken as part of the Master Philosophy Applied Epidemiology program at Australian National University.

Contact

Gemma Devlin, Master of Applied Epidemiology (MAE) Scholar, Australian National University
gemma.devlin@health.qld.gov.au.

Supervisor: Stephen Lambert
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Chapter 5: Epidemiology of recurrent invasive Group A Streptococcal disease, Queensland, 2006–2024

Prologue

Background

Invasive Group A Streptococcal (iGAS) disease has been a notifiable condition in Queensland since late 2005 and became nationally notifiable in 2022. This means that there are nearly two decades of iGAS data in the Queensland notifiable conditions system (NoCS). It had previously been noted that there were cases with recurrent episodes of iGAS within the surveillance data. Recurrent iGAS is rarely mentioned, much less well described in the literature. This project uses surveillance data collected over the last 20 years to describe recurrent iGAS, while also describing overall iGAS epidemiology.

My role

For this project I completed a relevant literature review and developed the research protocol. I prepared the ethics, governance and relevant data requests for the project. Data cleaning and analysis were performed using R, I developed the appropriate R code to enable this. I coordinated research team meetings for discussion regarding analysis and findings, and finally, I drafted manuscript for publication, which forms the body of this chapter.

MAE competencies

This Chapter met the following MAE competencies:

- Conduct an epidemiological study
- Literature review (Appendix 1)
- Draft manuscript for submission to a peer-reviewed journal.

Lessons learned

A central part of this project was the consideration and application of Indigenous Data Governance and Indigenous Data Sovereignty principles in research. While the study did not intentionally recruit First Nations peoples, the initial review of data indicated higher overall iGAS rates in First Nations peoples compared to non-First Nations people, and that First Nations peoples represented a significant proportion of recurrent iGAS notifications. A higher burden of disease in Indigenous populations internationally was also identified in the

available literature. This project allowed me to further understand and apply Indigenous Data Sovereignty principles in relation to routinely collected surveillance data. I had the opportunity to work with a First Nations health expert to develop appropriate analysis, contextualise presentation of results, as well as the best dissemination strategies for findings relevant to First Nations health. While these were key for the ethical approval process, they are also integral to building trust and respectfully contributing to public health research involving First Nations health. While the importance of these principles was acknowledged at my field placement, the pathway for meaningful and appropriate engagement for research involving First Nations people in the context of statewide routine surveillance data has not been well established. Larger projects, or where data will be collected prospectively in specific research projects, may have the option to set up community consultation, however, the feasibility and appropriateness of this in the timeframe of the MAE Program and with routinely collected statewide data is something that requires further discussion.

This project provided me the opportunity to use most, if not all, the skills I have developed over the course of the program. I was able to develop my technical skills and experience not only using but interpreting and contextualising statistical analysis methods such as survival analysis and Cox proportional hazards modelling for this study.

Public health impact

This 19-year analysis of iGAS recurrence addresses a significant gap in the literature and provides evidence for clinical decision making. Our findings show the recurrence risk increases with episode and intervals between episodes decrease. These findings could inform patient-level follow up protocols and guidelines and future vaccine strategies as novel vaccines are developed. Developing a vaccine that provides broad protection across diverse emm-types is highlighted in this project

The analysis of interactions between geographical remoteness and First Nations status highlights the need for parallel strategies and provides data for evidenced based public health action. The analysis also revealed pandemic related impacts and patterns of *emm*-types demonstrating the value of combining molecular and case-based surveillance to identify epidemiological changes. The diversity of *emm*-types observed in initial and recurrent episodes could inform vaccine development. The dissemination plan developed with the First Nations health expert on the research team is an important factor in ensuring the information

is available to inform local responses. Through publication, the manuscript will also contribute the literature for iGAS which is of interest both nationally and internationally.

Acknowledgments

I would first and foremost like to acknowledge and thank Kevin Toby, for his guidance and advice on appropriate and respectful research involving First Nations peoples and application of Indigenous Data Governance and Indigenous Data Sovereignty principles. For their encouragement and reassurance through all stages of this project, I thank my supervisors Emma Field and Stephen Lambert. I also acknowledge previous Master of Philosophy (Applied Epidemiology) (MAE) scholars, Jonathon Malo, whose project on recurrent invasive pneumococcal disease helped shape this project and Anthea Gomez, who initially undertook a high-level review iGAS data in Queensland, before leaving the MAE program to have her first child.

Intended Journal

Prepared in accordance with the author guidelines for a major article for *The Journal of Infectious Diseases*.

Title

Epidemiology of recurrent invasive Group A Streptococcal disease, Queensland 2006 to 2024.

Authors

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Word Count

Abstract: 257 (limit 250)
Main body: 3564 (limit 3500)
Tables/ Figures:8 (limit 7 with 4 panels)

Abstract

Background

Invasive Group A streptococcal (iGAS) disease recurrence patterns are not well understood. This study describes overall epidemiology and recurrence patterns of iGAS in Queensland.

Methods

Retrospective analysis of all notified iGAS cases in Queensland 2006–2024. Recurrence was defined as two or more episodes at least thirty days apart. Survival analysis and multivariable cox regression were performed to review recurrence risk factors.

Results

There were 5,533 notifications of iGAS between 2006–2024. The overall average annual incidence rate was 5.8/100,000 people/year. Age-standardised incidence rates for First Nations people averaged 46.5/100,000 people/year compared to 4.2/100,000 people/year for non-First Nations people.

Recurrence was recorded for 180 (3.4%) individuals with survival analysis showing episode free survival at one year was 98.4% after first episode, 88.9% following second episode. The median time from first to second episode was 404 days with reduced time intervals between recurrences.

Multivariable cox regression showed episode number was the strongest predictor for recurrence (HR 2.86 for second vs first episode), with age (HR 1.18 per decade) and geographical remoteness (HR 2.09) also significantly associated. Variation in *emm*-types was observed in first episode compared to recurrent episodes.

Conclusion

iGAS recurrence risk increases with each subsequent episode – inter-case intervals decrease, and *emm*-type variations are observed with recurrent cases. These findings can inform clinical guidelines and vaccine development. Significant case disparities in First Nations peoples warrants investigation. Enhanced surveillance, longitudinal studies, and

improved data sharing in line with the National Agreement on Closing the Gap priority reforms are needed for comprehensive understanding of disease burden and evidence-based prevention strategies.

Key words: Invasive Group A Streptococcal disease, Disease recurrence, Survival analysis, Geographic remoteness, Health equity, First Nations health, Australia.

Background

Invasive Group A Streptococcal disease (iGAS), caused by *Streptococcus pyogenes* (commonly referred to as group A streptococcus (GAS)), is a serious invasive bacterial infection occurring when bacteria invade normally sterile sites, such as blood, cerebrospinal fluid, or pleural fluid.[1] While GAS commonly colonises the throat and skin, without causing any symptoms, invasive GAS infections can manifest in a number of different life threatening clinical presentations, such as bacteraemia, sepsis, meningitis, septic arthritis or postpartum/neonatal sepsis with fatality rates reaching 30–50%.[1–3]

In 2005, the World Health Organization estimated 663,000 iGAS cases occurred globally each year resulting in an estimated 163,000 deaths.[4] During the COVID-19 pandemic period cases fell and then surged markedly in 2023, particularly in children, with the easing of non-pharmaceutical interventions.[5,6] Introduction of unfamiliar strains, changes in transmission patterns and behaviours in risk groups, and seasonality have been offered as explanations for previous upsurges.[7] Seasonality has been reported in northern hemisphere studies, however, Australian studies have not observed the same seasonal patterns.[7–9] Higher risk has been reported following an infection with varicella, hepatitis C or influenza viruses, and increases in these viruses may also be associated with a surges in iGAS.[10–12]

Clinical risk factors for iGAS have been identified as existing skin lesions/infections, cardiac disease, diabetes, HIV, and receiving renal dialysis.[1,8,13,14] Cases can occur where no risk factor has been identified, in particular when the disease occurs in children.[13,15] There is some diversity in the age groups most affected globally, however, most studies identify higher rates in the elderly and young children, and all report the predominance of males.[2,16–19]

Higher rates of iGAS disease are reported in First Nations peoples compared with non-First Nations people in the Northern Territory, Western Australia, and North Queensland. Disproportionate rates are also observed in Indigenous communities compared to non-Indigenous populations in Canada, among Native American and Alaskans in the United States, and among people with Pacifica, Māori and Asian ethnicities in New Zealand.[8,20–26] This higher burden of disease has been associated with high-density living, such as in household overcrowding and shared residential settings , remote residence, and social disadvantage, though microbiological factors and genetic vulnerability remain unexplored.[8,20,21] The emergence of highly virulent sub-lineages, such as $M1_{UK}$, identified in

2019 and becoming dominant globally, including in Australia, by 2020–2023 raises additional concerns about increased disease severity in priority populations.[27,28]

While some individuals have experienced more than one iGAS infection, recurrence is not well understood. Australian studies from Victoria and the Northen Territory report recurrence in 1.4–4% in the general population (up to 17% in dialysis patients), with previous iGAS infection identified as a potential risk factor. However, this risk factor is often not described or quantified further.[8,13,22] Prior infection with the same pathogen as a standalone risk factor has been identified in research into other invasive bacterial diseases, such as invasive pneumococcal disease (IPD).[29] In addition, there are currently no licenced vaccines for GAS, though several candidates targeting the M-protein and conserved antigens are in development. However, understanding variance across episodes and/ or emm-types will informdevelopment and implementation of utilising vaccines as an effective public health measure.[17]

This study describes the overall and recurrent epidemiology of iGAS in 2006–2024, in Queensland.

Methods

This retrospective case series analysed all confirmed and probable invasive Group A streptococcus cases identified per the Communicable Disease Network Australia (CDNA) case definition from 2006–2024 in Queensland.[1] Recurrent cases were defined as >1 episode of iGAS in the same individual ≥30 days apart. Population rates were calculated using denominator data from the Queensland Health Statistical Services data (Australian Statistical Geography Standard (ASGS) 2011 Edition for 2006–2010 and ASGS 2021 edition 3 for 2011–2024) with age standardisation using Australian Standard Population (2001).

Descriptive analyses examined counts and rates for age, sex, health service area, First Nations status, *emm*-type. Seasonality was assessed through monthly case counts variations by location. Episodes were grouped into first, second, or third and greater episodes. Case fatality estimations used disease specific death data from the Queensland notifiable conditions system (NoCS). Clinical presentation and risk factors were extracted and the associated the free text fields from NoCS and analysed using word frequency analysis and specific terms searched to identify additional variables.

Emm-type data were available for 2021 onwards. 95% confidence intervals used log-transformation assuming Poisson distribution. Statistical significance was set to $p < 0.05$.

Survival analysis used Kaplan-Meier estimations methods to estimate episode-free survival. Median time-to-recurrence was calculated only among individuals who experienced recurrence (conditional median). Deaths were censored at end of the study date (31 December 2024). Episode-free survival was compared between groups using a log rank test.

Cox proportional hazards modelling included episode number, age, sex, First Nations status and remoteness using complete case analysis. Geographic remoteness used ASGS Remoteness Areas using correspondence files and further categorised into three groups: Major Cities, Regional (Inner Regional and Outer Regional), and Remote (Remote and Very Remote). The model was stratified by First Nations status due to violation of the proportional hazards assumption ($p<0.001$ for both First Nations status and remoteness). Stratification by First Nations status was chosen given documented health disparities and disproportionately higher rates of iGAS amount Indigenous populations globally. This allowed for different baseline hazards while estimating effects of other covariates, remoteness was retained an adjusted covariate. Effect modification between remoteness and First Nations status was tested using an interaction term in the cox model. The analysis used Microsoft Excel and R (version 4.4.1) with survival/survminer packages.

This study was approved by the Metro South Human Research Ethics Committee HREC/2025/QMS/116494 and the Australian National University Hurman Ethics and Research Committee (H/2025/0402).

Results

From 1 January 2006 to 31 December 2024 there were 5,533 cases of invasive Group A streptococcal disease notified in Queensland residents. This represents 5,309 individuals, with 180 recording more than one episode over the period. The average annual number of cases was 291, ranging from 109 (2006) to 624 cases (2023) (**Figure 5.1**). There was a decrease in cases during the response to the COVID-19 pandemic period with a decrease of 17% from 2019 to 2020 (334 to 277 cases), before an observed increase in cases in 2022 (394) and 2023 (624). The annual incidence rates for overall and recurrent iGAS disease 2006 to 2024 in Queensland are presented in **Figure 5.1**.

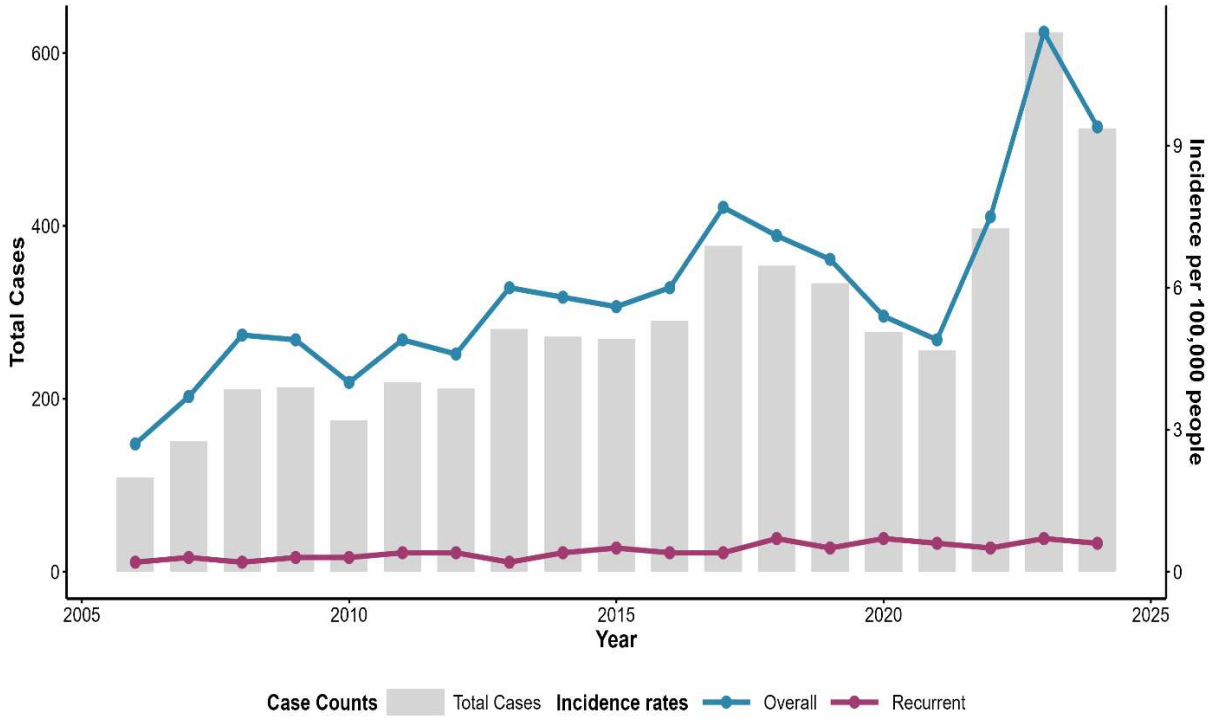

Figure 5.1: Annual case numbers and incidence rates of overall and recurrent invasive Group A Streptococcal disease 2006–2024, in Queensland.

Demographic characteristics of all cases (5,533) and stratified by individuals with single or recurrent disease (180) are presented in **Table 5.1**. No recurrent cases were observed in children younger than 5 years, compared with 9.9% (410/5129) of single episode cases. Age specific incidence rates are presented in **Figure 5.2**, with lower incidence rates observed in school age children and young adults compared with children younger than 5 years of age (particularly those under one year of age) and older adults. Most (70%) recurrent cases of iGAS occurred in individuals 50 years of age or older. The proportion of First Nations people was higher in those with recurrent disease (57% of recurrent cases, 21% of single cases).

The age-standardised annual incidence rate for iGAS disease in First Nations peoples and non-First Nations people as well as the rate ratio comparing the two are presented in **Figure 5.3.** The average annual rate ratio was 11.1 (95%CI 10.6–11.6) with the average incidence rates 46.5 (95%CI 41.2–51.8) per 100,000 people per year in First Nations people compared with 4.2 (95%CI 3.9–4.5) per 100,000 people per year in non-First Nations people**.**

When reviewing the trend of annual incidence rates in the period 2020–2021, the overall incidence decreased from 6.6 per 100,000 people per year in 2019 to 4.9 per 100,000 people per year in 2021, while the annual incidence rates in First Nations peoples remained stable, with the rate ratio increasing from 9.17 (95%CI 7.47–11.26) in 2019 to 15.07 (95%CI 12.12–18.76) in 2021. While the rate ratio dropped to its lowest value on record in 2023 (4.79, 95%CI 4.03–5.69), this appeared to be due to an increase in the incidence among rate non-First Nations peoples with only a modest decrease in rates among non-First Nations peoples.

Table 5.1: Demographics invasive Group A Streptococcal disease notification 2006–2024, in Queensland.

Characteristic	All Notifications		Individual Demographics		
	N	All Notifications[1]	N	Single N = 5,129	Recurrent N = 180
Sex	5,532*		5,308*		
Female		2,402 (43%)		2,229 (43%)	74 (41%)
Male		3,130 (57%)		2,899 (57%)	106 (59%)
Age group (years)	5,533		5,309		
<1 years		170 (3.1%)		170 (3.3%)	0 (0%)
1–4 years		340 (6.1%)		340 (6.6%)	0 (0%)
5–17 years		425 (7.7%)		420 (8.2%)	2 (1.1%)
18–49 years		1,657 (30%)		1,547 (30%)	49 (27%)
50–64 years		1,180 (21%)		1,043 (20%)	62 (34%)
65+ years		1,761 (32%)		1,609 (31%)	67 (37%)
First Nations status	5,296*		5,072*		
First Nations		1,274 (24%)		1,032 (21%)	103 (57%)
non-First Nations		4,022 (76%)		3,860 (79%)	77 (43%)

[1]All Notifications: all cases; Individual Demographics: unique individuals only
*Missing Sex = 1, First Nations = 237

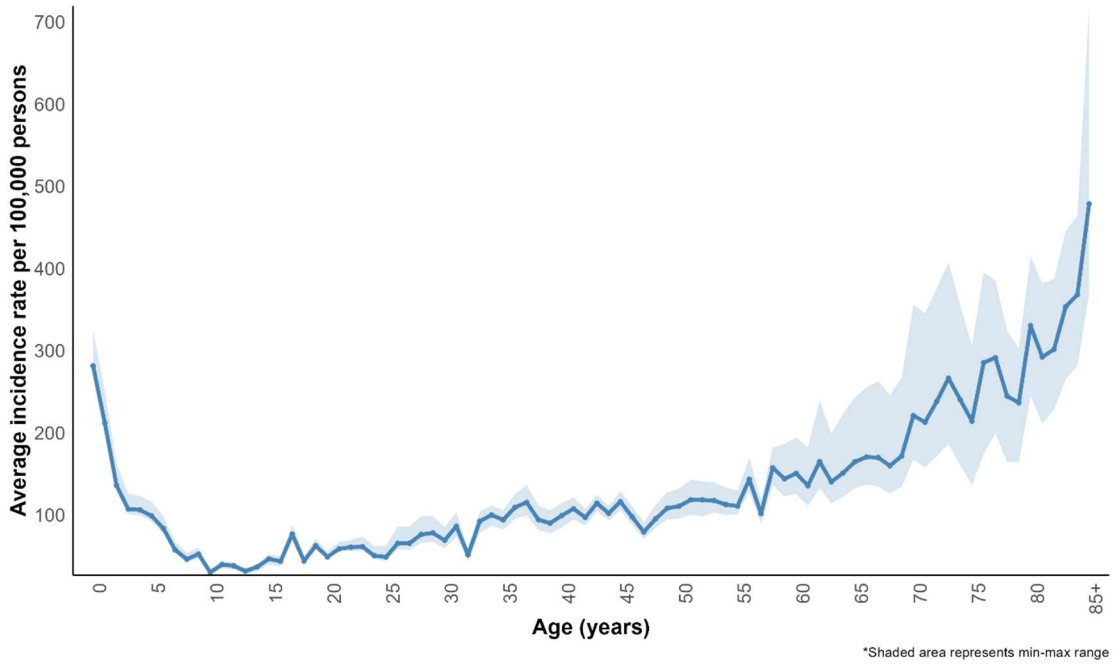

Figure 5.2: Queensland average annual age-specific iGAS incidence rate (with minimum and maximum age-specific rates annual rates) for overall notifications 2006–2024, in Queensland.

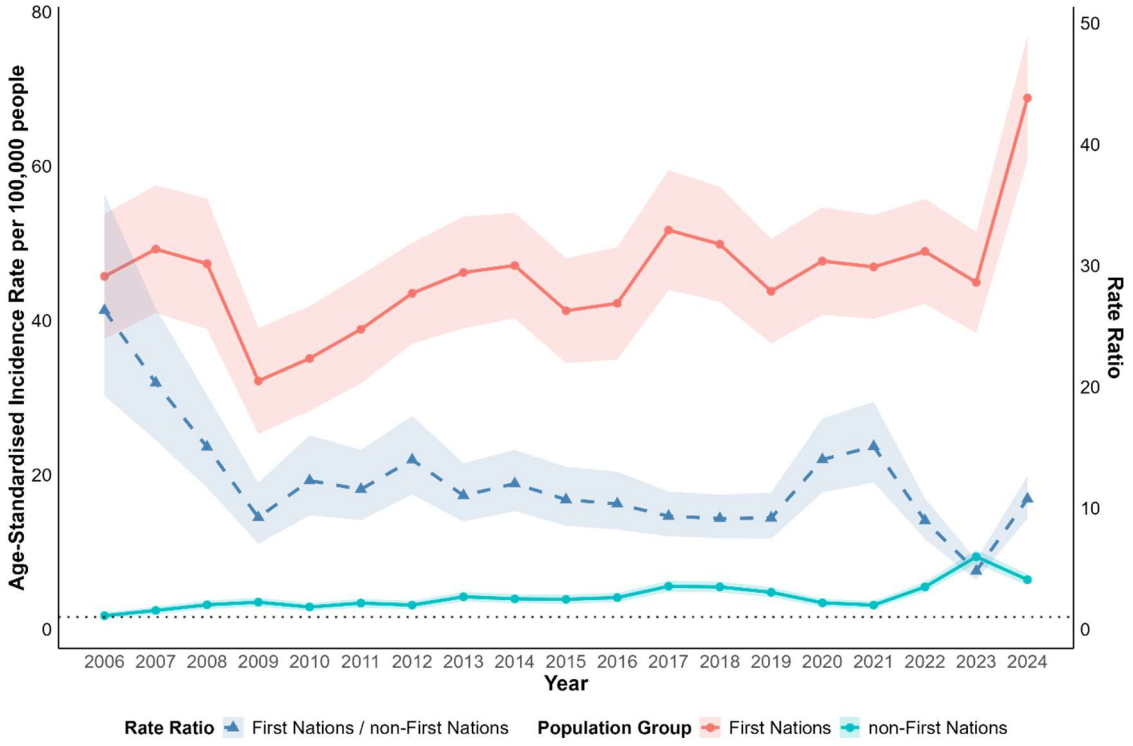

Figure 5.3: Age-standardised annual incidence rate by First Nations status and rate ratio with 95% CIs, 2006-2024, in Queensland.

The highest rates of iGAS were observed in Hospital and Health Service (HHS) areas in the northern parts of Queensland. Torres and Cape HHS and North West HHS recorded a five-year average (2020–2024) of 75 and 45 cases per 100,000 people per year, respectively **(Figure 5.4**). Monthly case counts over the 19-year period were analysed for an indication of seasonality. Overall, the monthly counts showed the highest number of cases were recorded in August/September. However, when reviewed by HHS, this varied with no single statewide dominant month in which cases peaked. Most variation was seen in South West and Central West HHSs with peaks in January and March, respectively. While Cairns and Hinterland HHS and Sunshine Coast HHS maintained consistent monthly case counts year-round.

Clinical presentations were recorded 1,907 cases (35.9%), with bacteraemia most frequent (1,381 cases, 72.4%) followed by cellulitis (250 cases, 13.1%), pneumonia (206 cases, 10.8%) and necrotising fasciitis (175 cases, 9.2%). Risk factors recorded for 1,806 cases (32.6%), were most frequently chronic disease (1,001, 55.4%), cardiovascular disease (597, 33.1%) and diabetes (447,24.8%). Among cases with recurrent episodes (>1 episode, n=180) the most common clinical presentation recorded was bacteraemia/sepsis (88/180, 48.9%) .

Overall iGAS specific case fatality across the 19-year period (2006–2024) was 3.1% (170/5,533). Data quality varied, with missing death information ranging from 3.2% in 2020 to 77% in 2006. Case fatality averaged 4.7% (range 3.1–6.8%) for 2022–2024, with missing death data from 17.3 to 19.5%. Three iGAS specific deaths were reported in recurrent cases, all occurring during or following the second episode.

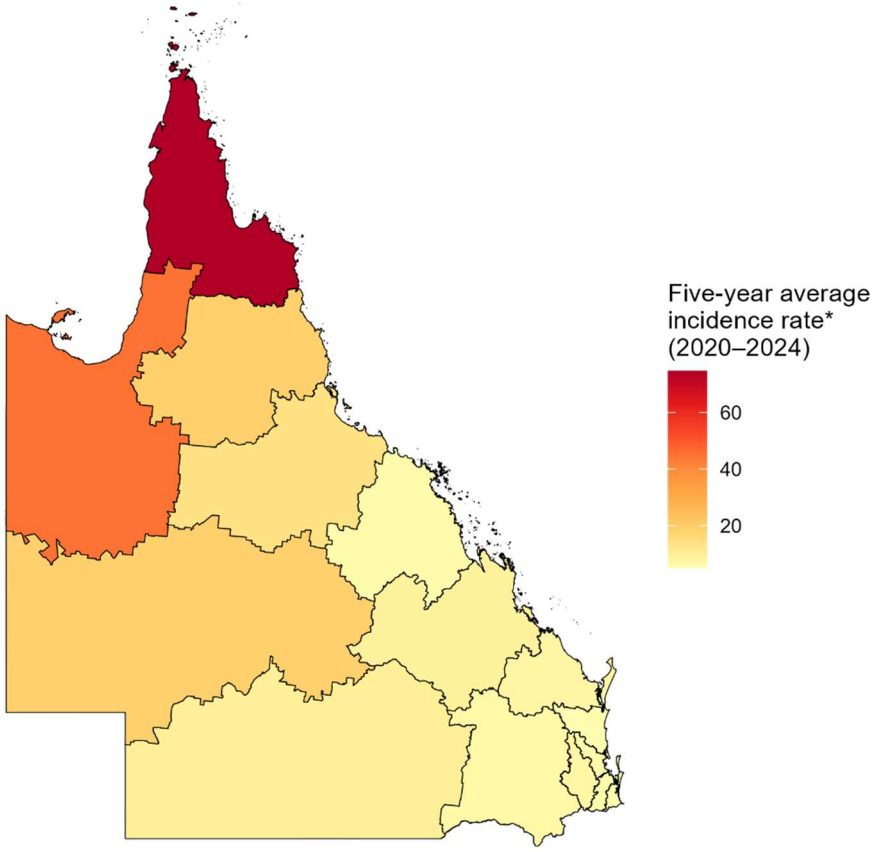

Figure 5.4: Map of 5-year average annual incidence rates of invasive Group A streptococcal disease cases by Hospital and Health service areas (2020–2024) in Queensland.

There were 5,532 episodes included in the survival analysis between 2006 to 2024, which included 5,309 unique individuals. Overall recurrence rate was 4% (223/5,532) and median time from first to second episode 404 days (1.1 years), then second to third episode was 313days (0.9years) and three or more episodes, 263 (0.7 years). The probability of remaining episode free following each occurrence is presented in **Figure 5.5**. After the first episode the probability of remaining episode-free at one year is 98.4%, after the second episode, 88.9% and following the third, 92.9%.

Multivariable cox proportional hazards modelling was performed including age, sex and First Nations status (**Table S 1**). Due to violating proportional hazards assumption indicating a change in risk over time, the model was stratified by First Nations status. Episode number was the strongest predictor of recurrence, with the risk 2.9 times higher after the second compared to the first (HR 2.86, 95% CI 1.96–4.17, p <0.001). Third and further episodes had

2.3-fold higher risk (HR 2.33, 95% CI 1.13–4.80, p<0.001). Age was also associated with recurrence risk, showing an increased risk of 18% with each 10-year increase in age (HR 1.18, 95% CI 1.11–1.26, p<0.001).

Further analysis of the hazards assumption violation and risk over time for First Nations status was completed and shown in **Figure S1**. Survival analysis revealed a difference at 3 months for non-Indigenous people and First Nations peoples of 99.4% vs 98.7%, respectively, this widened over time to 98.2% vs 91.9% at 3 years, respectively, supporting the use of the stratified model. Geographic remoteness showed a significant association with recurrence risk (**Figure S2**). Compared to major cities, residence in a remote area was associated with 2.09-fold higher recurrence risk (HR 2.09, 95% CI 1.38–3.17, p<0.001). Testing for effect modification showed no significant interaction between remoteness and First Nations status (p 0.087), suggesting geographic risk is similar across both cohorts. Remoteness also violated proportional hazards assumptions, however, stratification was not performed due to sample size constraints. The survival curves show that remote areas deviate from major cities and regional areas, with episode-free survival dropping to approximately 80% in remote areas compared to over 95% in major cities and regional areas by the end of follow-up, though this varied over time.

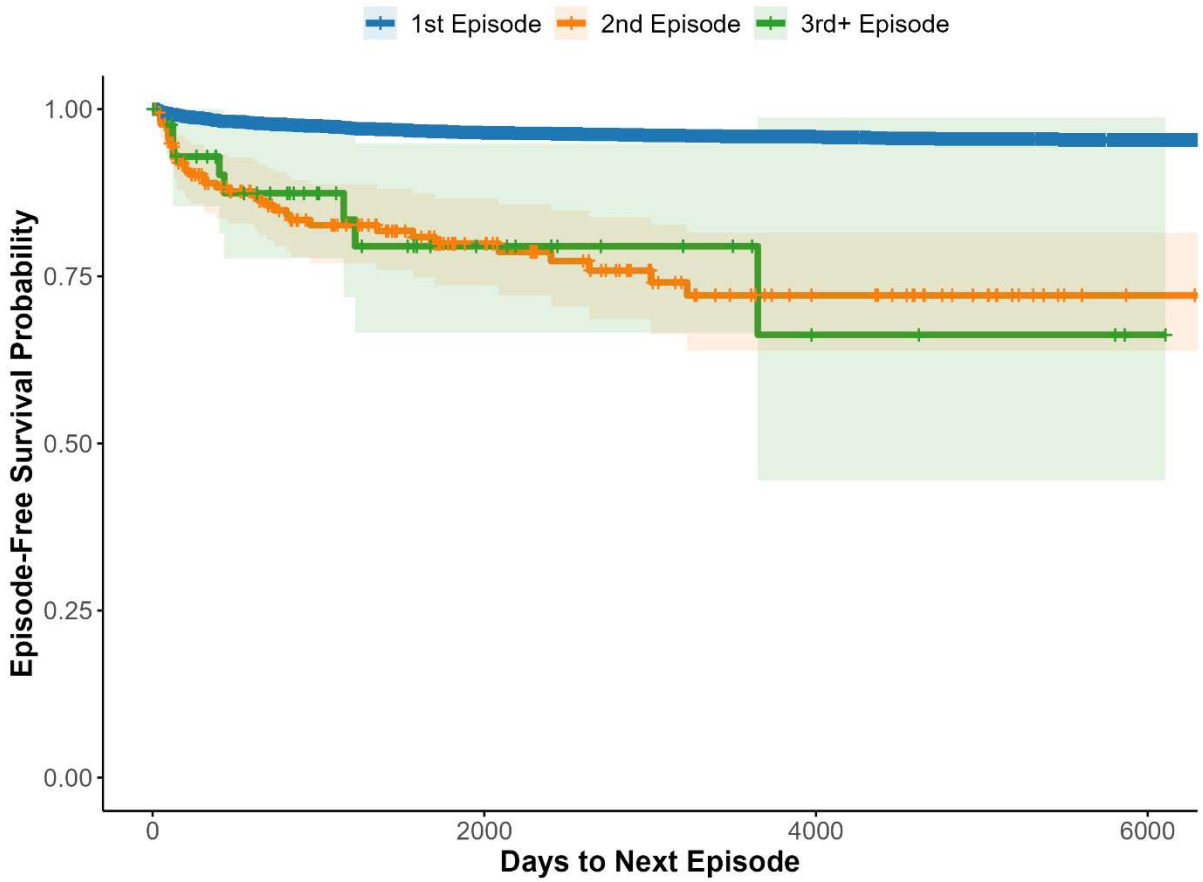

Figure 5.5: Kaplan- Meier episode- free survival probability curve by episode numbers stratified by First Nations status,

There were 1,544 cases (1,544/5,533) with *emm*-types available for analysis during the study period and of these, 129 *emm*-types were unique. The majority (98.9%, 1,528/1,544) of *emm*-types were recorded between 2021–2024. Of the 180 individual recurrent cases identified in the descriptive analysis, there were 35 with available *emm*-typing. The *emm*-type most identified in iGAS cases overall was *emm*1 (17%, 264/1,544), which showed an increase prominence over time from 1.4% in 2021 to 33.5% in 2023. This coincided with an increase in data completeness of *emm*-type information also increased across this period (57% to 90.9% respectively). Notably, 2023 was the peak year for cases in Queensland across this period.

Among the recurrent episodes *emm*108 was the most identified in the first recurrence (episode 2), identified in 48 episode first episodes and six second episodes among the same individuals. Only 50 of 180 episode 2 cases had *emm*-type data available, with *emm*1 identified in only two recurrent cases despite overall prevalence. Where *emm*-type data were

available for both episodes 1 and 2, 12 (34%) cases had the same *emm*-type across both episodes (none were the same from episodes 1–2 to episodes 3). Clinical presentations associated with these recurrent episodes with the same *emm*-type were bacteraemia and pneumonia, none recorded narcotising fasciitis in either episode 1 or 2. A summary of *emm*-types overall and across first and recurrent episodes is presented in **Figure 5.6.**

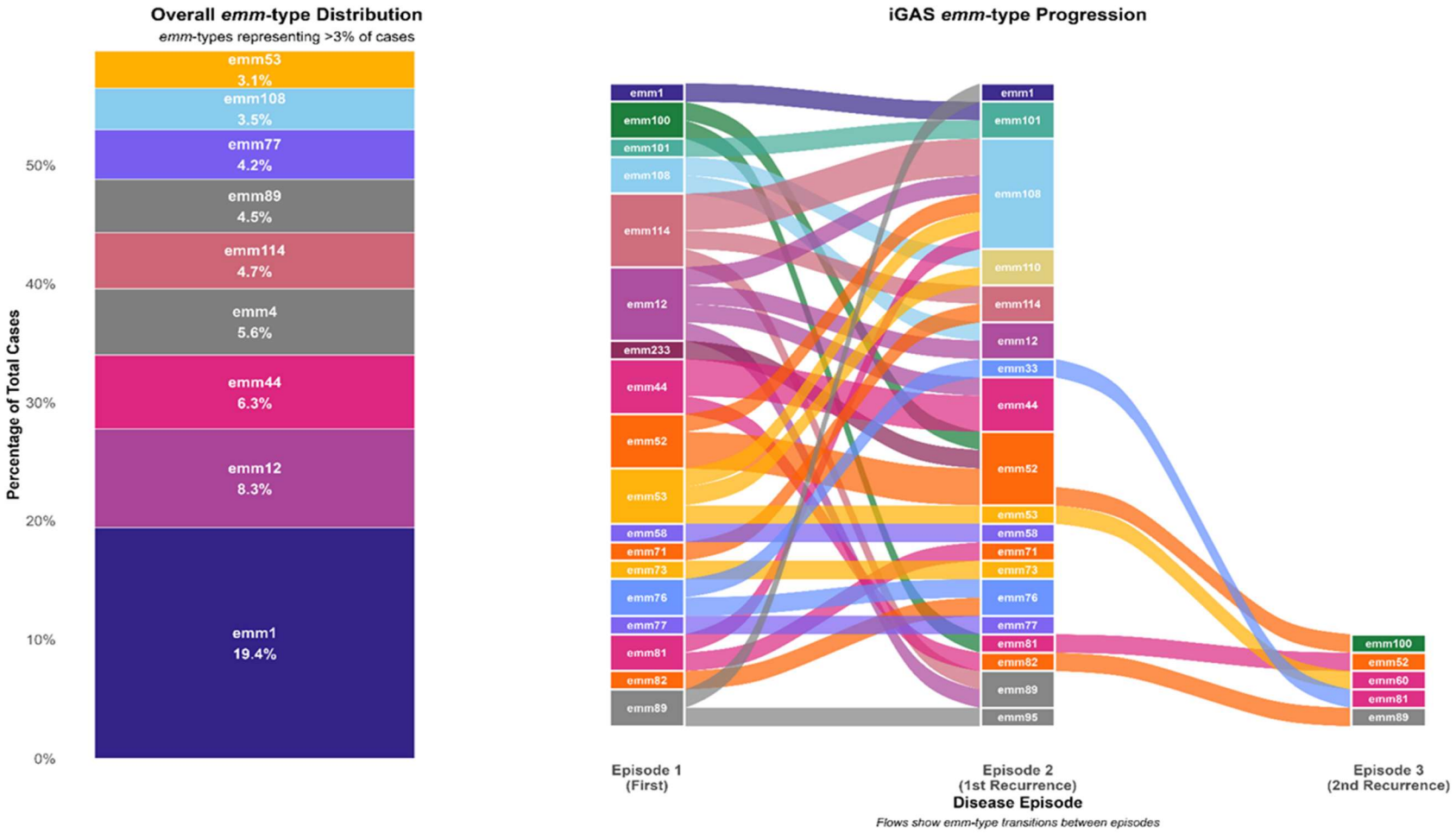

Figure 5.6 A. Distribution of iGAS cases by *emm*-type 2021–2024, Queensland. (A) Overall *emm*-type distribution*; (B) *emm*-type distribution by episode number in individuals with recurrence. * *Only emm*-types representing ≥3% of cases are shown in Panel A; 83 additional *emm*-types collectively representing 38.2% of cases are not displayed.

Discussion

Invasive group A streptococcal infections have been steadily increasing year on year in Queensland since becoming notifiable in 2005. A steep increase in 2023 coincides with several events. First, the easing of COVID-19 pandemic restrictions, iGAS becoming a nationally notifiable condition and development of a national guideline in 2022, as well emergence of highly virulent sub linages may have all contributed.[27] The rise in *emm*1 prevalence from 1.4% in 2021 to 33.5% in 2023 aligns with the documented global dominance of the sub-type $M1_{UK}$.[5,27] While data completeness of *emm*-typing increased during this period, the timing of the established $M1_{UK}$ suggests this sub-type likely contributed.

Children younger than 5 years and older adults were most affected, with older adults predominant in recurrent cases, consistent with other Australian studies. Geographically, northern Queensland HHS areas had the highest average overall incidence rates (2020–2024). Seasonal patterns varied across HHS areas, including within northern Queensland, with central and western areas showing the most pronounced monthly variation, peaking in January and March. This aligns with a Northern Territory study by Birrell et al. finding people with iGAS living in remote areas and those at greatest socio-economic disadvantage were disproportionally affected.[8] Seasonal observations in the Northen Territory over this period (2011–2021) were noted, although, population movement during the wet and dry seasons was identified as a contributing factor.[8] Population mobility data have not been collected in our study but could be explored further to describe temporal-geographical patterns in Queensland.

Studies from Victoria (2007–2017) and Northern Territory (2011–2021) reported recurrence prevalence of 1.4–4% across populations ranging from 128–1,979 cases.[8,13,22] Our Queensland data involving 5,309 individuals between 2006–2024 found a similar recurrence rate of 3.4%, representing the largest and longest Australian cohort to examine iGAS recurrence patterns. Over the period studied, most individuals with recurrence experienced two episodes, with a median time between first and second episode of 404 days and decreasing with subsequent recurrence. The dominant *emm*-types identified in the first individual episodes differed from those observed in subsequent individual episodes. This may be due to a change in dominant *emm*-types over time or immune mediated protection against the initial *emm*-type, reflecting a potentially important finding for vaccine development and implementation strategies.

Multivariate cox modelling for available risk factors demonstrated that recurrence risk increases with age and episode number. This is unsurprising when considering the age distribution of recurrent iGAS cases, with older adults most represented. When stratified by First Nations status this pattern persisted. Survival analysis of 5,532 episodes highlights the disparities observed in First Nations peoples, particularly the widening survival gap over time highlighting complex underlying factors requiring further investigation. Robust risk factor and individual level data, such as could be obtained through a larger longitudinal study or more consistent collection of these data during the notification process, would address these questions more comprehensively.

Population level disparities were particularly evident among First Nations peoples, who had higher incidence rates of iGAS for both overall and recurrent disease, with 57% of recurrent cases occurring in First Nations peoples compared to 21% of single cases. Geographic remoteness showed significant association with elevated recurrent risk (HR 2.09, 95% CI 1.38–3.17), though this effect may vary over time. This may reflect reduced access to timely healthcare and follow-up, as well as broader structural and systemic barriers in remote areas. The lack of significant interaction between First Nations status and remoteness suggests that the effect of remoteness on recurrent risk did not differ noticeably by First Nations status. Therefore, public health actions should aim to address both improved access to healthcare in remote areas and, barriers to healthcare for First Nations peoples, regardless of location.

The increased rate ratio (age-standardised rates) from 2019 to 2021 (9.17 to 15.07), against a background of falling overall crude incidence rates, combined with the geographically higher rates in north-west Queensland suggests co-occurring risk factors. While sample size precluded stratification by both First Nations status and remoteness (both of which violated the proportional hazards assumptions), the observed disparities indicate that factors beyond geographic isolation contribute to elevate incidence and recurrence risk. Given disruptions to healthcare, including reduced access to health services, restricted movement and extended shared residential spaces during the COVID-19 pandemic, these findings may reflect pandemic-related impacts for both geographically remote and First Nations populations. Further investigation using local data and context is needed to identify aspects that may be relevant to pandemic preparedness planning for these cohorts.

There are several limitations to this study. First, surveillance data rely on clinical and laboratory diagnosis with potential selection bias for probable cases (particularly for deep

wounds and necrotising fasciitis) based on clinician experience and healthcare setting. Second, incomplete data for clinical presentation and risk factors, limits the ability to undertake meaningful analysis of these and their associations. This is consistent with other optional fields in the surveillance system and reflects the limited passive nature of surveillance data where clinical details beyond core notifications fields are often incomplete. Third, the study does not capture a marker of severity or health care utilisation, such as linked hospital data, or primary care or Aboriginal Controlled Community Organisations (ACCHOs) data. While an indicator of severity was not available in our study, the Victorian study by Thomson et al[13] using hospitalisation data reported a median length of stay in hospital of 10 days and one-third of cases (578/1,744) admitted to intensive care. Similarly, a ten-year study across 10 states in the United States identified that of the 21, 312 iGAS cases, 95% were hospitalised and almost 40% were admitted to intensive care, highlighting the severe nature of iGAS.[26] ACCHOs provide culturally capable, safe and responsive community controlled primary health care that addresses health needs and social determinants for First Nations communities.[30,31] This presents a gap in understanding in care-seeking behaviours, treatment pathways and outcomes that may differ from state-based health settings, particularly in chronic disease management or conditions preceding invasive GAS disease. This study did not collect any information on changes to health infrastructure or clinical practices that may have occurred over this period. Some changes in recent years included the COVID-19 pandemic and associated restrictions, as well as iGAS becoming nationally notifiable in Australia. However, the surveillance definition adopted nationally was similar to Queensland's preceding surveillance definition. In addition, deaths were censored at end of the study period as date of death was not accurately captured in the surveillance data, which may have overestimated recurrence free survival time.

The majority of *emm*-typing information is only available from 2021, this restricts the interpretation of strain distribution across the whole study period, with potential to miss earlier changes in circulating strains Queensland surveillance data consistently include bacterial isolation (even where nucleic acid amplification testing is used) though, changes in diagnostic approaches, laboratory capabilities or testing protocols have not been accounted for such as the use of PCR testing which may have affected case ascertainment over time

This study spans a 19-year period, providing a comprehensive timeframe that shows recurrence patterns and health equity gaps not previously documented at this scale. Recurrence risk increases substantially with each episode, advancing age, geographic remoteness and First Nations status. The independent effects of remoteness and First

Nations status indicate parallel strategies are required to identify and address complex health equity gaps for these cohorts. This builds the foundations for informed clinical care pathways and follow up protocols, particularly for older cohorts who show an increased recurrence risk.

Immediate priorities should include coordinated and targeted enhanced surveillance strategies. Critical enhancements to enable data sharing between ACCHOs through data sharing agreements of aggregate and unit level data, where appropriate, for a comprehensive understanding of disease burden, health care utilisation, and prevention strategies, aligned with the Frameworks for the Governance of Indigenous Data.[32] As iGAS is now nationally notifiable (2022), there is an opportunity to develop national datasets for a statistically appropriate disaggregation of First Nations health insights.

Given the complexities of iGAS with individual risk factors, intermediate factors such as housing, access to care and systematic factors such as health equity, surveillance data can only answer limited questions. Longer term priorities should include a longitudinal study of a cohort identified at the time of their first iGAS episode and followed over time or, more robust data linkage. These approaches would better capture individual risk factors and cohort characteristics, potentially expanding to broader Group A Streptococcal burden including acute rheumatic fever/rhematic heart disease and acute post streptococcal glomerulonephritis, particularly for First Nations peoples and communities.

Additionally, further integrating *emm*-type monitoring and whole genome sequencing with enhanced surveillance data are needed to understand transmission networks and virulence factors that may be impacting iGAS epidemiology. More emm-type data will allow analysis of emm-type variation across episodes, which could be incorporated in surveillance definitions of recurrence. This is particularly important for vaccine development, but also essential for monitoring antimicrobial resistance patterns and distinguishing if disease patterns are driven by specific pathogen characteristics or behavioural or social determinants, which require different intervention approaches.

Supplementary Figures

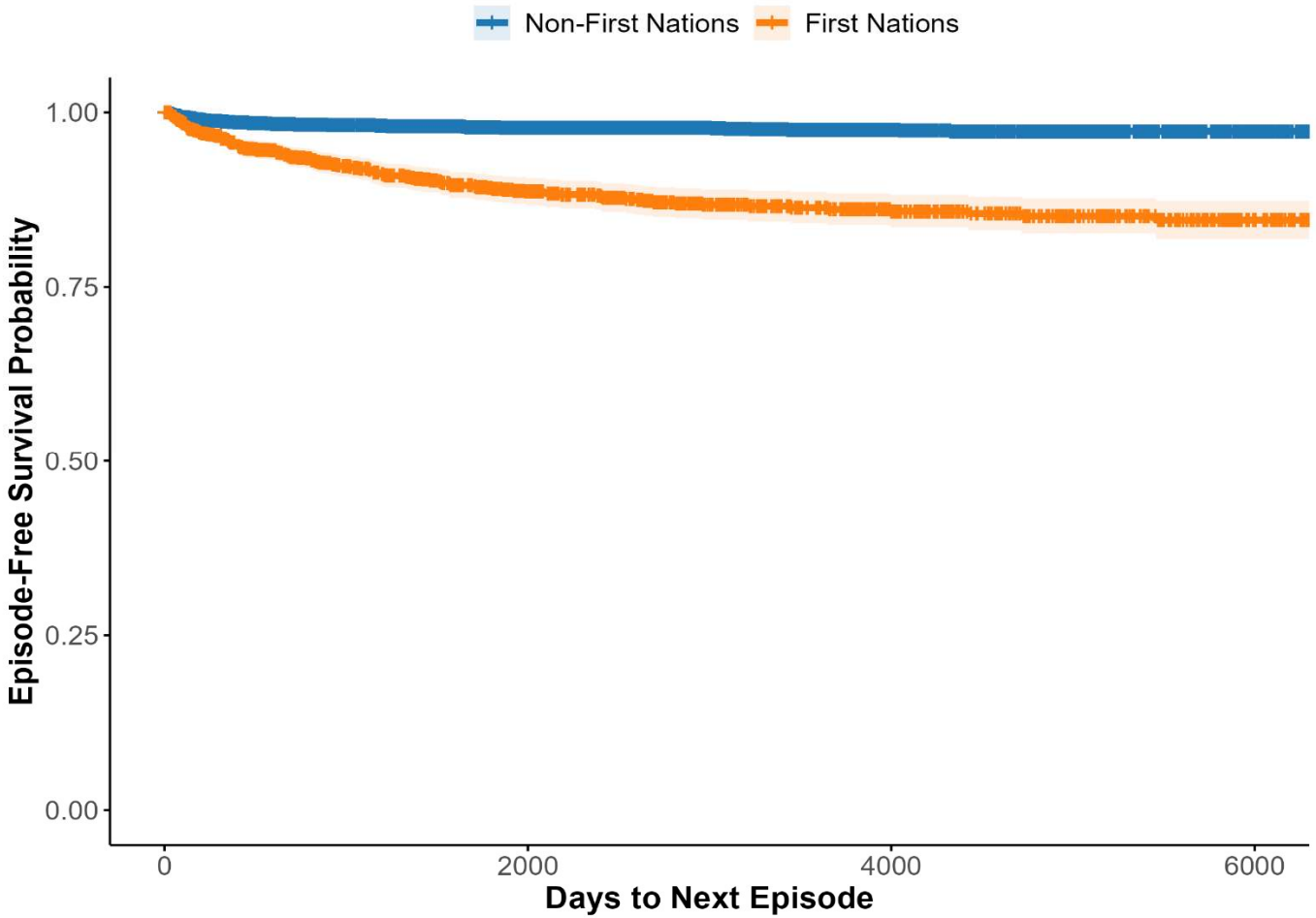

Figure S1. Kaplan-Meier episode- free survival probability curve by First Nations status,2006–2024, in Queensland.

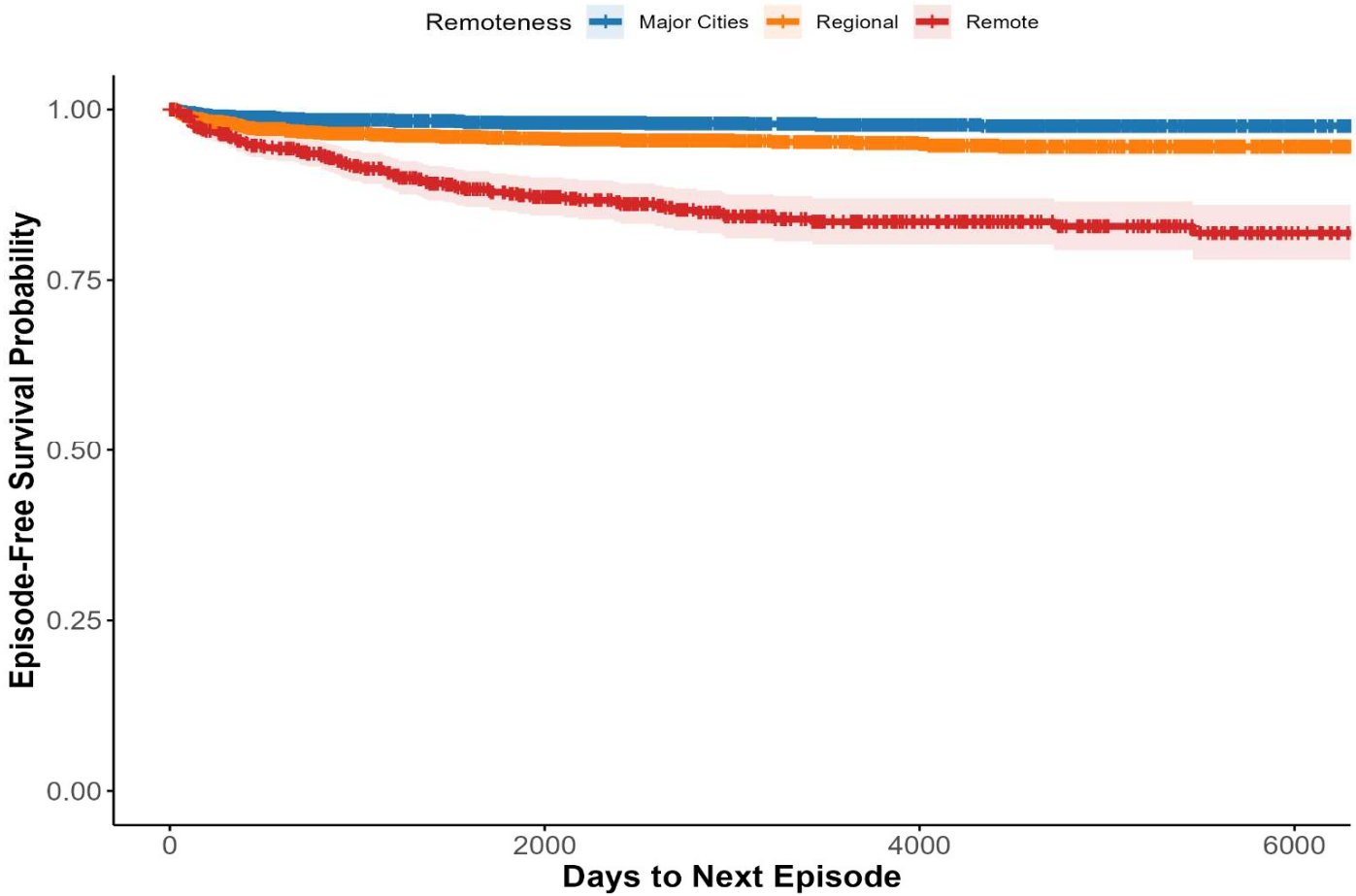

Figure S2: Kaplan-Meier episode- free survival probability curve by geographical remoteness, 2006–2024, in Queensland.

Table S 1: Adjusted Hazard Ratios for recurrent iGAS episodes from Stratified Cox Proportional Hazards Model, Queensland 2006-2024

Variable	Adjusted HR	95% CI	p-value
Episode Number			
Second episode (vs First)	2.86	1.96–4.17	<0.001
Third+ episodes (vs First)	2.33	1.13–4.80	0.021
Geographic Remoteness			
Regional (vs Major Cities)	1.39	0.96–2.00	0.078
Remote (vs Major Cities)	2.09	1.38–3.17	<0.001
Age (increase per 10 years)	**1.18**	**1.11–1.26**	**<0.001**
Sex			
Female (vs Male)	0.89	0.68–1.17	0.403

Model stratified by First Nations status due to violation of proportional hazards assumption. n=5,229 episodes, 222 recurrence events. C-index=0.668

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Appendix 1

Literature review

To review the current literature on overall and recurrent invasive Group A streptococcal disease (iGAS) in Australia from a public health perspective, a focused literature review was conducted across multiple databases. The databases Scopus, PubMed, ProQuest and the Australian National University (ANU) catalogue were selected for their relevance to public health and epidemiology. Search terms included comprehensive terminology related to iGAS, severe streptococcal infections and the Australian health context.

Database search strategy

The search terms for the three databases Scopus, PubMed and ProQuest combined clinical terminology for iGAS along with geographic and public health terms.

Search terms

("invasive Group A streptococcal disease" OR "invasive Group A streptococcal infection" OR iGAS OR "severe Group A streptococcal" AND Australia* AND "public health") For ProQuest, additional limiters were applied including peer-review status, English language, publication within the last five years, and public health subject classification, yielding a refined set from an initial 19,449 results to 274 relevant articles.

Study selection

Studies were included if they reported invasive manifestations of the pathogen Group A Streptococci (Streptococcus pyogenes) within Australia and international populations, included public health surveillance or response activities and provided original data and analysis. Articles focusing solely on superficial infections, healthcare associated infections, or non-Australian populations were excluded from the review at this stage.

The terminology around iGAS can vary in the literature, with some studies using broader terms such as “severe streptococcal disease” or specific clinical presentations such as necrotising fasciitis or bacteraemia without explicit reference to the invasive nature in the abstract. To address potential gaps in the database search, reference lists of included articles were manually reviewed through citations, to identify any additional relevant

publications. The search was subsequently extended to include international publications where these were identified during the citation review process and provided relevant comparative context for Australian findings.

The search yielded 74 records, 14 articles from Scopus , 16 from PubMed, 34 from ProQuest following systematic filtering, and 10 results from the ANU catalogue. After removing duplicates and applying inclusion criteria, 53 relevant studies formed the basis of this review.

Additionally, relevant policy documents were incorporated into the review, including national case definitions for iGAS surveillance and clinical management guidelines. These documents provided essential context for understanding the Australian public health framework surrounding iGAS monitoring and response.

Chapter 6: Teaching activities

Background

There are two teaching competencies to be completed as part of the MAE program. These are to:

- Prepare and conduct a lesson for first year MAE students in small groups (POPH8914 Issues in Applied Epidemiology requirement).

- Prepare and participate in peer-to-peer teaching sessions delivered to a small sub-group of the cohort ("*lessons from the field*").

These competencies were achieved through:

- Delivery of teaching session "Stakeholders in a response to an outbreak of syphilis" to first year students in course block 3, 2025 (Appendix 1: Teaching to first year MAE cohort)

- Lesson from the field "Joining an outbreak response remotely" delivered to group on 30 May 2025 and participation in the lessons delivered by the other members of my group (**Appendix 2: Lessons from the field**)

To complete the competency for the teaching session our cohort divided into five groups to deliver five sessions. Through discussions and reflection, it was decided that each out these sessions would be tied into an overarching theme. After an initial whole cohort meeting, we decided to use an outbreak as a scenario, with infectious syphilis as the disease of interest. We then divided into smaller groups according to our interests.

The lesson from the field around joining an outbreak response remotely was generated from my observations and experience in the outbreak response with the Gold Coast Public Health Unit and how remote work has been incorporated during and post the COVID-19 pandemic. The session facilitated discussion around opportunities and challenges.

Lessons learned

Teaching Session

The group discussion and sharing of ideas in the session to the first-year cohort was insightful, and I enjoyed hearing aspects of the outbreak that we had not considered in our planning. When planning our session, there was time allocated to sharing topics iscussed in the small groups with the wider cohort, this part of the session generated more discussion than we had considered. As such we reduced some of the activities towards the end of the session to allow the discussion to continue. This taught me that with group discussions, you cannot plan how they unfold, identifying key outcomes of the lesson to deliver first and having activities planned as optional extras towards the end would have been beneficial. It also underscores to me the value in acknowledging adult learning and that everyone brings with them their own experience.

Lesson from the field

Facilitated group discussion was also used in the lessons from the field session that I delivered, however, as this was a smaller group, the discussion was not as long and required additional prompting. I learnt when including this as a part of the lesson plan, additional consideration to the size of the group also plays an important part in timing and content.

After reviewing the responses to the evaluation question in both the lessons from the field and teachings session, I reflected on the type of questions used for feedback. I learned that the type of question and, the way feedback questions are asked, are important for gaining meaningful feedback to allow for improvements for both presenter and content. For example, broad questions, intended to allow a range of responses, may produce general comments, whereas more specific questions can provide clearer suggestions for improving both the presentation and content.

Acknowledgments

I would like to acknowledge the 2024 MAE cohort, for their willingness to share ideas and participate in our cohort planning and discussions sessions. I acknowledge my teaching group Maggie Miller, Josie Jones and Alison Brown’s valuable contributions to the planning and delivery of our session. Thank you to my lessons from the field group Sarah Sim, Clare

Kinnear, Edura Jalil and Alison Brown, firstly for sharing their insightful and varied lessons, and, participating in the lesson I delivered.

Appendix 1: Teaching to first year MAE cohort

Stakeholders in a response to an outbreak of syphilis

The group I joined for this teaching exercise included Maggie Miller, Josie Jones, and Alison Brown. I was nominated as the group leader which entailed setting up meetings, documents, and following up any questions for the wider cohort. Members from other subgroups were included in some of our meetings so that there was flow across the sessions. Our teaching session was the first of the day and set the scene for the outbreak scenario. The session was titled *Stakeholders in a response to an outbreak of syphilis*.

Learning outcomes for our session were:

- Identify different viewpoints in an outbreak response.
- Identify different perspectives and priorities of key stakeholders responding to an outbreak.
- Identify the role that an MAE scholar may take on during an outbreak.
- Describe some challenges and possible solutions in the public health response to an outbreak involving multiple stakeholders.

Learning objectives for our session were:

- To be able to list the different stakeholders and describe the different priorities in an outbreak or public health issue using a scenario (multijurisdictional outbreak of syphilis).
- To demonstrate challenges and opportunities for stakeholders in the scenario.
- To provide a holistic viewpoint of outbreak response.

Students were asked to provide an evaluation of the session via an online survey directly after it was delivered (questions and responses presented in **Figure 6.1**). Feedback questions were a mix of evaluating lesson experience and understanding checks. The formal feedback was

overall very good, a few students informally (verbally) reported that the opportunity to provide feedback explicitly on the presentation delivery was missing.

Figure 6.1: Teaching session feedback summary

Questions ***Lesson experience***	**Average (1–5)**	**Responses** **(18 students)**
Were the instructions easy to understand?	4.8 (1= strongly disagree, 5 = strongly agree)	18
How well do you think you could apply the content in the future?	4.7 (1= not very well, 5 = extremely well)	17
Can you provide a one-word summary of this lesson?	Example comments: Fun, Engaging, Applicable, Interactive, Enjoyable, very useful, collaboration	17
Questions ***Understanding***	**Appropriate answers**	**Responses**
Can you list a stakeholder that was discussed?	100%	16
Can you list a challenge for the stakeholder you listed and a potential solution to this challenge?	100%	17

Appendix 2: Lessons from the field

Joining and contributing to an outbreak response team remotely

Lesson overview

In this lesson from the field, we are going to discuss working in an outbreak investigation team, remotely, using a scenario and follow up questions. Please read through the scenario, and the resources provided, and answer the discussion questions listed prior to our meeting.

During our scheduled meeting there will be a brief overview, group discussion of questions, we will review the outbreak response steps and outbreak control teams roles (from the lens of working remotely), and qualities of effective teams. I will also present some learnings from my experience joining an outbreak response from a separate location.

Learning objectives:

It is anticipated that after this session participants will be able to:

- Identify challenges and opportunities for participating in an outbreak response team remotely,
- Describe at least one solution to overcome a challenge described,
- Identify key components of effective teams and how these principles can be applied to a team environment where members are working remotely, and
- Identify steps of the outbreak investigation that could be supported by remote working.

Expected time

Pre-reading of scenario and resources 30–45 mins

Discussion and presentation 30–45 mins

PART 1:

Scenario:

You have just been appointed Epidemiologist in a small public health unit in your state (congrats!). On your second week you receive this email from your manager. (note the previous emails in the email chain)

From: Sue Sann
Sent: Tuesday, April 29, 2025 3:01 PM
To: Sam Orange
Subject: FW: OCT stand up gastro outbreak RACF

Hi Sam,

I know you have just started with us but Smallville public health unit have requested assistance with an outbreak investigation, can you please provide some Epi support to the team there as their Epi is currently on leave. First meeting is in 30 mins, invite to follow.

If you have any concerns or questions, please come and chat I will be in my office until 3.30pm before I go to my next meeting. You got this!

Cheers,

Sue

Director, Otherville Public Health Unit

From: Sue Sann
Sent: Tuesday, April 29, 2025 3:00 PM

To: Roger Dodger
Subject: RE: OCT stand up gastro outbreak RACF

Hi Roger,

Happy to help out. Please send through the invite.

Cheers,

Sue

Director Otherville Public Health Unit

From: Roger Dodger
Sent: Tuesday, April 29, 2025 2:36 PM
To: Sue Sann
Subject: OCT stand up gastro outbreak RACF

Hi Sue,

Help! Our Epi is currently on leave, and we could really use some Epi support to investigate this outbreak! We are having our first Outbreak Control Team meeting in 1 hour (3.30pm). I will forward the invite.

Thanks in advance

Roger

Director Smallville Public Health Unit

As hinted above, an outbreak investigation team has been stood up at Smallville public health unit to investigate a gastroenteritis outbreak at an aged care facility in their jurisdiction. The epidemiologist for the public health unit is currently on leave, and the current arrangement is that you will provide epidemiological support for the outbreak team remotely. Your public health unit is a 3-hour drive from Smallville public health unit, and the aged care facility is a further 1-hour drive from there.

Task

Consider the above scenario, reflect your own experiences and read through the resources below before answering the following questions for discussion in our scheduled meeting:

- List some challenges working with a new team?
- List some challenges working with the outbreak team remotely?
- Can you think of ways to overcome these challenges?
- What would some of your first actions/priorities be?

Resources to read prior:

Chapter 10: Spina A, Rossetto EV, Batra N. 10. Field epidemiology and outbreak investigation. In: Fisher D, editor. Infectious Disease Emergencies: Preparedness and Response [Internet]. 1st ed. NUS Press; 2025. Available from:

https://emergencies.pubpub.org/pub/field-epidemiology

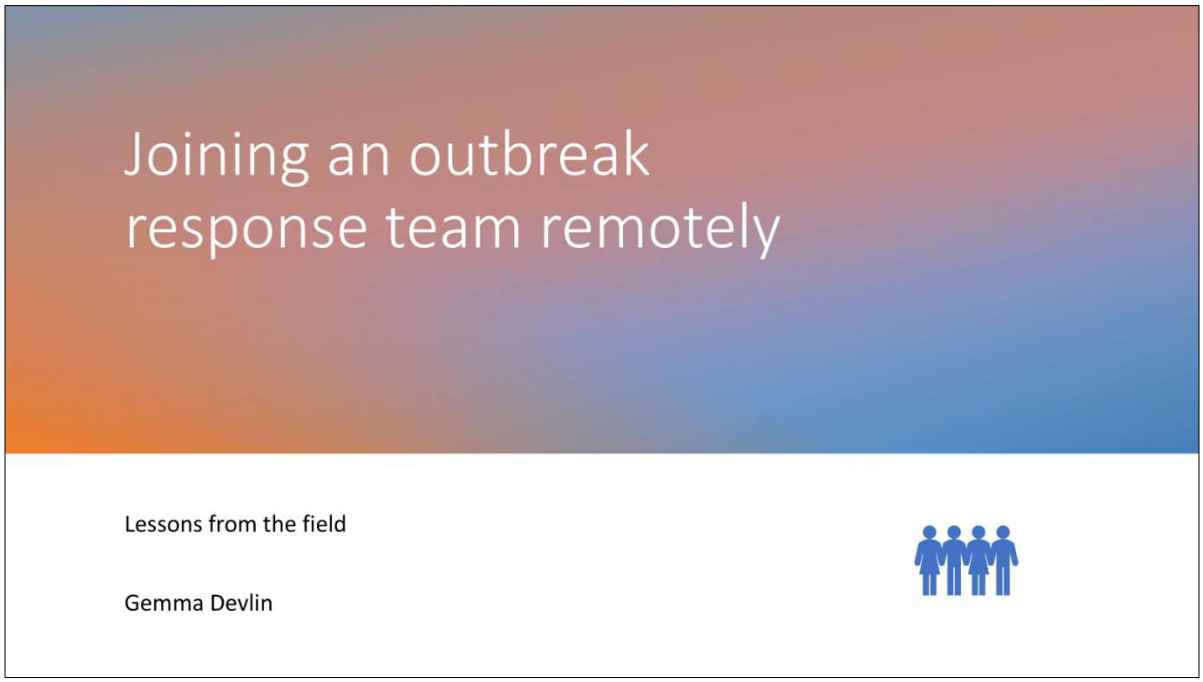
Chapter 6: Devnarain N, Karim SSA. 6. Teamwork and decision-making. In: Fisher D, editor. Infectious Disease Emergencies: Preparedness and Response [Internet]. 1st ed. NUS Press; 2025. Available from:

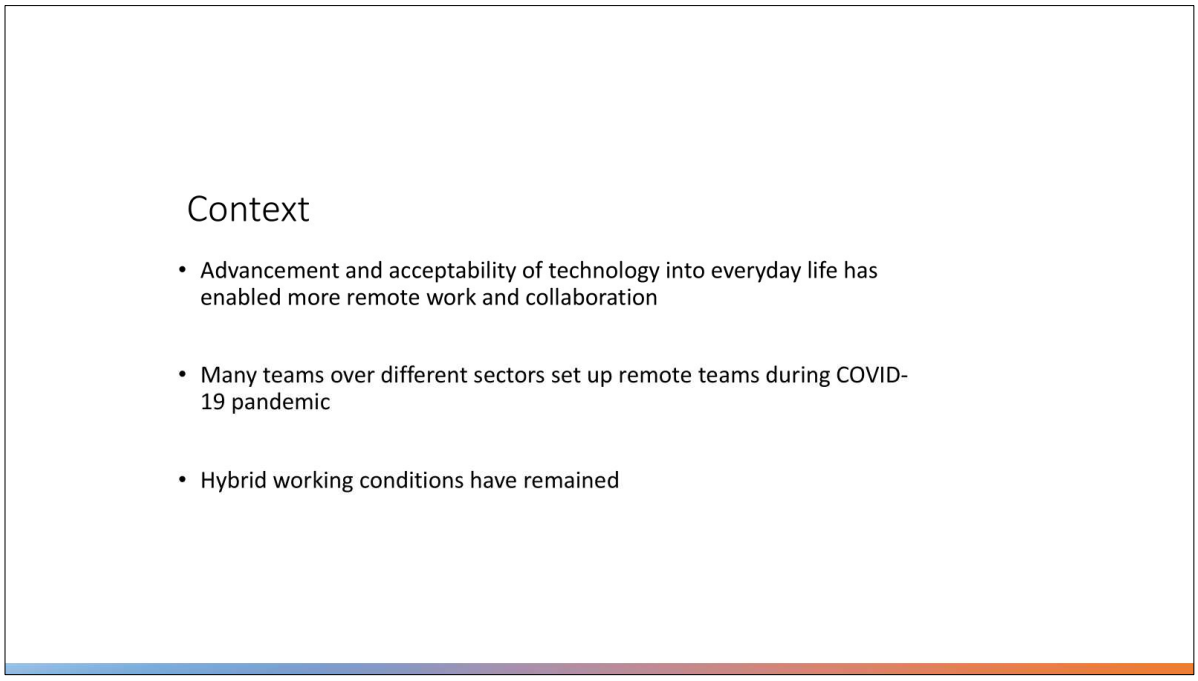
https://emergencies.pubpub.org/pub/teamwork-and-decision-making

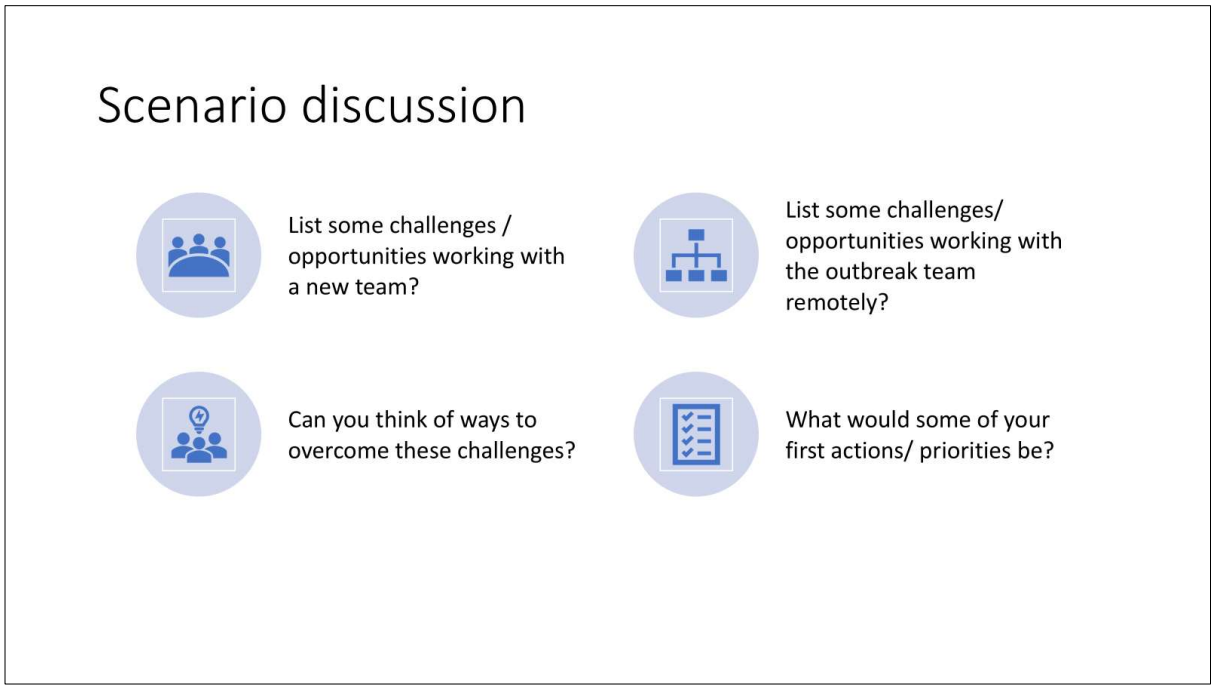
(optional) Queensland Health Guideline for the investigation and management of suspected foodborne illness outbreaks December 2018 (Sections: Summary of outbreak investigation steps, Chapter 1 & Chapter 2)

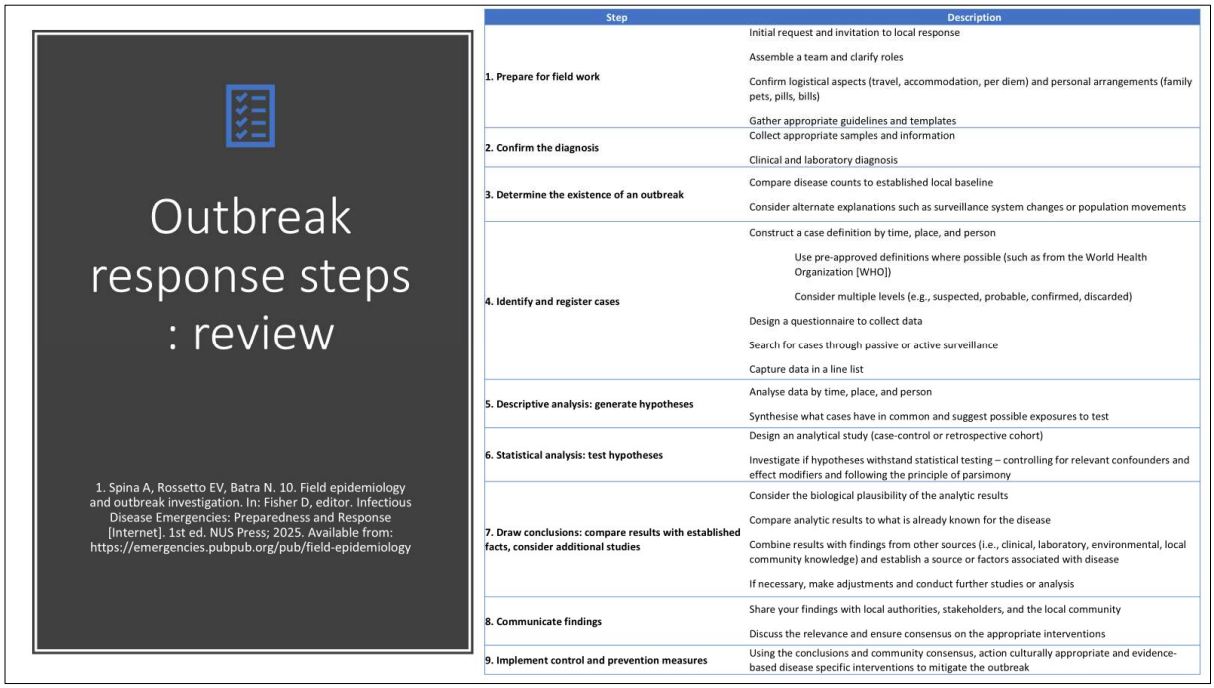
PART 2:

PowerPoint presentation and facilitated discussion delivered 30 May 2025 (slides below).





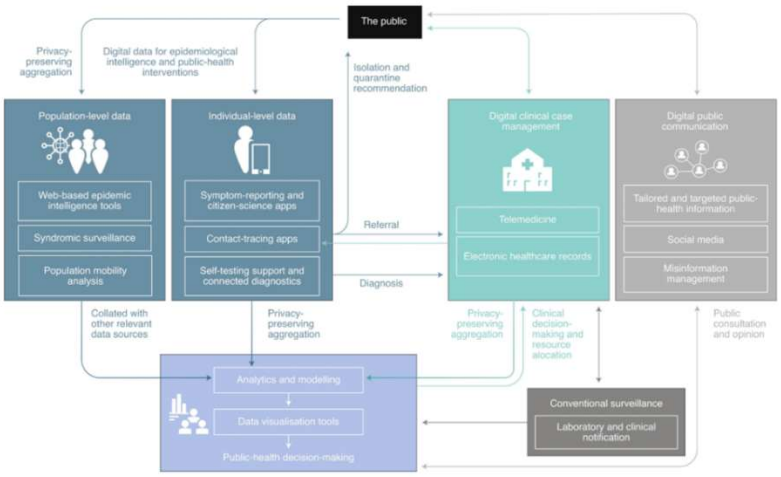




Step	Description
1. Prepare for field work	Initial request and invitation to local response Assemble a team and clarify roles Confirm logistical aspects (travel, accommodation, per diem) and personal arrangements (family pets, pills, bills) Gather appropriate guidelines and templates
2. Confirm the diagnosis	Collect appropriate samples and information Clinical and laboratory diagnosis
3. Determine the existence of an outbreak	Compare disease counts to established local baseline Consider alternate explanations such as surveillance system changes or population movements
4. Identify and register cases	Construct a case definition by time, place, and person Use pre-approved definitions where possible (such as from the World Health Organization [WHO]) Consider multiple levels (e.g., suspected, probable, confirmed, discarded) Design a questionnaire to collect data Search for cases through passive or active surveillance Capture data in a line list
5. Descriptive analysis: generate hypotheses	Analyse data by time, place, and person Synthesise what cases have in common and suggest possible exposures to test
6. Statistical analysis: test hypotheses	Design an analytical study (case-control or retrospective cohort) Investigate if hypotheses withstand statistical testing – controlling for relevant confounders and effect modifiers and following the principle of parsimony
7. Draw conclusions: compare results with established facts, consider additional studies	Consider the biological plausibility of the analytic results Compare analytic results to what is already known for the disease Combine results with findings from other sources (i.e., clinical, laboratory, environmental, local community knowledge) and establish a source or factors associated with disease If necessary, make adjustments and conduct further studies or analysis
8. Communicate findings	Share your findings with local authorities, stakeholders, and the local community Discuss the relevance and ensure consensus on the appropriate interventions
9. Implement control and prevention measures	Using the conclusions and community consensus, action culturally appropriate and evidence-based disease specific interventions to mitigate the outbreak

Fig. 4: The flow of information in a digitally enabled and integrated public-health system during an infectious-disease outbreak.

From: Digital technologies in the public-health response to COVID-19



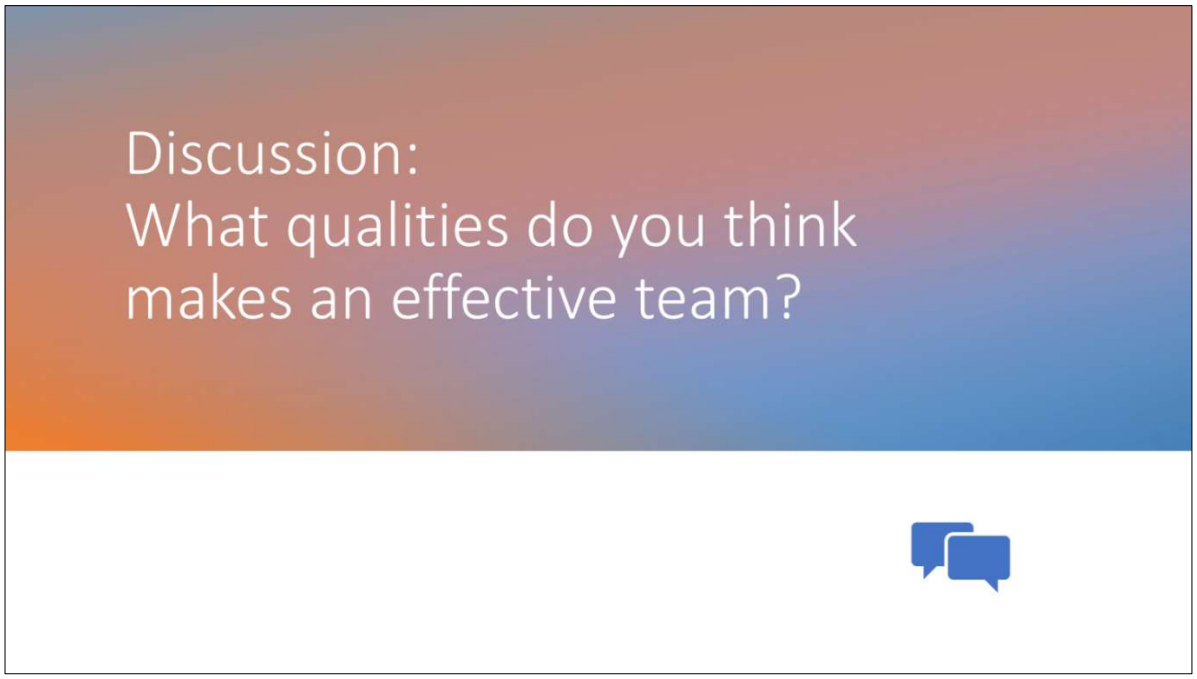
Digital data are created by the public, both at the population level and at the individual level, for epidemiological intelligence and public-health interventions, and for the support of clinical case management. They are also informed by conventional surveillance via laboratory and clinical notification. This feeds into public-health decision-making and communication with the public through digital channels. Other relevant sources of information include population, demographic, economic, social, transport, weather and environmental data.

Budd, J., Miller, B.S., Manning, E.M. *et al.* Digital technologies in the public-health response to COVID-19. *Nat Med* **26**, 1183–1192 (2020). https://doi.org/10.1038/s41591-020-1011-4

Outbreak response team roles: review

An outbreak control team broadly consists of:

- a surveillance officer
- a clinician
- laboratory technician
- communications officer
- other relevant disciplines e.g. entomologist, animal health officer, specialist clinician, environmental health, food safety officer… others?



Qualities of effective teams

Multidisciplinary	Trained	Built for purpose	Adequately sized
Adaptable	Transparent	Willing to collaborate	Coordinated

Devnarain N, Karim SSA. 6. Teamwork and decision-making. In: Fisher D, editor. Infectious Disease Emergencies: Preparedness and Response [Internet]. 1st ed. NUS Press; 2025. Available from: https://emergencies.pubpub.org/pub/teamwork-and-decision-making