

Applied Epidemiology of Communicable Diseases in Australia

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

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Originality statement

I hereby declare that this submission is my own work and to the best of my knowledge it contains no material previously published or written by another person, or substantial material that have been which have been accepted for the award of any other degree or diploma at the Australian National University or any other educational institution, except where due acknowledgement is made in the thesis. Any contribution made to the research by other 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.

A handwritten signature in black ink, appearing to be 'Tracy Shuk Fan Tsang', written in a cursive style.

Tracy Shuk Fan Tsang

October 2020

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Acknowledgements

The completion of this Master of Philosophy in Applied Epidemiology (MAE) journey would not have been possible without the support of supervisors, family and friends. Firstly, I would like to thank my field supervisors at the Communicable Diseases Epidemiology and Surveillance Section (CDESS) within the Office of Health Protection and Response, Australian Government Department of Health: Dr Allison Cairns and Ms Rose Wright. They have been very generous with their time, and provided constructive feedback and directions when needed. It has been a great privilege to be part of CDESS, and getting to work with epidemiologists with a wealth of knowledge about national communicable diseases surveillance.

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Abstract

While placed in the Communicable Diseases Epidemiology and Surveillance Section within the Office of Health Protection and Response (previously known as the Office of Health Protection), Australian Government Department of Health in Canberra, I completed four projects to meet the core competency requirements of the Master of Philosophy (Applied Epidemiology) (MAE) program. My placement also provided numerous opportunities to conduct disease surveillance and response outside of my core MAE projects such as the opportunity to be part of the coronavirus disease 2019 (COVID-19) Epidemiology and Surveillance Team in the National Incident Room.

This thesis presents the projects undertaken: investigating a suspected viral gastroenteritis outbreak in the Australian Capital Territory; describing the epidemiology of gonorrhoea in Australia between 1999 and 2018; evaluating the performance of the primary surveillance system for COVID-19 against its surveillance objectives; and describing the epidemiology of COVID-19 in Australia between 1 January and 26 April 2020 including identification of pre-existing comorbidities that are associated with severe COVID-19 illness. This thesis also describes the teaching activities I prepared to fulfil the teaching requirements of the MAE program. The primary objective of my Lessons from the Field was for participants to gain expertise in performing advanced searches using the MEDLINE (via Ovid) database.

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Chapter 1

Master of Philosophy in Applied Epidemiology experience

1 MAE experience

For my Master of Philosophy in Applied Epidemiology (MAE), I was placed in the Communicable Disease Epidemiology and Surveillance Section (CDESS) within the Office of Health Protection and Response (previously known as the Office of Health Protection), Australian Government Department of Health in Canberra. CDESS is responsible for the surveillance and epidemiological analyses of nationally notifiable diseases, which informs policy development and response activities.

My placement in the Australian Government Department of Health provided many unique opportunities outside of my core MAE projects. The opportunity to be part of the coronavirus disease 2019 (COVID-19) national response team in the National Incident Room (NIR) was definitely a highlight of my MAE. My time in the NIR was stressful and frustrating at times but incredibly eye-opening. During the initial phase of the pandemic, a typical day in the NIR included constant media monitoring for confirmed COVID-19 cases announced by other countries and territories, assisting the NIR Surveillance Manager in responding to media requests, and preparing situation updates to be used by the Chief Medical Officer in press conferences. I also got to work alongside staff from various Australian Government departments and agencies including the Department of Defence, the Department of Foreign Affairs and Trade, and Department of Prime Minister and Cabinet. Between February and April 2020, I rotated through multiple roles within the NIR Epidemiology and Surveillance Team, and undertook the following tasks:

- prepared daily whole of government situation reports and talking points
- performed data analysis and interpretation of COVID-19 notifications
- assisted in the publication of the weekly COVID-19 epidemiology reports
- drafted epidemiology reports for the National Cabinet
- prepared daily case updates for online publication by the Communication Branch

Preparing a monthly measles report for the World Health Organization Regional Office for the Western Pacific (WPRO) was another unique opportunity. The report contains tabulated information on the year-to-date measles notifications in Australia. It is required to maintain Australia's measles elimination status and contributes to the WPRO's monthly Measles-Rubella Bulletin. The opportunity to undertake Watch Officer duties was another remarkable experience. Acting as the first point-of-contact for Australia's National Focal Point (the National Incident Room), the Watch Officer monitors the National Incident Room's 24/7 hotline and inbox during business hours, and responds to routine incidents. Through this, I gained exposure to Australia's obligations under the *International Health Regulations (2005)*, particularly with regards to international and domestic infectious disease exposures and multi-jurisdictional contact tracing.

I was also very fortunate to have the opportunity to gain hands-on experience by working alongside epidemiologists in the Communicable Disease Control (CDC) team at ACT Health. In May 2019, under the guidance of the Public Health Specialist and disease surveillance epidemiologist, I conducted an investigation in collaboration with the CDC team into a cluster of influenza-like illness cases amongst a school in Canberra. Results of this investigation are not presented in this thesis. In August 2019, I spent another week at ACT Health to assist in a suspected viral gastroenteritis outbreak investigation in Canberra. While there, I learnt how to interview suspected cases over the phone using a structured foodborne outbreak case questionnaire, and had the opportunity to attend a follow-up inspection of the catering premises involved in the outbreak with a Public Health Officer.

There were many firsts in the past two years, and to name a few: first abstract submission to a national conference, first time preparing a manuscript for publication in a peer-reviewed journal, and first time creating a conference poster. Through the MAE, I developed skills and competencies required in field epidemiology. I am so grateful for the guidance and support I have received in the past two years. The MAE journey has truly been a rewarding one.

2 Summary of core competencies

Table 1 is a summary of the projects I undertook to acquire the required MAE core competencies.

Table 1. Summary of MAE projects and required competencies they fulfil

	Chapter 2	Chapter 3	Chapter 4	Chapter 5	Chapter 6
Investigate an acute public health problem	✓				
Analyse a public health dataset		✓			
Establish a public health surveillance system			✓		
Design and conduct an epidemiological study				✓	
Literature review				✓	
Report for non-scientific audience	✓				
Peer-reviewed publication		✓			
Conference abstract and presentation	✓	✓			
Teaching requirements					✓

Chapter 2

An outbreak investigation of viral gastroenteritis among people who consumed food supplied by a catering service, Canberra, August 2019

Abbreviations used in this chapter

ACT	Australian Capital Territory
ACTGAL	ACT Government Analytical Laboratory
CDC	Communicable Disease Control
CI	Confidence interval
OR	Odds ratio
PCR	polymerase chain reaction
SPC	Standard Plate Count

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1 Prologue

1.1 My role

Under the guidance of the OzFoodNet epidemiologist at ACT Health, I conducted a retrospective investigation in collaboration with the Communicable Disease Control (CDC) team into a suspected viral gastroenteritis outbreak in the Australian Capital Territory. I was part of the outbreak investigation team and undertook the following tasks:

- interviewed event attendees over the phone
- created an online survey that was adapted from the paper-based questionnaire
- crafted case definitions
- organised distribution of online survey via emails and mobile phone text messages
- cleaned, analysed and interpreted data
- wrote report (Appendix 1)
- attended follow-up inspection of the catering premises with a Public Health Officer.

1.2 Lessons learnt

This was the first foodborne outbreak investigation I had been involved in, and was a valuable learning opportunity. Some significant lessons learnt were:

- **The importance of creating a good outbreak investigation questionnaire:** While I circulated the online survey for review and pilot testing, some of the flaws of the online questionnaire were only identified at the data analysis stage. This highlighted the importance of having a clear purpose and objective when creating an outbreak investigation questionnaire as it will save you from future headaches when performing data cleaning and analyses. If I were to create an outbreak investigation questionnaire again, a data analysis plan would ideally be created to guide the question types and response options. However, I acknowledge that due to the urgency of outbreaks, it may not always be possible to plan ahead of time. I would also cross check my questionnaire with ones that have been pre-tested and utilised in previous outbreak investigations.
- **The need to include Public Health Officers in a foodborne outbreak investigation:** I gained an appreciation for having Public Health Officers as part of the outbreak investigation team. They play an important role in a foodborne outbreak investigation and management by: facilitating the collection of food samples and environmental swabs and providing advice on infection control and preventive measures.

1.3 Public health implications

The environmental investigation led to an Improvement Notice being issued to the catering service. Recommendations were provided by the Public Health Officers which resulted in improved sanitation and hygiene of the catering premises, and the development and implementation of additional policies and procedures on cleaning, food handling and staff illness.

1.4 Acknowledgements

I would like to acknowledge and thank the following people and organisations for their guidance and assistance with the investigation:

- Rebecca Hundy, Vanessa Johnston, Timothy Sloan-Gardner and staff from the CDC section, ACT Health Protection Service
- Public Health Officers from the ACT Health Protection Service
- staff at the ACT Government Analytical Laboratory.

1.5 Master of Philosophy in Applied Epidemiology core requirements

- ✓ Investigate an acute public health problem or threat
- ✓ Write a report to a non-scientific audience (Appendix 1)
- ✓ Prepare an abstract and oral presentation of the project at a national or international scientific conference
 - ❖ Viral gastroenteritis among people who consumed food supplied by a catering service, Canberra, August 2019. Presented at the 59th OzFoodNet face-to-face meeting, 3 December 2019. Canberra, Australia. (Appendix 2).

2 Abstract

Introduction: In August 2019, an outbreak of gastroenteritis occurred among people who consumed food supplied by a catering service in Canberra, Australia. A retrospective investigation, including an unmatched case-control study, was conducted to identify the cause of illness, and to implement control measures to prevent further illness.

Methods: Persons who attended a catered event on 5 August 2019 and consumed the food provided were interviewed, using a structured paper-based questionnaire or an online survey. An unmatched case-control study was conducted to identify the source of illness. Data were analysed using Stata/SE 13.1 (StataCorp, Texas, USA).

Results: Fifty-eight per cent (117/203) of the known attendees and 4 staff members from the catering service were interviewed; 77 cases and 34 controls were included in the study. The median duration of illness was 17.7 hours. Vomiting (67/77, 87%) was the most commonly reported symptom, followed by nausea (62/77, 81%) and fatigue (61/77, 79%). Multivariable analysis revealed a statistically significant association between illness and consumption of sandwiches (aOR 4.41, 95% CI 1.59–12.19, $p=0.004$) and wraps (aOR 11.22, 95% CI 3.65–34.43, $p<0.001$). *Salmonella* and *Campylobacter* were not detected in food samples collected from the catering premises. Standard plate count returned satisfactory levels of colony-forming units. Norovirus was detected in one of two human faecal samples provided for laboratory testing.

Conclusion: Based on the information gathered, a definitive source of the outbreak could not be established. However, we suspect that non-compliances with food safety standards: inadequate handwashing amongst food handlers and delayed exclusion of symptomatic food handlers from the catering premises facilitated the spread of viral gastroenteritis. This investigation highlights the importance of food safety training amongst food handlers and strict food handling procedures. By following appropriate food safety principles and practices, the risk future of foodborne outbreaks would be minimised.

3 Introduction

Gastroenteritis is an infection and inflammation of the stomach and intestines. Causes of gastroenteritis include viruses, bacteria, parasites or bacterial toxins.¹ Norovirus is the most common cause of viral gastroenteritis in many developed countries, including the United States and United Kingdom, and results in substantial morbidity and mortality.²⁻⁴ In Australia, it was estimated that 1.8 million cases of foodborne gastroenteritis due to norovirus occur per year.⁵

Norovirus is a non-enveloped, single-stranded RNA virus that belongs to the *Caliciviridae* family.⁶ The incubation period is generally 24–48 hours.⁷ Symptoms of norovirus infection can include vomiting, diarrhoea, nausea and abdominal cramps, and usually resolve within 12–60 hours.^{8,9} Antiviral medication to treat norovirus infection is not available; treatment is mainly supportive, focusing on prevention and treatment of dehydration.⁹ Faecal-oral route is the primary route of transmission, which occurs through consumption of contaminated food or water, or direct contact with infected persons or contaminated surfaces.^{6,9}

Norovirus has several features that facilitate its spread during an outbreak. With a low infectious dose, it allows droplet transmission or person-to-person spread. Prolonged asymptomatic viral shedding increases the risk for secondary transmission, which is of particular concern among food handlers. The virus remains relatively stable in the environment, therefore making it difficult to be eliminated from contaminated sources. Substantial strain diversity, coupled with the lack of long-term immunity, permits repeat infections to occur.⁷

3.1 Identification of an outbreak

On 7 August 2019, the ACT Health Protection Service received two separate complaints. The complainants reported multiple people ill with gastrointestinal symptoms after consuming food supplied by the same catering service in Canberra, Australia on 5 August 2019. Public Health Officers conducted an initial inspection of the food premises on 8 August 2019 and identified a third complaint that was submitted directly to the catering service in relation to food that was delivered on 5 August 2019. An outbreak investigation was subsequently initiated and an acute response team was formed, which included Health Protection Service staff members and myself. A timeline of the key events in this outbreak investigation is presented in Figure 1.

The objective of the investigation was to identify the cause of illness and to implement control measures to prevent further illness.

ACT Health Protection Service received 2 separate complaints. The complainants reported multiple people ill with gastrointestinal symptoms after consuming food supplied by the same catering service.

Due to multiple ill staff, management of catering service voluntarily ceased operation for one day to sanitise premises and delivery vans.

Public Health Officer conducted follow-up inspection.



Figure 1. Timeline of events: Investigation into viral gastroenteritis among people who consumed food supplied by a catering service, August 2019, Canberra

4 Methods

4.1 Case definition

A case was defined as someone who had consumed food supplied by the catering service on 5 August 2019 and experienced gastrointestinal symptoms (vomiting and/or diarrhoea) within 48 hours. Those who consumed food supplied by the catering service on 5 August 2019 but did not experience any gastrointestinal symptoms were included as controls.

4.2 Epidemiological investigation

Electronic forms for catering delivered between 5 and 7 August were obtained from the catering service. Each form contained a contact name, phone number and the catering packages ordered. The person listed on the order form was contacted. A list of the event attendees and their contact details was requested if the contact person reported attendees ill with gastrointestinal symptoms following the consumption of the food prepared by the catering service. We contacted all the groups that received catering on 5 August. More than a third (13/30) of the groups that received catering on 6 August were also contacted, however, there were no complaints of gastrointestinal symptoms among attendees, therefore we restricted our investigation to those who received catering on 5 August. Information on the electronic forms was consolidated in Microsoft Excel and we discovered that some catered events took place on multiple days (i.e. a two-day event held on 5 and 6 August, or three-day event on 5, 6 and 7 August).

Identified attendees were initially interviewed over the phone on 8 and 9 August 2019 using a structured paper-based questionnaire. Interviews were conducted by trained interviewers and included questions on onset and symptoms of illness, and a four-day food diary. Once we had a better estimate of the size of the outbreak, an online survey (Appendix 2) was utilised for data collection due to the large number of attendees. The online survey was adapted from the structured paper-based questionnaire and included specific foods from the catering packages instead of a four-day food diary. Invitations to the online survey were sent via email or SMS text message on 13 August 2019. Follow-up reminders were sent on 16 and 20 August 2019, and data were exported on 25 August 2019.

Data from the paper-based questionnaire and the online survey were merged in Microsoft Excel. Preliminary data cleaning was performed, including:

- renaming variables
- identifying and removing duplicates
- generating a new variable to distinguish between phone and online interviews

- recoding missing data.

An unmatched case-control study was conducted to identify the source of illness. Data were analysed using Stata/SE 13.1 (StataCorp, Texas, USA). A Shapiro-Wilks test was used to determine the distribution of age among cases and controls. After checking for normality in the age distribution of both cases and controls, means were calculated and compared using a t-test. Univariable analysis was conducted to calculate odds ratios, 95% confidence intervals and *P*-values for each food item consumed by cases and controls. For cells with counts less than 5, *P*-values were calculated using the Fisher's exact test.

Food items with $p < 0.25$ in the univariable analysis were included in an initial multivariable logistic regression model. The model was refined by removing food items that were not statistically significant ($p > 0.05$), using a backward elimination approach. The final model was used to calculate adjusted ORs, 95% CIs and *P*-values. The initial and final models were compared using the likelihood ratio test. Hosmer and Lemeshow test was used to test model fit. A *P*-value less than 0.05 was considered statistically significant for all analyses.

The first question of the online survey asked whether the respondent recently attended an event or meeting where food was provided by a catering service. Response options were "Yes, on Friday 2 August 2019", "Yes, on Monday 5 August 2019", "Yes, on Tuesday 6 August 2019", "Yes, on Wednesday 7 August 2019", and "No" (Appendix 3). Respondents were able to select all that apply. Respondents were then asked to select food that they consumed at the event that was supplied by a catering service. However, this question on food consumption was not repeated for respondents who attended an event that took place on multiple days. As a result, we were unable to ascertain what was consumed on which specific days for cases and controls who attended an event that took place on multiple days. Therefore, a sensitivity analysis was performed to limit the analysis to people who only consumed food from a catered event on 5 August 2019. There were also slight differences in questions between the paper-based questionnaire and the online survey, therefore a second sensitivity analysis was performed by limiting the analysis to people who were interviewed using the online survey.

4.3 Environmental investigation

The environmental investigation was led by Public Health Officers. An OzFoodNet epidemiologist, a public health registrar and Public Health Officers inspected the catering premises on 8 August 2019, including the bathrooms and handwashing and food storage facilities. During the inspection, environmental swabs and samples were obtained for laboratory testing. A follow-up inspection of the premises was conducted on 12 August 2019.

4.4 Laboratory investigation

Suspected cases who were still experiencing gastrointestinal symptoms at the time of the investigation were asked to provide faecal samples. Samples were provided to their general practitioner and submitted to private pathology providers, either tested by polymerase chain reaction (PCR) or by traditional culture. Tests for *Cryptosporidium* and *Giardia* were conducted using antigen detection tests.

Samples and environmental swabs collected from the environmental investigation were tested by the microbiology unit of the ACT Government Analytical Laboratory, ACT Health Protection Service. The tea towel, cloth and environmental swabs were tested for *Salmonella*. Food samples were tested for *Salmonella*, *Campylobacter* and *Escherichia coli*, and Standard Plate Count analysis was conducted.

5 Ethics

Ethics approval was not sought as this study was conducted as part of a public health investigation under the *Public Health Act 1997*.

6 Results

6.1 Epidemiological investigation

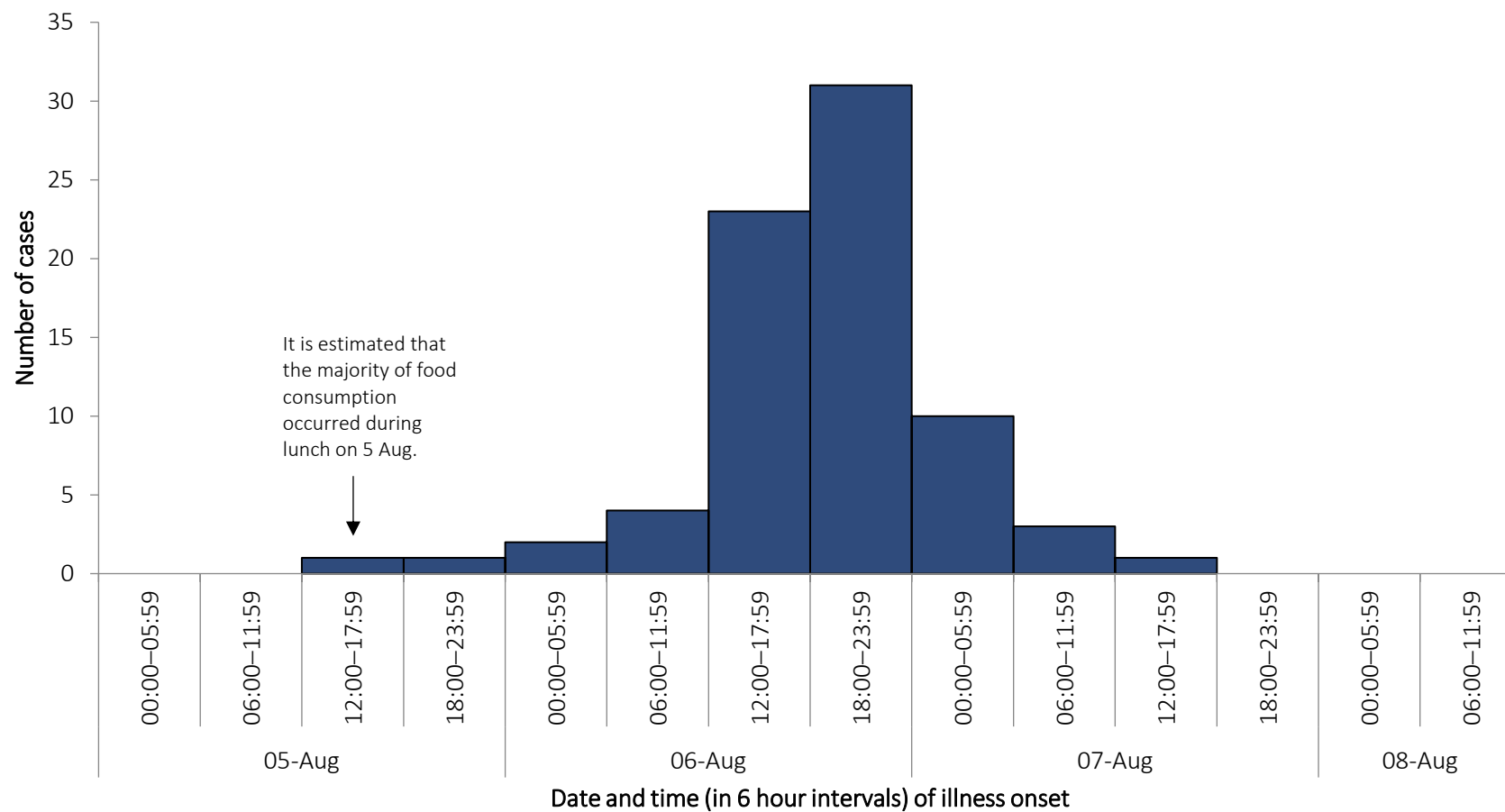
In total, 208 people of interest were identified. This included 203 people who attended a catered event on 5 August and 5 staff members from the catering service. Of these, 27 people were interviewed over the phone and 172 people received an invitation to the online survey. Nine people did not receive an invitation to the online survey as a mobile number or an email address was not provided to us. The catering service reported that four staff (three food handlers and one delivery driver) were ill with gastrointestinal illness since 6 August; one on 6 August and three on 7 August. However, further interviews with the staff members to obtain information on gastrointestinal illness prior to the outbreak was not conducted.

Fifty-eight per cent (121/208) of the study participants were interviewed. Of those interviewed, 92% (111/121) were included in the study: 77 cases, and 34 controls. Seven people were excluded due to having an illness onset outside of the 48 hour window as defined in the case definition, and three were excluded for having symptoms other than vomiting and/or diarrhoea. For the 70 cases for whom date of birth was available, the mean age was 44 years (SD=11.3). We did not include a question on time of food consumption in the online questionnaire, and as a result we were unable to calculate the median incubation period. However, based on information provided

by the catering service, most orders (8/13) placed for 5 August were lunch catering packages, suggesting that the catered food was likely consumed during lunch on 5 August. Duration of illness was calculated for 72 of the 77 cases, and was a median of 17.7 hours (range 1 hour–7 days). The epidemic curve (Figure 2) was indicative of a point source outbreak with 79% (62/77) of cases reported an illness onset date of 6 August 2019. Vomiting was the most commonly reported symptom among cases, followed by nausea and fatigue (Table 1). Ten per cent of cases (8/77) sought medical attention from a general practitioner, and 4% (3/77) presented to a hospital emergency department.

Table 1. Symptoms of cases who consumed food from a catering service on multiple days including 5 August 2019, Canberra (N=77)

Symptom	n	%
Vomiting	67	87
Nausea	62	81
Fatigue	61	79
Diarrhoea	57	74
Stomach cramps	54	70
Chills	47	61
Muscle and body aches	41	53
Headache	37	48
Fever	36	47
Blood in stools	3	4



*1 case excluded due to missing onset time

Figure 2. Epidemic curve of case onset dates and times following consumption of food supplied by a catering service on multiple days including 5 August 2019, Canberra (N=76)*

For the 25 controls for whom date of birth was available, the mean age was 45 years (SD=11.05). There was no statistically significant difference in the distribution of age ($p=0.65$) between cases and controls.

Results of the univariable analysis are shown in Table 2. Wraps were found to be statistically significantly associated with illness ($p<0.001$). Sandwiches, wraps, sweet slices and Danish pastries all had a $p<0.25$ and therefore included in the initial multivariable logistic regression model. All food items were statistically significantly associated with illness except Danish pastries ($p=0.11$) in the initial model. As a result, the model was refined by removing Danish pastries. In the final multivariable analysis, sandwiches (aOR 4.41, 95% CI 1.59–12.19, $p=0.004$) and wraps (aOR 11.22, 95% CI 3.65–34.43, $p<0.001$) remained statistically significantly associated with illness (Table 3).

The initial and final multivariable models were compared using the likelihood ratio test ($p=0.076$), indicating that the fit of the final multivariable model was not any worse than the initial model. The Hosmer-Lemeshow test ($p=0.002$) indicated there was a statistically significant difference between the final model and the initial model.

Table 2. Univariable analysis of selected food consumed by cases (n=77) and controls (n=34) from a catering service on multiple days including 5 August 2019, Canberra

Food consumed	Cases		Controls		OR	95% CI	P-value
	n	%	n	%			
Sandwiches	45	58	13	38	2.27	0.99–5.19	0.05
Wraps	49	64	8	24	5.69	2.27–14.25	<0.001
Fruit	32	42	16	47	0.80	0.36–1.80	0.59
Sweet slices	7	9	7	21	0.39	0.12–1.20	0.10
Danish pastries	17	22	2	6	4.53	0.98–20.87	0.05
Muffins	6	8	1	3	2.79	0.32–24.11	0.44
Scones	1	1	1	3	0.43	0.03–7.15	0.52

Table 3. Multivariable analysis of selected food for gastroenteritis, from a catering service on multiple days including 5 August 2019, Canberra

Food consumed	Initial Model			Final Model		
	Adjusted OR	95% CI	P-value	Adjusted OR	95% CI	P-value
Sandwiches	4.78	1.70–13.44	0.003	4.41	1.59–12.19	0.004
Wraps	9.19	2.97–28.46	<0.001	11.22	3.65–34.43	<0.001
Sweet slices	0.17	0.04–30.34	0.02	0.20	0.05–0.79	0.02
Danish pastries	4.64	0.71–30.34	0.11	–	–	–

Results of the sensitivity analyses (Tables 4 and 5) were largely consistent with those from the primary analysis. When limiting the analysis to people who only attended the catered events on 5 August 2019, wraps remained statistically significantly associated with illness despite a small decrease in the odds ratio (Table 4). When limiting the analysis to people who were interviewed using the online survey, wraps again remained statistically significantly associated with illness however, the associated odds ratio increased moderately (Table 5).

Table 4. Sensitivity analysis results: univariable analysis of selected food consumed by cases (n=49) and controls (n=26) who only consumed food at a catered event on 5 August 2019, Canberra

Food consumed	Cases		Controls		OR	95% CI	P-value
	n	%	n	%			
Sandwiches	23	47	7	27	2.40	0.86–6.74	0.10
Wraps	27	55	5	19	5.15	1.67–15.89	0.004
Fruit	20	41	13	50	0.69	0.26–1.80	0.45
Sweet slices	4	8	6	23	0.30	0.08–1.17	0.09
Danish pastries	11	22	2	8	3.47	0.71–17.05	0.20
Muffins	4	8	1	4	2.22	0.24–20.98	0.65
Scones*	0	0	1	4	0.53	0.00–20.69	0.35

* Odds ratio, confidence interval and P value calculated using exact logistic regression.

Table 5. Sensitivity analysis results: univariable analysis of selected food consumed by cases (n=61) and controls (n=32) who were interviewed using the online survey, Canberra

Food consumed	Cases		Controls		OR	95% CI	P-value
	n	%	n	%			
Sandwiches	34	56	12	38	2.10	0.87–5.04	0.10
Wraps	43	70	8	25	7.17	2.71–18.93	<0.001
Fruit	28	46	16	50	0.85	0.36–2.00	0.71
Sweet slices	7	11	7	22	0.46	0.15–1.46	0.19
Danish pastries	17	28	2	6	5.80	1.25–26.95	0.02
Muffins	6	10	1	3	3.38	0.39–29.39	0.42
Scones	1	2	1	3	0.52	0.03–8.54	1.00

6.2 Environmental investigation

Multiple staff from the catering premises reported as being ill with gastrointestinal symptoms on 6 and 7 August 2019. As a result, management of the catering service voluntarily ceased operation for one day on 7 August 2019 to sanitise the premises and delivery vans. An initial inspection occurred on 8 August 2019, and samples were obtained for laboratory testing. These included:

- 1 tea towel
- 1 cloth
- 5 environmental swabs
- 5 food samples from the shop front:
 - cooked whole chicken breast
 - egg and lettuce sandwich
 - fresh fruit
 - chicken Caesar wraps
 - ham and salad sandwich.

There were no leftovers of the food prepared on 5 August 2019 for catering, therefore food samples were obtained from the shop front. A GlitterBug test conducted at the inspection identified inadequate hand hygiene practices amongst food handlers. The only hand washing facility in the kitchen was insufficient in size which prohibits easy and effective handwashing. A lack of policies and procedures in place for exclusion of ill staff was also identified. Based on the findings of the inspection, an Improvement Notice was issued. A follow-up inspection was undertaken by a Public Health Officer on 12 August 2019. Identified issues with food safety practices were rectified and the Improvement Notice was revoked on 26 August 2019.

6.3 Laboratory investigation

Two cases provided faecal samples to their general practitioner for laboratory testing. Both samples returned 'not detected' results for the following:

- Bacteria: *Campylobacter*, *Salmonella*, *Shigella*, *Aeromona species*
- Parasites: *Cryptosporidium*, *Giardia*
- Viruses: *Rotavirus*, *Adenovirus*

Both samples were also tested for *Norovirus* and one returned a 'detected' PCR result. One of the faecal samples was tested using an enteric PCR test, which included tests for *Dientamoeba fragilis*, *Entamoeba histolytica* and *Blastocystic species*. This sample returned a 'not detected' result for these protozoans.

Salmonella was not detected in the tea towel, cloth or environmental swabs. Food samples obtained from the shop front tested negative for *Salmonella* and *Campylobacter*. SPC returned satisfactory levels of colony-forming units.

7 Discussion

This investigation describes an outbreak of viral gastroenteritis among people who consumed food from the same catering service on 5 August 2019. The epidemic curve, featuring a sharp increase in the number of cases followed by a gradual decline, suggests a common point source outbreak. The epidemiological investigation found a statistically significant association between gastrointestinal symptoms and consumption of sandwiches or wraps. This finding is consistent with previous norovirus outbreaks where ready-to-eat food items are at greatest risk of being contaminated.^{10,11} However, we could not confirm the above hypothesis as laboratories do not routinely test for viruses in food samples. While only two cases provided faecal samples, both samples were tested for bacterial, parasitic and viral pathogens in private laboratories. All tests returned 'not detected' results except one returned a 'detected' result for norovirus. This further adds weight to our hypothesis that norovirus was the aetiological agent. Poor hand hygiene amongst food handlers and the lack of exclusion policies on staff illness, identified in the environmental investigation, may have facilitated the spread of viral gastroenteritis.

7.1 Limitations

A major limitation of this study was the absence of food and clinical samples. We acknowledge that further interviews with the catering service staff members should have been part of the source investigation. Ideally, we would ask about their role in food preparation and

gastrointestinal illness before and during the outbreak. This would assist in determining whether the outbreak is related to contaminated food at the point of service by an infected food handler, as infected handlers are often the suspected source. Outbreaks suggesting asymptomatic, including pre-symptomatic and post-symptomatic, transmission of norovirus from implicated food handlers have been reported.¹²⁻¹⁴ While the Australian Government Department of Health recommends that food handlers with gastrointestinal symptoms are to be excluded from work for 48 hours after all symptoms have stopped, the guideline also acknowledges there is currently limited evidence on infectivity during the post-symptomatic phase. Further research is needed to understand the role that post-symptomatic food handlers play in the context of foodborne outbreaks.¹⁵ None of the food handlers provided faecal samples for laboratory testing, and as a result, we were unable to test our hypothesis that this outbreak was caused by person-to-person transmission. Additionally, due to a lack of samples of the epidemiologically implicated foods, we were unable to identify the food vehicle responsible for this outbreak.

Our initial plan to conduct a retrospective cohort study was not feasible due to the poor survey response rate. As a result, we adjusted the study design to a case control study. Therefore, associations were measured using odds ratio rather than risk ratios. We acknowledge that a limitation of using odds ratio is that it can over-estimate the relative risk for outcomes that are common.^{16,17} It is possible that our study captured a greater proportion of those who experienced gastrointestinal symptoms than those who did not as people who were unwell may be more likely to respond to our online survey, thereby introducing selection bias into our study. The retrospective nature of our study makes it prone to recall bias. Although interviews were conducted soon after the initiation of our investigation, it is possible that some individuals experienced difficulties in remembering what they ate at the catered event. We tried to minimise the recall bias by developing the questions in the online survey around the menu of the catering packages. We acknowledge that the online survey could have included photos of the food items as prompts to assist with the recall process.

There were a few issues related to the setup of the online survey. Sex was unintentionally left out when generating the demographics section. As a result, we were unable to control for the potential confounding effects of sex in our data analyses. We were also unable to determine what was consumed on which specific days for cases and controls who attended an event that took place on multiple days. As a result, we performed a sensitivity analysis by restricting the study population to include people who only attended the catered event on 5 August 2019. Results were largely consistent with those from the primary analysis. This suggests that the uncertainties and assumptions made around exposure ascertainment were unlikely to have introduced

measurement bias into the study. Similarly, when restricting the study population to only include people who were interviewed using the online survey, results were largely consistent with those from the primary analysis, except an increased association between wrap consumption and gastrointestinal illness was observed. This suggests that the type of data collection method may have an effect on the true measure of association. However, this effect was not consistently observed in the sensitivity analysis.

8 Conclusion

Based on the information gathered, a definitive source of the outbreak could not be established. A viral-mediated gastrointestinal illness, such as norovirus, was suspected based on the duration of illness and symptoms reported by cases. This investigation highlights the importance of compliances with food safety standards and having appropriate exclusion policies on staff illness. By following appropriate food safety principles and practices, the risk of future foodborne outbreaks would be minimised.

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10 Appendices

10.1 Appendix 1: Outbreak investigation summary report

The following outbreak investigation summary report was distributed to the study participants who provided consent to be contacted again to learn the outcome of the investigation.



Report of investigation into viral gastroenteritis among people who consumed food supplied by a catering service in August 2019.

An outbreak investigation by the Health Protection Service (HPS) was initiated after two separate complaints were received on 7 August 2019. The complainants reported multiple people ill with gastrointestinal symptoms after consuming food supplied by the same catering service.

Investigation summary

- Over 200 people who consumed food from the catering service between 5 and 7 August 2019 were contacted, approximately half of which were ill.
- Symptoms of those ill included vomiting, diarrhoea, nausea, abdominal pain, fever and fatigue.
- The time taken for symptoms to start, duration of illness and symptom profile for those reported being unwell, was suggestive of a viral gastroenteritis illness.
- All of those who were ill consumed food from the same catering service, however a conclusive source of the outbreak could not be established.
- Several inspections of the catering service were undertaken. Any issues with food handling procedures and processes that were identified during those inspections have since been rectified.

Norovirus

Norovirus is a very common viral infection that causes gastroenteritis (inflammation of the digestive system). Illness caused by norovirus usually starts suddenly and causes vomiting and diarrhoea. Symptoms usually begin about 24 to 48 hours after ingestion of the virus and last for one to three days. Norovirus is highly infectious, and outbreaks are common. Infection can result from direct contact with an ill person or from contact with a contaminated environment or item.

Onsite Inspection

Two inspections of the catering service were undertaken by Environmental Health Officers on 8 August and 12 August 2019. The inspections reviewed food handling processes and procedures, including food storage and transport, cleanliness and staff hygiene. The catering service worked closely with HPS during the investigation and has addressed any issues that were identified.

Findings

While all those who were ill consumed food from the same catering service, based on the information gathered, a definitive source of the outbreak could not be established.

For more information, please contact the Communicable Disease Control Section, ACT Health Protection Service, on (02) 5124 9213.

Date: 30 September 2019

10.2 Appendix 2: Presentation for the 59th OzFoodNet face-to-face meeting

**ACT**
Government

ACT Health

Viral gastroenteritis among people who consumed food supplied by a catering service, Canberra, August 2019

59th OzFoodNet F2F
3–4 December 2019

Tracy Tsang
MPhil (Applied Epidemiology) Scholar

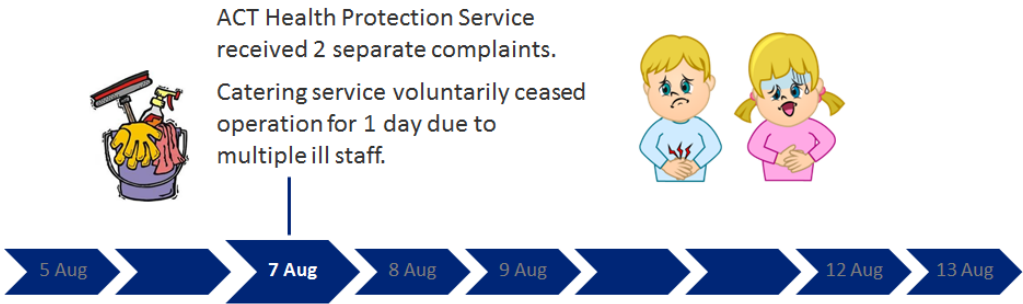
Australian National University

Australian Government
Department of Health

Timeline of events



Timeline of events



3



Timeline of events



4



Timeline of events



5



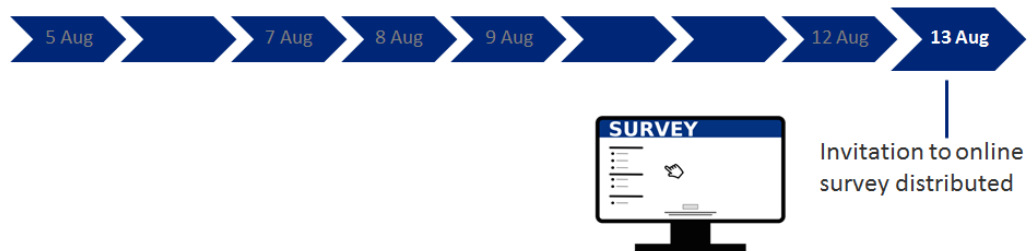
Timeline of events



6



Timeline of events



7

Methods

Epidemiological investigation

- Electronic catering order forms available
- Paper-based and online surveys
- Case-control study

Environmental/lab investigation

- Inspection of catering premises
- Swabs and samples for lab testing
 - Tea towel, cloth and environmental swabs tested for *Salmonella*
 - Food samples tested for *Salmonella*, *Campylobacter* and *E. coli*, and SPC conducted

8

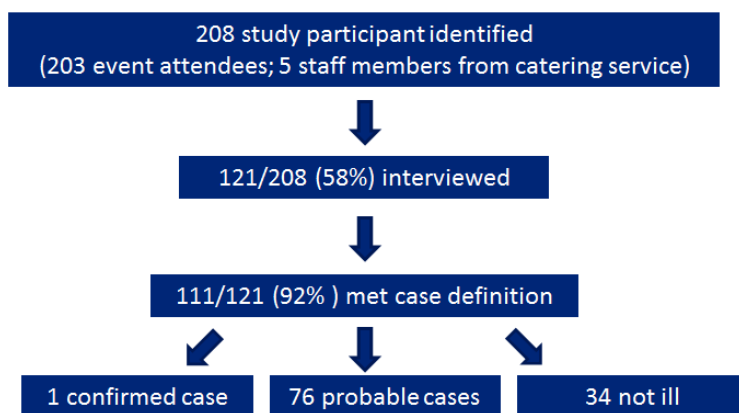
Case definitions

Probable case: someone who had consumed food supplied by the catering service on 5 August 2019 and experienced gastrointestinal symptoms within 48 hours

Confirmed case: someone who had consumed food supplied by the catering service on 5 August 2019 and experienced gastrointestinal symptoms within 48 hours AND had a laboratory result positive for norovirus

9

Methods

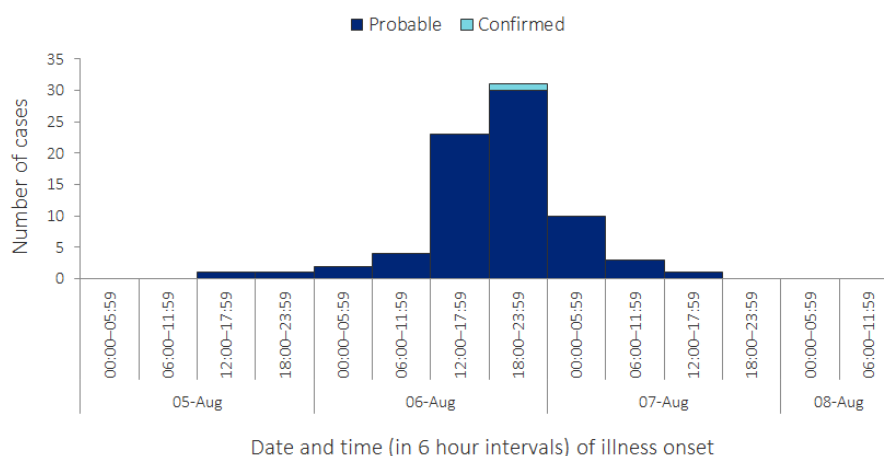


10

Profile of cases

Mean age = 44 years

Median duration of illness = 17.7 hours



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ACT

ACT Health

Results – Case-control study

77 cases, 34 controls

	Cases		Controls		Univariable		
	n	%	n	%	OR	95% CI	P-value
Sandwiches	45	58	13	38	2.27	0.99–5.19	0.05
Wraps	49	64	8	24	5.69	2.27–14.25	<0.001
Fruit	32	42	16	47	0.80	0.36–1.80	0.59
Sweet slices	7	9	7	21	0.39	0.12–1.20	0.10
Danish pastries	17	22	2	6	4.53	0.98–20.87	0.05
Muffins	6	8	1	3	2.79	0.32–24.11	0.44
Scones	1	1	1	3	0.43	0.03–7.15	0.52

For cells with counts less than 5, *P*-values were calculated using the Fisher's exact test.

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ACT

ACT Health

Results – Case-control study

77 cases, 34 controls

	Initial Model			Final Model		
	Adjusted OR	95% CI	P-value	Adjusted OR	95% CI	P-value
Sandwiches	4.78	1.70–13.44	0.003	4.41	1.59–12.19	0.004
Wraps	9.19	2.97–28.46	<0.001	11.22	3.65–34.43	<0.001
Sweet slices	0.17	0.04–30.34	0.02	0.20	0.05–0.79	0.02
Danish pastries	4.64	0.71–30.34	0.11	–	–	–

Food items with $p < 0.25$ in the univariable analysis were included in an initial multivariable logistic regression model.

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Results – Environmental/lab investigation

Samples and environmental swabs

- *Salmonella* and *Campylobacter* not detected; *E. coli* <3cfu/g
- SPC: satisfactory levels of colony-forming units

Faecal samples from 2 cases

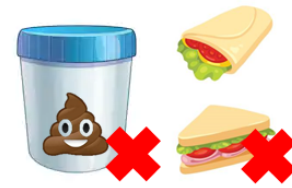
- 1 positive for norovirus

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Limitations

Absence of food and clinical samples

- No faecal samples from food handlers
- No leftovers of food prepared on 5 Aug
- Unable to test food for norovirus



Selection bias

- People who were unwell may be more likely to respond

Recall bias

- Developed questions in the online survey around menu of the catering packages
- Unable to adjust for sex in the multivariable analysis

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ACT

ACT Health

Conclusions

Definitive source of the outbreak could not be established

Spread of viral gastroenteritis

- Inadequate handwashing amongst food handlers
 - Glitterbug test conducted during inspection
- Only hand wash sink in kitchen inadequate in size
- Delayed exclusion of symptomatic food handlers

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ACT

ACT Health

Acknowledgements

MAE supervisors

- Kathryn Glass
- Rose Wright

Communicable Disease Control team (ACT Health)

Environmental Health Officers (ACT Health)

Staff at the ACT Government Analytical Laboratory

10.3 Appendix 3: Online survey for data collection

Question 1

Did you recently attend an event/meeting where food was provided by a catering service?

Please select all that apply.

- ☐ Yes, on Friday 2nd August 2019
- ☐ Yes, on Monday 5th August 2019
- ☐ Yes, on Tuesday 6th August 2019
- ☐ Yes, on Wednesday 7th August 2019
- ☐ No

Question 2

What are the details and location of the event/meeting?

Question 3

Of the food supplied by the catering service, what did you eat? Please select ALL foods that you ate. This includes morning and afternoon tea.

If possible, please provide a brief description of the foods you ate (e.g. chicken/beef sandwiches). If a food is not listed, please specify in the box below.

- ☐ Sandwiches
- ☐ Wraps
- ☐ Fruit
- ☐ Sweet slices
- ☐ Danish pastries
- ☐ Muffins
- ☐ Scones
- ☐ Others (please specify below)

Please provide brief description of food items here.

Question 4

Have you experienced any gastrointestinal symptoms since attending the catered event/meeting?

- ☐ Yes
- ☐ No

Question 5

What date and time did your symptom start? (Please provide a best estimate of both date and time)

Date/Time

DD/MM/YYYY hh:mm

Question 6

What symptoms did you experience? Please select all that apply.

- ☐ Vomiting
- ☐ Diarrhoea
- ☐ Stomach cramps
- ☐ Blood in stools
- ☐ Nausea
- ☐ Fever
- ☐ Chills
- ☐ Muscle and body aches
- ☐ Headache
- ☐ Fatigue
- ☐ Other (please specify)

Question 7

What date and time did your vomiting or diarrhoea stop? (please provide a best estimate of both date and time)

Date/Time

DD/MM/YYYY hh:mm

Question 8

Did you seek medication attention as a result of your illness? Please select all that apply.

- ☐ Yes, consulted a general practitioner
- ☐ Yes, visited a hospital emergency department
- ☐ Yes, had a hospital admission
- ☐ No

Question 9

Did you provide a sample for pathology testing?

- ☐ Yes
- ☐ No

Question 10

If you consent for us to do so, we may contact the pathology service to confirm your results. By providing some personal details we are able to do this. Note: Your personal information is kept confidential and is protected by public health and privacy legislation.

Full name

Date of birth (dd/mm/yyyy)

State of residence

Question 11

In the 2 days after the onset of your illness, do you know of anyone (e.g. family members, friends, colleagues) with a similar illness?

- ☐ Yes, please provide details in box below
- ☐ No
- ☐ Don't know

Question 12

What is your full name?

Question 13

What is your date of birth?

Question 14

What state/territory do you live in?

- ☐ ACT
- ☐ Other (please specify)

Question 15

Are you of Aboriginal or Torres Strait Islander origin?

- ☐ No
- ☐ Yes, Aboriginal
- ☐ Yes, Torres Strait Islander
- ☐ Yes, both Aboriginal and Torres Strait Islander

Question 16

What is your current occupation?

Question 17

Where is the place of employment?

Question 18

Do you consent for ACT Health to contact you if we require further information?

☐ Yes

☐ No

Question 19

Would you like to be contacted again to learn the outcome of this investigation?

☐ Yes

☐ No

Question 20

Please provide any further information here.

This may include contact information for any colleagues that have attended the same event/meeting. We may contact them directly or forward this survey through to them. Alternatively, you can forward this survey to them on the next page.

Chapter 3

Epidemiology of gonorrhoea in Australia, 1999–2018

Abbreviations used in this chapter

ABS	Australian Bureau of Statistics
CDNA	Communicable Disease Network Australia
MBS	Medicare Benefit Schedule
MSM	men who have sex with men
NAAT	nucleic acid amplification tests
NNDSS	National Notifiable Diseases Surveillance System
PrEP	pre-exposure prophylaxis
STI	sexually transmissible infection
WHO	World Health Organization

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1 Prologue

1.1 My role

I was the lead investigator for this project and undertook the following tasks:

- designed the project plan
- completed the ethics application
- extracted data on gonorrhoea tests from the Medicare Australia Statistics website
- cleaned, analysed and interpreted data using Stata
- created graphs using Microsoft Excel.

1.2 Lessons learnt

This project was my first introduction to Stata. Despite the challenges faced, I found the experience very rewarding. Some significant lessons learnt were:

- **Calculating age-standardised rates in Stata:** This was definitely one of the achievements I am most proud of as we were taught how to calculate age-standardised rates in Microsoft Excel rather than Stata.
- **The importance of understanding caveats around disease notifications submitted by states and territories:** Not until I had spoken to the state/territory epidemiologists did I realise some data fields are not routinely used by jurisdictions. For example, site of infection data were not available from the Northern Territory due to the setup of their notification system. Therefore, analyses by site of infection have excluded cases from the NT.

1.3 Public health implications

Gonorrhoea continues to be difficult to control. Increased testing is likely to be a contributing factor to the increased notification rates observed. However, there are limitations associated with using Medicare Schedule Benefit testing data as the denominator. Consideration should be given to having states and territories collect gonorrhoea test counts directly from laboratories in order to help ascertain whether increases in testing have had an impact on the number of notifications of gonorrhoea.

1.4 Acknowledgements

I would like to thank my project supervisor Ms Amy Bright, Communicable Disease Epidemiology and Surveillance Section, for her input into study methodology and ethics application. Amy has a wealth of knowledge about sexually transmissible infection surveillance, and has provided valuable insight into the National Notifiable Diseases Surveillance System.

I would also like to thank my MAE supervisors, Dr Allison Cairns, Ms Rose Wright and A/Prof Kathryn Glass, for their continual guidance and feedback into the study and draft chapters.

I would like to thank the data team, Communicable Disease Epidemiology and Surveillance Section, for extracting the gonorrhoea notifications from the National Notifiable Diseases Surveillance System.

I wish to thank Dr Gary Lum, Medical Adviser at the Australian Government Department of Health, for sharing his knowledge on the limitations of the Medicare Benefits Schedule data.

I wish to acknowledge the epidemiologists in each state and territory who took their time to explain the data caveats around the gonorrhoea notifications notified by their state or territory.

1.5 Master of Philosophy in Applied Epidemiology core requirements

- ✓ Analyse a public health dataset such as surveillance data
- ✓ Prepare an advanced draft of a paper for publication in a national or international peer-reviewed journal (Appendix 1)
- ✓ Prepare an abstract and oral presentation of the project at a national or international scientific conference (Appendix 2 and Appendix 3)

2 Abstract

Introduction: Despite the availability of treatment, notification rates for gonococcal infection have continued to increase in recent years. Reduced susceptibility to ceftriaxone and resistance to azithromycin emerging in urban Australia is also of concern. The key objective of this study was to describe the epidemiology of gonorrhoea in Australia between 1999 and 2018. Secondary objective was to review trends in gonorrhoea testing subsidised through the Medicare Benefit Schedule (MBS) in Australia between 2012 and 2018.

Methods: Gonorrhoea notifications reported to the National Notifiable Diseases Surveillance System between 1 January 1999 and 31 December 2018 were extracted and analysed using Stata/SE 13.1 (StataCorp, Texas, USA). Time trend analyses were performed by sex, age group, notifying state/territory, Aboriginal and Torres Strait Islander status, remoteness areas and site of infection. Gonorrhoea tests subsidised through the Medicare Benefit Schedule between 1 January 2012 and 31 December 2018 were extracted from the Medicare Australia Statistics website, and used as the denominator to estimate test positivity.

Results: Nationally, the gonorrhoea notification rate was 4.4 times higher in 2018 (126.9 per 100,000) than in 1999 (29.1 per 100,000). Infection rates remained high among the Aboriginal and Torres Strait Islander peoples, particularly among those residing in the Northern Territory (2,086 per 100,000 in 2018). While gonorrhoea notification rates increased in all categories of remoteness between 2012 and 2018, the largest increase was observed in major cities. The number of gonorrhoea tests subsidised through the MBS increased by a factor of 1.4 from 2012 (1,094,913 tests) to 2018 (1,548,438 tests), and test positivity increased from 1.27% to 1.99%.

Conclusions: Gonorrhoea is a major public health concern. Prevention and control strategies tailored to population groups with high or increasing rates of gonorrhoea are essential to tackling this public health threat in Australia.

3 Introduction

Gonorrhoea is the second most common bacterial sexually transmissible infection (STI), and is caused by a Gram-negative intracellular diplococci bacterium, *Neisseria gonorrhoeae*.^{1,2} It is transmitted through unprotected vaginal, anal or oral sexual intercourse with an infected person.³ The incubation period is generally 1–14 days.¹ Clinical presentation of gonorrhoea differs slightly between males and females. In males, symptoms of gonorrhoea may include urethral discharge and dysuria; in females, symptoms may include vaginal discharge and cervicitis. Ano-rectal symptoms such as discharge, anal itching and painful bowel movements can occur in both males and females. However, 10–15% of males and up to 80% of females with gonorrhoea remain asymptomatic.⁴ Untreated gonorrhoea may lead to serious complications such as pelvic inflammatory disease in females, which can cause infertility and ectopic pregnancy.³ It may also increase the risk of acquiring human immunodeficiency virus (HIV).⁵ Dual antibiotic treatment with ceftriaxone and azithromycin was introduced in 2014 to delay the emergence of *Neisseria gonorrhoeae* strains resistant to ceftriaxone. Dual antibiotic treatment is currently recommended, except in some remote Australian locations, where penicillin is still the first-line treatment.⁴

In 2007, a duplex nucleic acid amplification test (NAAT) for *Neisseria gonorrhoeae* and *Chlamydia trachomatis* was introduced in Australia. By 2012, the majority of Australian laboratories started routinely performing the duplex NAAT, even if only a test for *Chlamydia trachomatis* was requested. However, these laboratories reported only billing Medicare if a test for *Neisseria gonorrhoeae* was requested by the clinician.⁶

Sexually transmissible infections remain a public health challenge globally. The World Health Organization (WHO) estimated that 87 million new gonorrhoea cases occurred in people aged 15–49 years in 2016.⁷ In Australia, gonorrhoea is a nationally notifiable disease and notification rates have continued to increase since 1993.⁸ The highest notification rates for gonorrhoea are seen in Aboriginal and Torres Strait Islander peoples living in remote and very remote communities.^{8,9} Notifications among females, and males in major cities have also been increasing.^{8,10}

Since the early 1980s, *Neisseria gonorrhoeae* has developed resistance to a variety of antimicrobials including penicillin, tetracycline and fluoroquinolones. As a result, third-generation cephalosporins (a class of antibiotics that includes ceftriaxone) are the last remaining options as first-line treatment. However, a 2014 global report on antimicrobial resistance described an alarming trend, with decreased susceptibility of *Neisseria gonorrhoeae* to third-generation

cephalosporins observed in 36 countries.¹¹ Given third-generation cephalosporins are the last remaining options and very few potential candidates in the drug development pipeline, gonorrhoea may become untreatable.

4 Objectives

The key objective of the study was to describe the epidemiology of gonorrhoea in Australia between 1999 and 2018. The secondary objective was to review trends in gonorrhoea tests subsidised through Medicare Benefit Schedule (MBS) in Australia between 2012 and 2018.

5 Methods

5.1 Study type

A retrospective case series was conducted on gonorrhoea notifications reported to the National Notifiable Diseases Surveillance System (NNDSS) between 1 January 1999 and 31 December 2018.

5.2 Case definitions

The initial national surveillance case definition for gonococcal infection was first developed in 2004 by the Communicable Disease Network Australia. It recommended only confirmed cases should be notified. A confirmed case required the following laboratory definitive evidence:¹²

1. Isolation of *Neisseria gonorrhoeae*, **OR**
2. Detection of *Neisseria gonorrhoeae* by nucleic acid testing, **OR**
3. Detection of typical Gram-negative intracellular diplococci in a smear from a genital tract specimen.

The initial case definition was last reviewed in November 2018 and ‘Detection of typical Gram-negative intracellular diplococci in a smear from a genital tract specimen’ was removed as a source of laboratory definitive evidence. The revised case definition was subsequently implemented in January 2019. While there was a change in case definition, it did not apply to our study period.

5.3 Data sources

National Notifiable Diseases Surveillance System

The NNDSS coordinates the national surveillance of communicable diseases in Australia. Notifications are collected according to the public health legislation in each state and territory. Computerised, de-identified unit records of notifications are then supplied to the Australian

Government Department of Health under the *National Health Security Act 2007*.¹³ Gonorrhoea notifications reported to the Australian Government Department of Health between 1 January 1999 and 31 December 2018 were extracted from the NNDSS. Fields from the dataset included notifying state/territory, postcode of residence, year of diagnosis, date of birth, sex, Aboriginal and Torres Strait Islander status, laboratory diagnosis method and site of infection.

Medicare Benefits Schedule

The Australian Government Services Australia holds administrative datasets for Medicare Benefits Schedule items, including the number of microbiological tests performed and claimed for communicable diseases diagnostics. Item number 69316 (chlamydia testing alone) in addition to 69317 and 69319 (duplex NAAT for chlamydia and a second or third organism respectively, which typically reflects the duplex NAAT for chlamydia and gonorrhoea), were used as a proxy for gonorrhoea tests. Gonorrhoea tests (using item numbers 69316, 69317 and 69319) subsidised through the MBS between 1 January 2012 and 31 December 2018 were extracted from the Medicare Australia Statistics website and exported into Microsoft Excel.¹⁴ The exported data included Medicare items processed by year, state/territory, age group and sex.

5.4 Data analysis

Gonorrhoea cases notified to the NNDSS between 1 January 1999 and 31 December 2018 were summarised by year of diagnosis, sex, age group, notifying state/territory, Aboriginal and Torres Strait Islander status, remoteness area and site of infection. Analyses by Aboriginal and Torres Strait Islander status were only reported from 2009 and restricted to states and territories in which Aboriginal and Torres Strait Islander status was reported for $\geq 50\%$ of notifications for each year. Analyses by site of infection included data from all jurisdictions (the Australian Capital Territory (ACT), New South Wales (NSW), Queensland (Qld), South Australia (SA), Tasmania (Tas), Victoria (Vic) and Western Australia (WA)) except the Northern Territory (NT) which did not report these data to the NNDSS. Analyses by site of infection were restricted to years 2006 to 2017 as the STI enhanced surveillance fields were only endorsed by the CDNA in December 2005. Site of infection data from 2018 were not included due to poor data completeness from the majority of the jurisdictions.

Mid-year resident population estimates were used to calculate annual notification rates per 100,000 population.¹⁵ The direct method was used to calculate age-standardised rates, with 2001 Australian census data as the standard population. While a more recent census was conducted in 2006, the Australian Bureau of Statistics and the Australian Institute of Health and Welfare recommend that the 2001 Australian census data continue to be used for age-standardisation

analyses until the final 30 June 2026 estimates become available.¹⁶ Age-standardised rates by Aboriginal and Torres Strait Islander status were calculated by year using estimated and projected populations from 2001 to 2026.¹⁷ Age-standardised rates by remoteness areas were calculated by year using the estimated resident population from 2001 to 2018 by Statistical Area Level 1 and Statistical Area Level 1-derived areas of Australia, according to the 2016 edition of the Australian Statistical Geography Standard. Estimates were final for 2001 to 2016, revised for 2017, and preliminary for 2018.

Remoteness area is a geographical classification defined by the Australian Bureau of Statistics (ABS) which divides Australia into five categories of remoteness on the basis of a measure of relative access to services. The five categories are: major cities of Australia, inner regional Australia, outer regional Australia, remote Australia and very remote Australia.¹⁸ Cases notified to the NNDSS were mapped to a category of remoteness using the reported postcode of residence, which may not necessarily represent the place where the infection was acquired.

To estimate gonorrhoea test positivity, we used the Medicare Benefit Schedule testing data (item numbers 69316, 69317 and 69319) as the denominator, and the number of gonorrhoea cases notified to the NNDSS as the numerator. Test positivity was estimated by year, sex and state/territory.

Graphs presented in this chapter were created using Microsoft Excel.

6 Ethics

Ethics approval was obtained from the Australian National University Human Research Ethics Committee (protocol no. 2019/310).

7 Results

Between 1 January 1999 and 31 December 2018, there were 246,948 gonorrhoea notifications reported to the NNDSS. The median age of persons notified with gonorrhoea was 27 years, and most were males (71%) (Table 1). Most of the notifications were in people residing in major cities (60%).

Gonorrhoea notifications increased steadily since 1999 except for a decrease in 2007 (Figure 1). The gonorrhoea notification rate was 4.4 times higher in 2018 (126.9 per 100,000) than in 1999 (29.1 per 100,000). The most substantial annual increases observed were in 2010 and 2016

(Figure 1). Increases in gonorrhoea notification rates coincided with changes in laboratory diagnostic methods during our study period, transitioning from culture-based methods to NAAT. In 1999, culture-based methods were the most popular diagnostic method used to test for gonorrhoea. A subsequent slow decline in culture-based methods was seen between 2005 and 2006. This decline was accompanied by a rapid increase in both NAAT testing alone and NAAT testing with culture, particularly between 2015 and 2016 (results not shown).

Table 1. Characteristics of gonorrhoea notifications reported to the NNDSS, Australia, 1999–2018

Characteristics	Total cases = 246,948
Median age	27 years
<i>Sex</i>	
Males	174,315 (71%)
Median age	29 years
Females	72,077 (29%)
Median age	23 years
Missing/unknown	556 (0.2%)
<i>Aboriginal and Torres Strait Islander status</i>	
Aboriginal and Torres Strait Islander	71,215 (29%)
Non-Indigenous	102,615 (42%)
Missing/unknown	73,118 (30%)
<i>Jurisdiction</i>	
ACT	1,755 (0.7%)
NSW	66,271 (27%)
NT	33,491 (14%)
Qld	44,923 (18%)
SA	11,264 (5%)
Tas	871 (0.4%)
Vic	50,482 (20%)
WA	37,891 (15%)
<i>Remoteness area</i>	
Major cities	149,123 (60%)
Inner and outer regional	33,462 (14%)
Remote and very remote	58,841 (22.2%)
Overseas resident	753 (0.3%)
Missing/unknown	8,769 (3.6%)

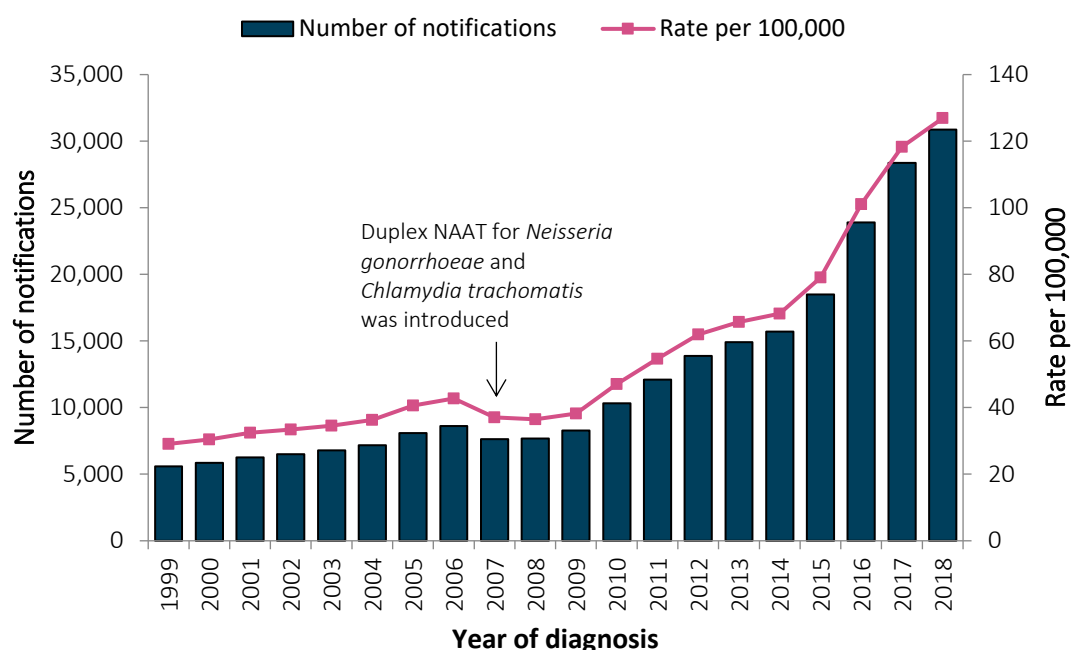


Figure 1. Gonorrhoea notifications and notification rate per 100,000 population, Australia, 1999–2018

7.1 Gonorrhoea notifications by jurisdiction

Gonorrhoea notification rates increased between 1999 and 2018 in all jurisdictions. Whilst gonorrhoea notification rates in 2018 differed between jurisdictions, an increase was seen in all jurisdictions except Qld where notification rate fell by 4% (Figure 2). Notification rates were highest in NT, followed by WA in the past 20 years (1999–2018). In NT, notification rates fluctuated across the study period, and the most recent decrease occurred between 2015 (702.9 per 100,000) and 2017 (676.8 per 100,000), followed by a rapid increase in 2018 (823.9 per 100,000) (Figure 3). Between 2009 and 2018, almost 90% of gonorrhoea notifications in NT were reported to be in Aboriginal and Torres Strait Islander peoples. In WA, a sharp increase in notification rates was observed in 2016, followed by rates stabilising between 2016 and 2018 (Figure 3). Although NT and WA had the highest notification rates in the past 20 years, both jurisdictions had the smallest increase in notifications during the study period. The largest increase occurred in ACT and Vic where notification rates rose from 6.1 per 100,000 in 1999 to 73 per 100,000 in 2018, and from 14.5 per 100,000 in 1999 to 123.7 per 100,000 respectively.

Between 1999 and 2018, the greatest increases in notifications in males and females occurred in ACT, Vic and NSW. Together, these six groups accounted for 36% (n=1,994) of notifications in 1999 but had increased to 61% (n=18,858) in 2018.

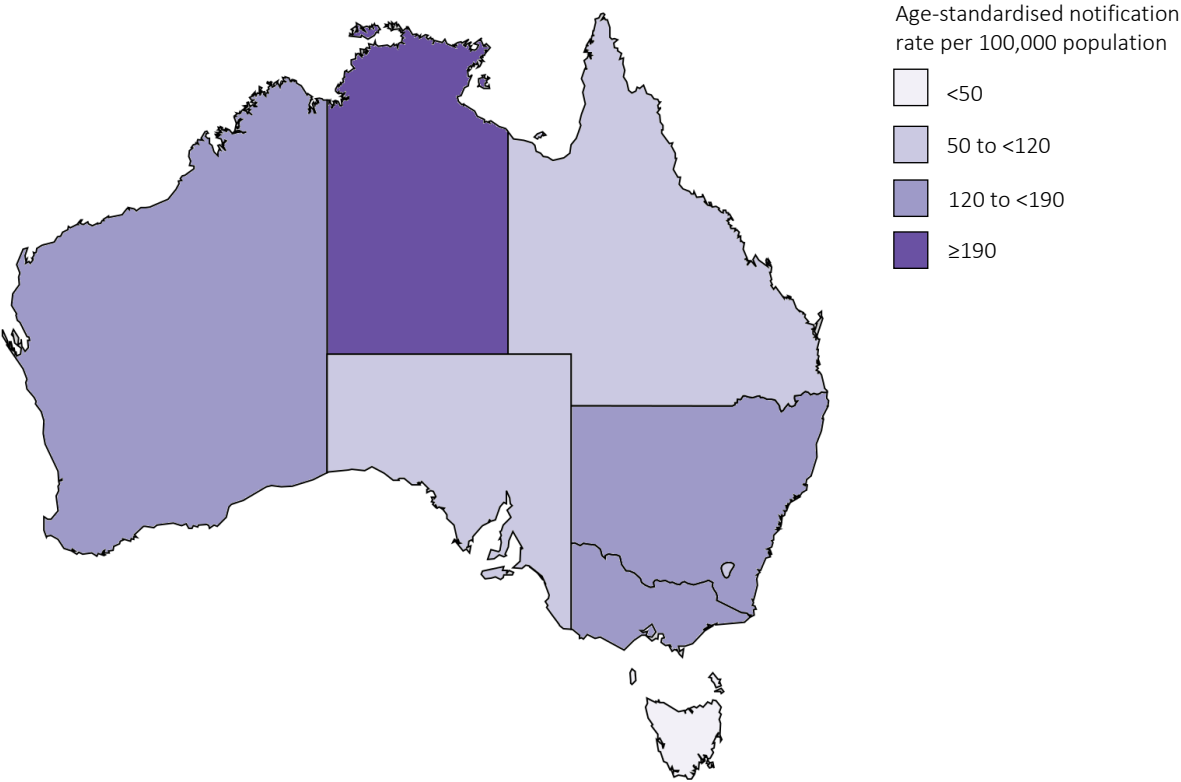
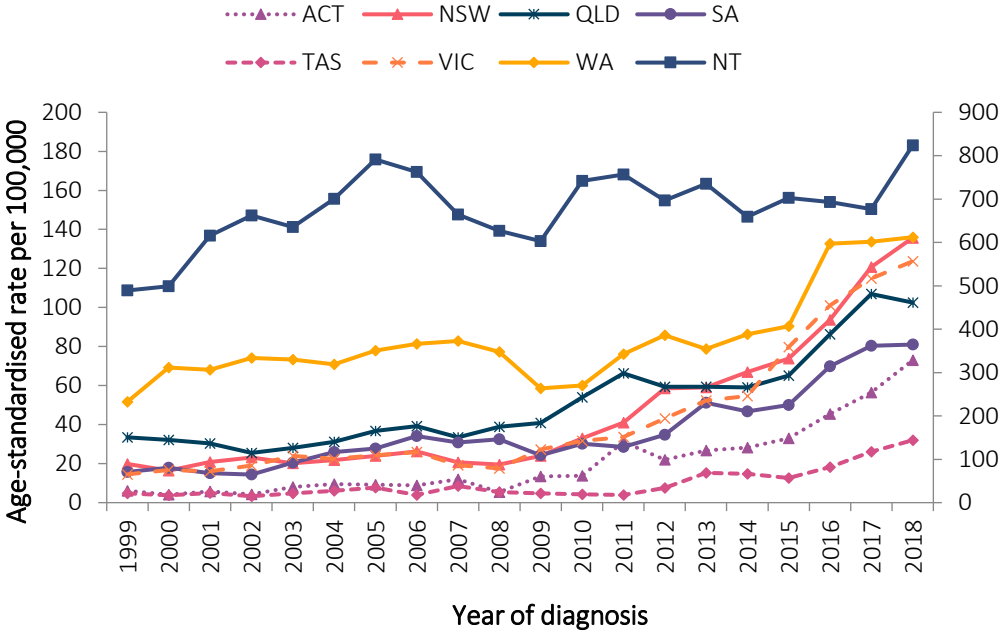


Figure 2. Gonorrhoea notification rate per 100,000 population by jurisdiction, Australia, 2018



*Notification rates for NT are plotted on the secondary axis on the right.

Figure 3. Gonorrhoea notification rate per 100,000 population by jurisdiction, Australia, 1999–2018

7.2 Gonorrhoea notifications by age and sex

Gonorrhoea notification rates increased in all age groups between 1999 and 2017, with the highest notification rates seen in the age group 20–24 years (Figure 4). In 2018, notification rate fell by 7% in the age group 20–24 years (341.6 per 100,000), and the notification rate in the age group 25–29 years (367.0 per 100,000) surpassed that of the age group 20–24 years.

Age-standardised rates have been higher in males than females throughout the past 20 years (1999–2018) (Figure 5). Notification rates in males increased by a factor of 4.7 from 39.5 per 100,000 in 1999 to 186 per 100,000 in 2018. A similar trend was observed among females although a lesser magnitude where notification rates increased by a factor of 3.6 from 18.7 per 100,000 in 1999 to 67.5 per 100,000 in 2018. A sharp increase in notifications was observed in 2016 for both males and females. The proportion of notification by sex varied during the study period, however males consistently accounted for the majority of notifications. In 1999, males accounted for approximately 68% of notifications, and by 2018, this increased to 74%. Male to female ratio increased from 2.2:1 in 1999 to 2.8:1 in 2018.

In males, gonorrhoea notification rates were highest in the age group 20–24 years from 1999 to 2014 (Figure 6). From 2015 to 2018, notification rates were highest in the age group 25–29 years. In 2018, notification rates increased in all age groups except age groups 15–19 years (8% decrease) and 20–24 years (2% decrease). In females, gonorrhoea notification rates were highest in the age group 15–19 years from 1999 to 2014 (Figure 7). From 2015 to 2018, notification rates were highest in the age group 20–24 years. In 2018, notification rates among females followed a similar trend to what was observed in males. Notification rates increased in all age groups except age groups 15–19 years (6% decrease) and 20–24 years (2% decrease).

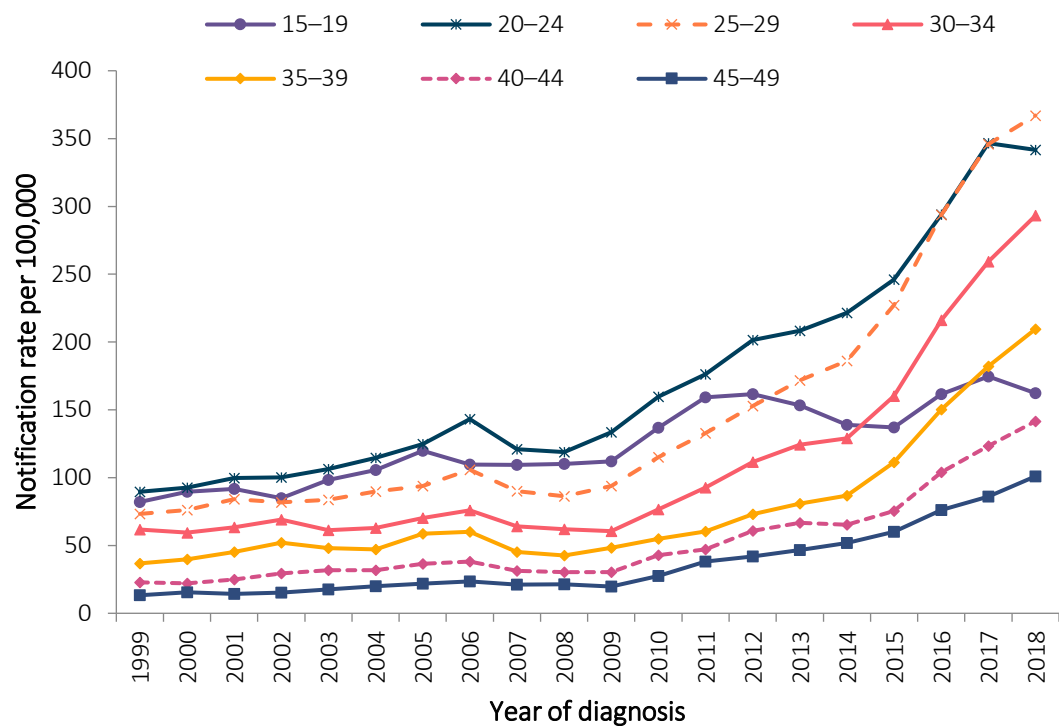


Figure 4. Gonorrhoea notification rate per 100,000 population by age group, Australia, 1999–2018

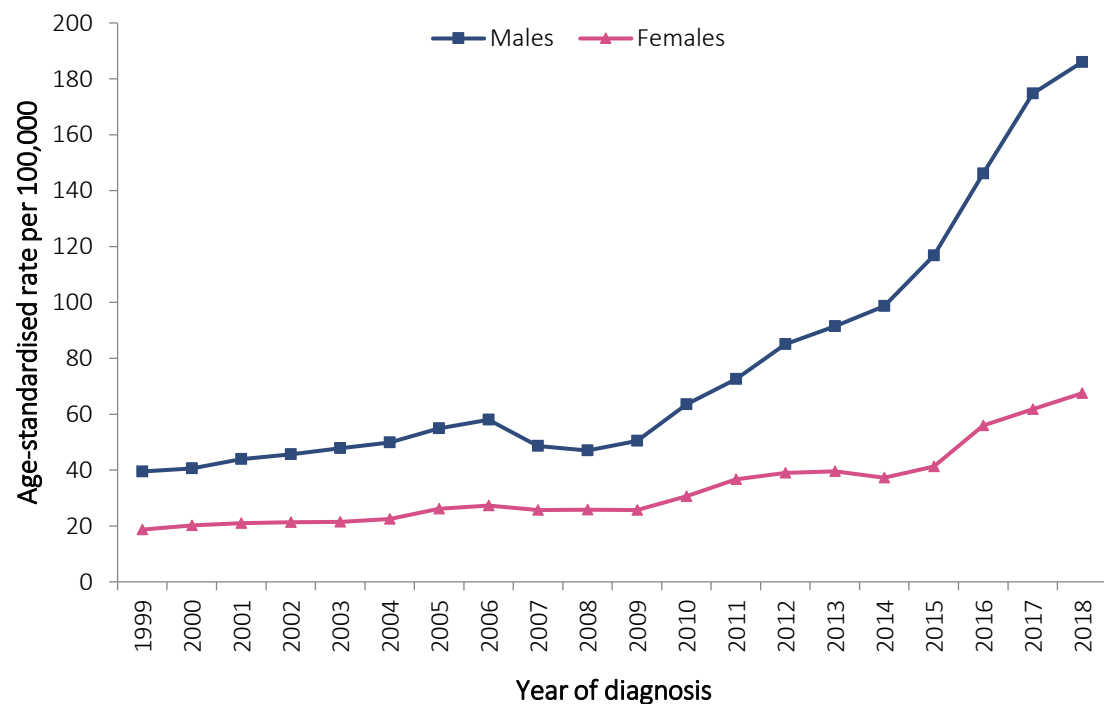


Figure 5. Gonorrhoea notification rate per 100,000 population by sex, Australia, 1999–2018

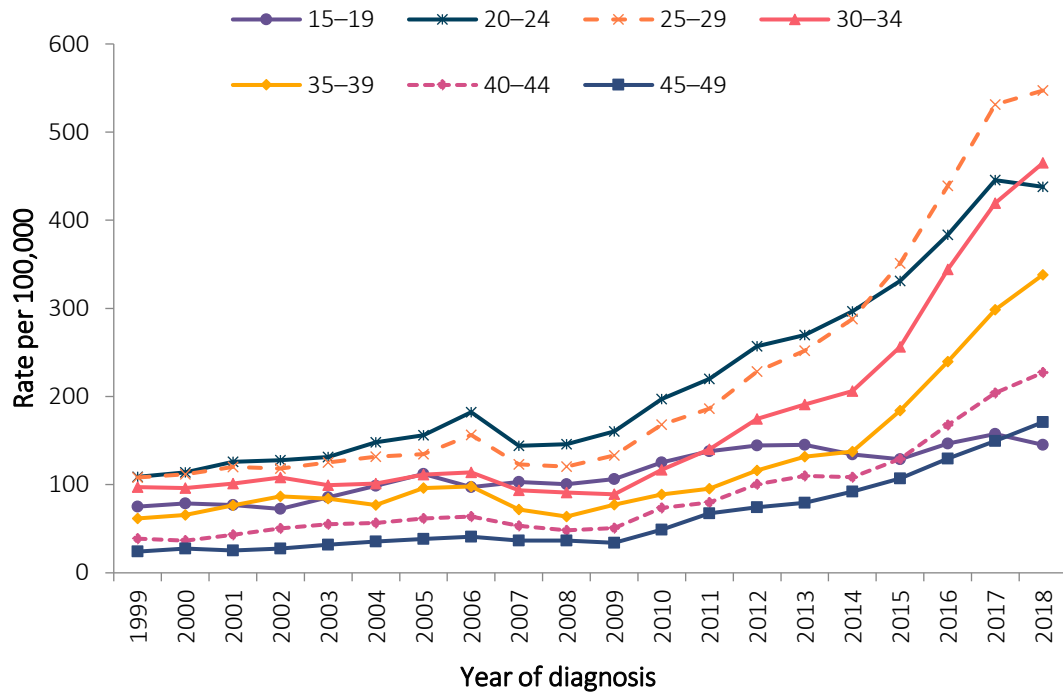


Figure 6. Gonorrhoea notification rate per 100,000 population by age group, males, Australia, 1999–2018

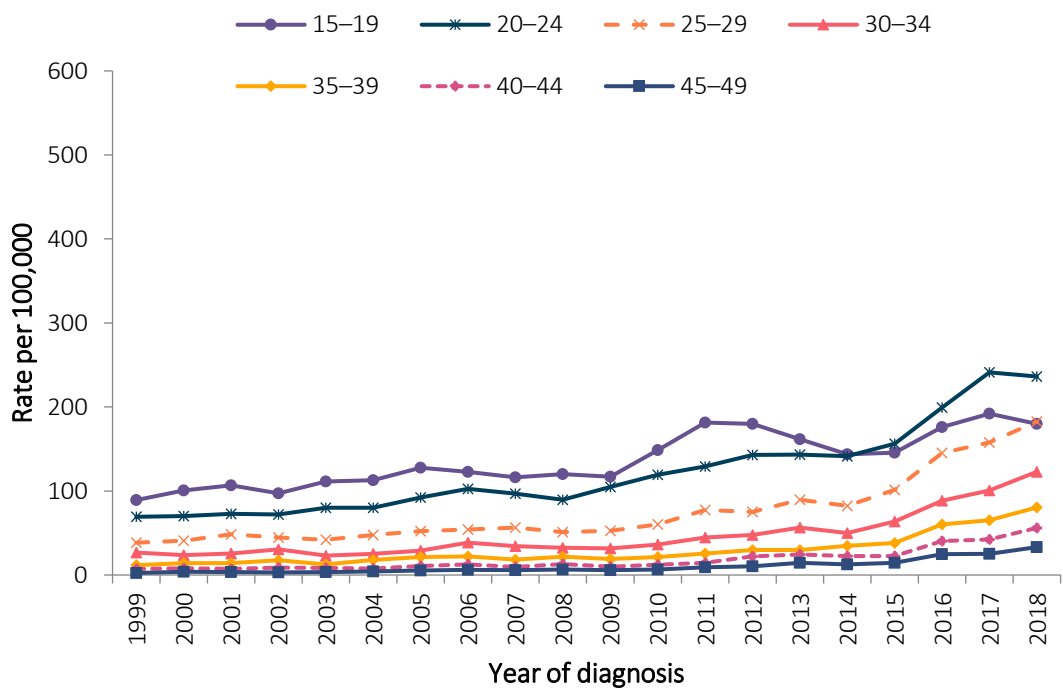


Figure 7. Gonorrhoea notification rate per 100,000 population by age group, females, Australia, 1999–2018

7.3 Gonorrhoea notifications by Aboriginal and Torres Strait Islander status

Overall completeness of the Aboriginal and Torres Strait Islander status during the study period was approximately 70%, with a further 30% being reported as unknown.

Of the gonorrhoea cases notified to the NNDSS in 2009, the non-Indigenous population accounted for approximately 32% of notifications. This proportion continued to increase and by 2018, accounted for almost 55% of notifications (Figure 8).

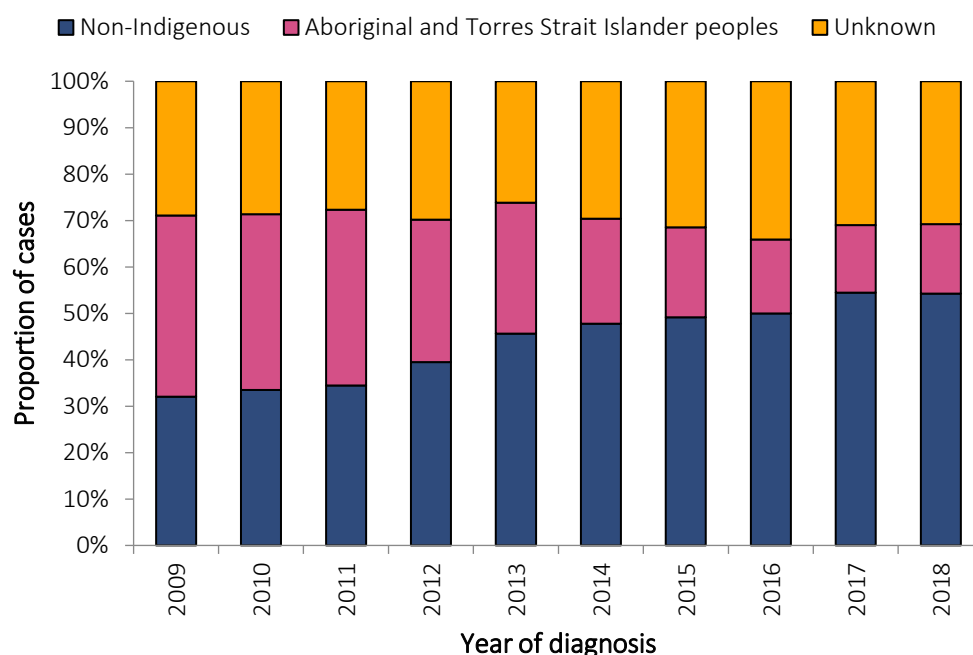


Figure 8. Proportion of cases by Indigenous status, Australia, 2009–2018

While it is important to acknowledge the high notification rates in Aboriginal and Torres Strait Islander people, and that gonorrhoea remains a public health problem, deficit discourse was avoided when describing differences in incidence. Nationally, the age-standardised notification rates per 100,000 population among Aboriginal and Torres Strait Islander peoples were higher than the rates in the non-Indigenous population over the past 10 years (2009–2018). In 2009 the notification rate in the Aboriginal population was 25 times as high as in the non-Indigenous population (589.6 per 100,000 compared with 23.9 per 100,000). By 2018, this disparity between the two population groups has decreased. The notification rate in the Aboriginal population (709.3 per 100,000) was 7 times higher compared to the non-Indigenous population (98.8 per 100,000).

Among Aboriginal and Torres Strait Islander peoples, notification rates continued to rise from 2009 (589.6 per 100,000) to 2011 (785.1 per 100,000). Between 2012 and 2015, notification rates

began to fall with sharp declines in 2012 (10% decrease), and 2014 (19% decrease) (Figure 9). Notification rates started trending upwards again in 2016 and reached 709.3 per 100,000 by 2018. In the non-Indigenous population, the age-standardised notification rates continued to increase from 2009. Notification rates between 2009 and 2018 increased by a factor of 4.1 from 23.9 per 100,000 in 2009 to 98.8 per 100,000 in 2018, in contrast to the Aboriginal population which increased by a factor of 1.2 from 589.6 per 100,000 in 2009 to 709.3 per 100,000 in 2018.

Between 2009 and 2018, the age-standardised notification rates among the Aboriginal and Torres Strait Islander peoples was highest in the NT (2,085.6 per 100,000), followed by WA (958.6 per 100,000) (Figure 9). In the non-Indigenous population, highest notification rates were also observed in the NT (137.4 per 100,000), followed by Vic (123.6 per 100,000). In 2018, the age-standardised notification rates were higher among Aboriginal and Torres Strait Islander peoples than the non-Indigenous populations in all jurisdictions except Tasmania.

The overall male to female ratio was 0.9:1 and 3.3:1 for Aboriginal and non-Indigenous populations respectively. Among the Aboriginal and Torres Strait Islander peoples, the gonorrhoea notification rates were higher in females than males (Figure 10). In 2018, the highest rate was seen in female Aboriginal and Torres Strait Islander peoples aged 15–19 years (2,683.4 per 100,000), followed by those aged 20–24 years (2,342.6 per 100,000) and 25–29 years (1,920.9 per 100,000). In the non-Indigenous population, the opposite was observed. Gonorrhoea notification rates were higher in males than females over the study period (Figure 10). In 2018, the highest rate was seen in non-Indigenous males aged 25–29 years (458.5 per 100,000), followed by those aged 30–34 years (384.9 per 100,000).

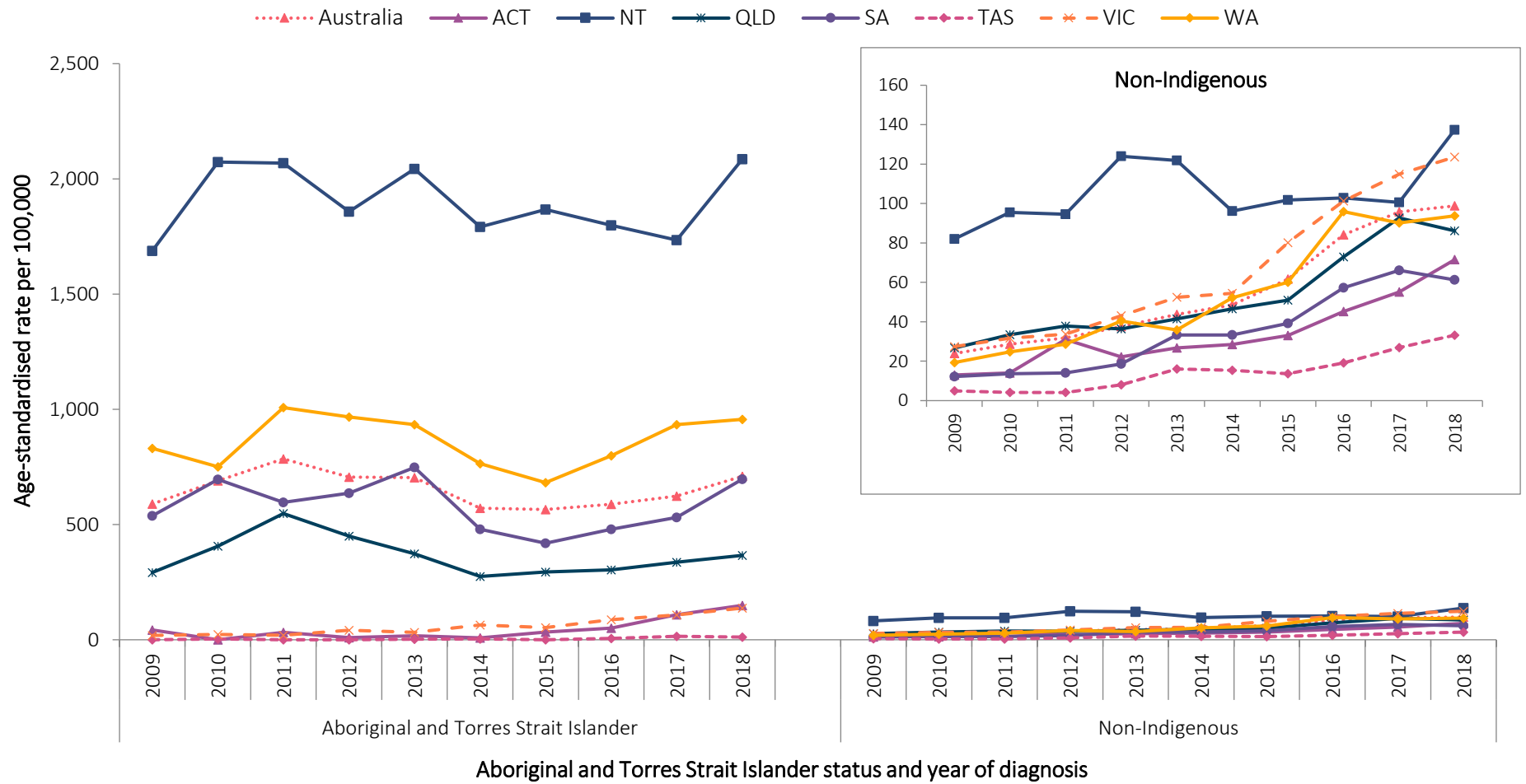


Figure 9. Gonorrhoea notification rate per 100,000 population by Aboriginal and Torres Strait Islander status and jurisdiction, Australia, 2009–2018

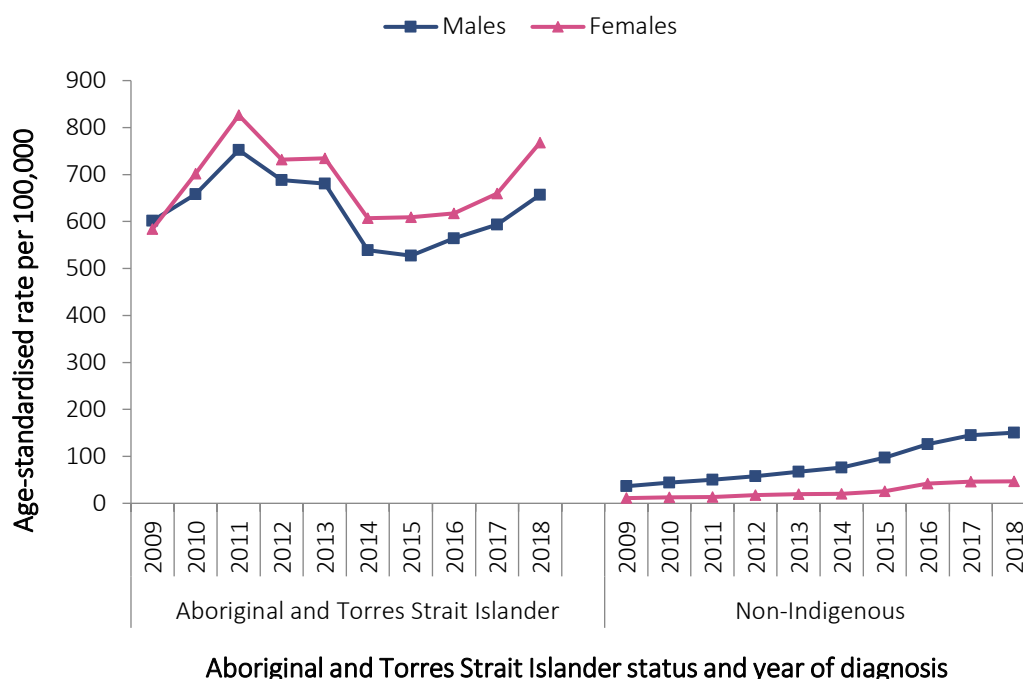


Figure 10. Gonorrhoea notification rate per 100,000 population by Aboriginal and Torres Strait Islander status and sex, Australia, 2009–2018

7.4 Gonorrhoea notifications by remoteness

Between 2001 and 2018, gonorrhoea notification rates increased in all categories of remoteness. While the highest rates of gonorrhoea were in remote and very remote areas of Australia, the greatest increase in notification rate was in major cities (Figure 11). Between 2001 and 2018, notification rates increased by a factor of 6.7 in major cities from 18.5 per 100,000 to 123.2 per 100,000, and by a factor of 3 in regional areas from 20.2 per 100,000 to 63.1 per 100,000.

Notifications by Aboriginal and Torres Strait Islander status differed by remoteness category. For gonorrhoea notifications reported in remote and very remote areas of Australia between 2009 and 2018, more than 90% of notifications were in Aboriginal and Torres Strait Islander peoples. While most gonorrhoea notifications in major cities were in the non-Indigenous population, almost 40% of cases had unknown Aboriginal and Torres Strait Islander status.

The sex distribution of gonorrhoea cases also differed by remoteness category. Females from major cities had a greater increase in the number of gonorrhoea notifications between 2001 and 2018 than males. Age-standardised rates increased by a factor of 12 from 4.5 per 100,000 population 2001 to 53.5 per 100,000 in 2018. For males, age-standardised rates increased by a factor of 6 from 34.1 per 100,000 in 2001 to 200.2 per 100,000 in 2018. Males still accounted for the majority of notifications reported in major cities during the study period, but the proportion of female cases has increased from 12% in 2001 to 21% in 2018. The male to female ratio among

cases reported in major cities decreased correspondingly from 7.3:1 in 2001 to 3.7:1 in 2018. The overall male to female ratios among cases reported in inner and outer regional areas, and remote and very remote areas during the study period were 1.5:1 and 0.9:1 respectively.

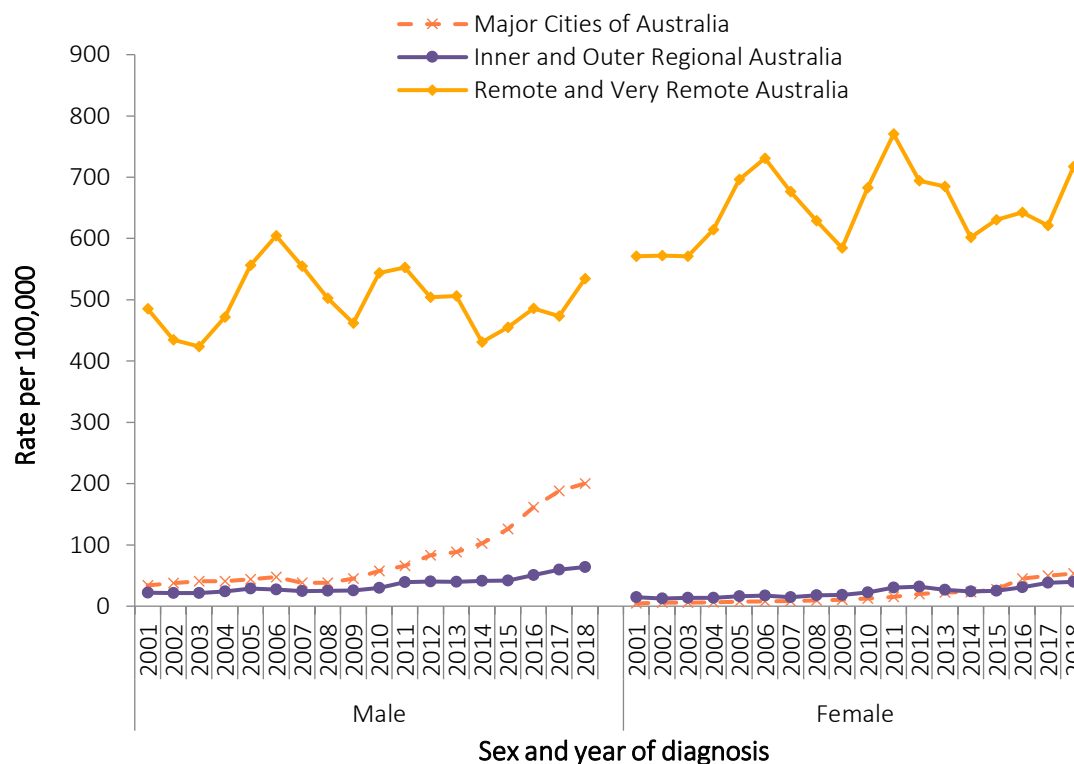


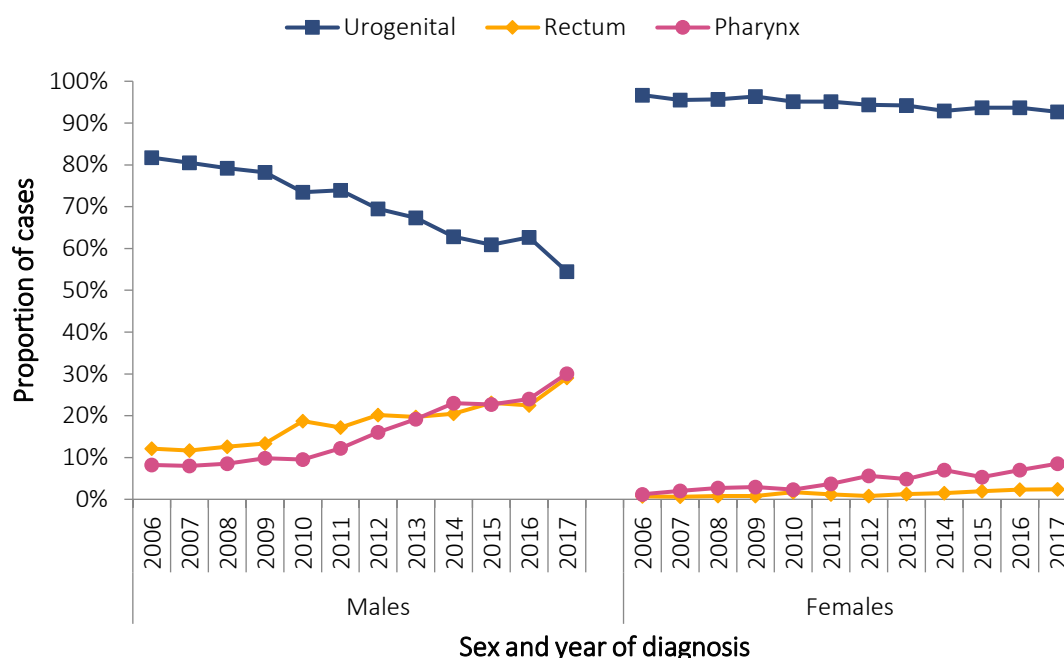
Figure 11. Gonorrhoea notification rate per 100,000 population by remoteness area and sex, Australia, 2001–2018

7.5 Gonorrhoea notifications by site of infection

Overall completeness of the site of infection during the study period was approximately 70%, with a further 30% being reported as no data available or unknown.

The urogenital tract remained the most commonly reported site of infection in both males and females. The proportion of males with urogenital gonorrhoea decreased during the study period, despite a threefold increase in the number of urogenital infections between 2006 ($n=3,439$) and 2017 ($n=10,188$) (Figure 12). While a similar trend was observed among females, the magnitude was much less profound than males. Between 2006 and 2017, an increase in the proportion of males and females with rectal gonorrhoea was observed. In males, the proportion increased from 12% in 2006 to almost 30% in 2017. In females, the proportion with rectal gonorrhoea increased more than threefold from slightly less than 1% in 2006 to 2.4% in 2017. A similar trend was observed in the proportion of males and females with oropharyngeal gonorrhoea. In males, the proportion with oropharyngeal gonorrhoea increased more than threefold from 8.2% in 2006 to 30% in 2017. In females, the proportion with oropharyngeal gonorrhoea increased substantially

from 1.2% in 2006 to 8.5% in 2017. Nationally, the proportion of notifications with gonorrhoea isolated from more than one known site increased from 2.0% (n=115) in 2006 to 10.3% (n=2,570) in 2017. The proportion increased from 2.3% (n=97) to 12.4% (n=2,312) in males, and from 0.4% (n=6) to 3.6% (n=218) in females.



* Data for 2018 were not included due to poor data completeness from most jurisdictions.

Figure 12. Proportion of cases with urogenital, rectal and oropharyngeal gonorrhoea by sex, Australia, 2006–2017*

7.6 Test positivity

There was a 1.4-fold increase in the number of gonorrhoea tests performed from 1,094,913 in 2012 to 1,548,438 in 2018. Gonorrhoea positivity also increased from 1.3% in 2012 to 2.0% in 2018 (Figure 13).

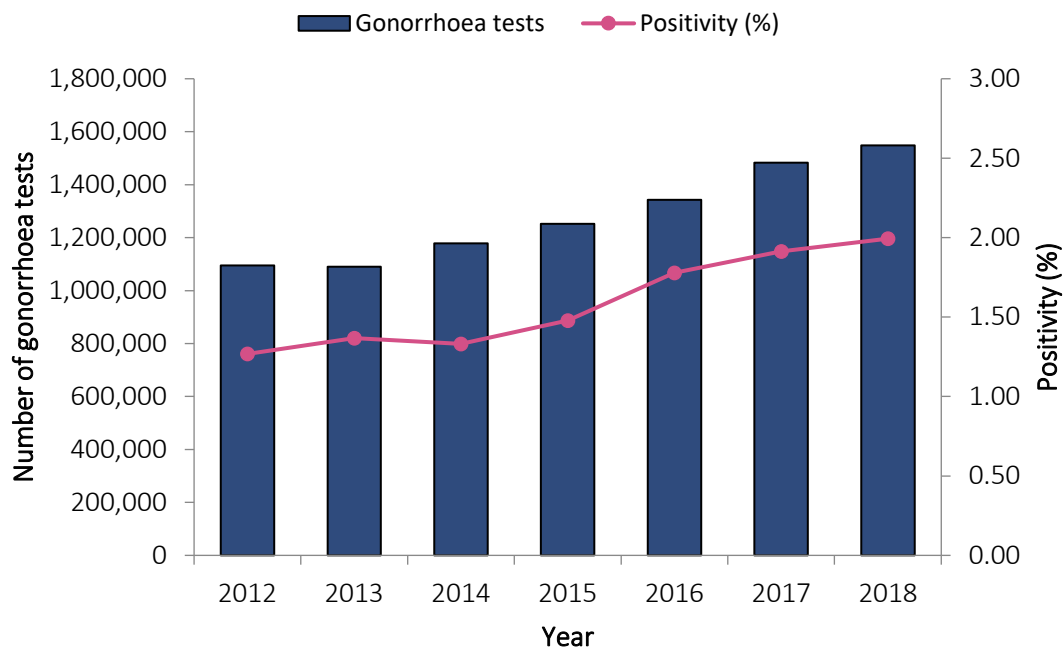


Figure 13. Number of gonorrhoea tests and positivity (%), Australia, 2012–2018

Whilst more gonorrhoea tests were performed in females than males between 2012 and 2018, the proportions of tests that were positive was higher in males (Figure 14).

Males also had a greater increase in gonorrhoea tests than females across all age groups between 2012 and 2018. Gonorrhoea testing increased by a factor of 1.7–1.9 among males aged 25–54 years, and by a factor of 2.1–2.4 for males aged over 55 years. A similar trend was observed in females where the magnitude of increase in testing was higher among older age groups. Gonorrhoea testing increased by a factor of 1.5–1.9 among females aged 25–64 years, and by a factor of 2.4 for females aged over 65 years. The smallest increase in the number of gonorrhoea tests performed in both males and females was among those aged 15–24 years. During the same period, gonorrhoea positivity increased across all age groups in both males and females (Figure 14).

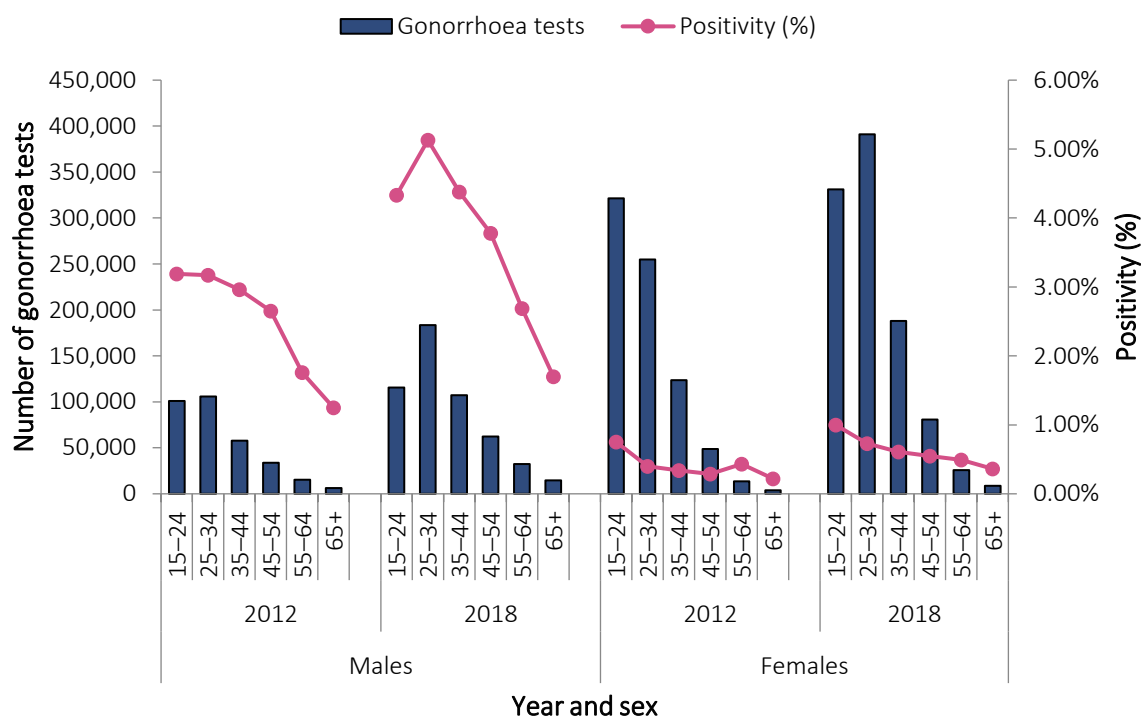


Figure 14. Number of gonorrhoea tests and positivity (%) by sex and age group, Australia, 2012 and 2018

Test positivity in all jurisdictions followed a steady upward trend between 2012 and 2018 except the Northern Territory, where a decline in test positivity was observed (Table 2).

Table 2. Test positivity (%) by jurisdiction, Australia, 2012–2018

Jurisdiction	Test positivity (%)						
	2012	2013	2014	2015	2016	2017	2018
ACT	0.67	0.85	0.85	0.95	1.26	1.44	1.74
NSW	1.28	1.33	1.39	1.43	1.75	2.14	2.34
NT	5.10	5.08	4.14	4.09	3.62	3.29	3.91
Qld	1.17	1.20	1.10	1.17	1.48	1.71	1.57
SA	1.03	1.42	1.19	1.30	1.52	1.47	1.49
Tas	0.18	0.36	0.31	0.23	0.32	0.43	0.51
Vic	0.92	1.15	1.18	1.72	1.99	1.99	2.10
WA	1.38	1.29	1.32	1.27	1.78	1.67	1.62

8 Discussion

This study describes the epidemiology of gonorrhoea in Australia between 1999 and 2018. Nationally, the gonorrhoea notification rate increased by a factor of 4.4 between 1999 (29.1 per 100,000) and 2018 (126.9 per 100,000). Similar trends are observed in the United States of America and Europe.^{19,20} The increased routine use of the duplex nucleic acid amplification tests for *Neisseria gonorrhoeae* and *Chlamydia trachomatis* may partially explain the increase in gonorrhoea notifications. In addition, the increased testing was likely to have identified asymptomatic cases that would otherwise remain undetected.

Our findings on the distribution of gonorrhoea notifications by geographical location, sex, Aboriginal and Torres Strait Islander status, and site of infection were broadly comparable with those reported in the last national epidemiological review published in 2014.⁸ ACT and Vic had the greatest increase in notification rates, and high notification rates persisted in NT. We hypothesise that this is a reflection of the jurisdiction population structure where Aboriginal and Torres Strait Islander peoples comprised 30% of the NT population.²¹ This hypothesis also applies to other sexually transmissible infections in NT, and may explain the jurisdiction's substantially higher notification rates for chlamydia and infectious syphilis.⁹

While notification rates were highest in the age groups 15–19 years and 20–24 years, these age groups also had the smallest increase in gonorrhoea testing rates. This is of concern, as these age groups should be targeted for testing, particularly for those aged 15–19 years. According to the *Guidelines for Preventive Activities in General Practice*, people aged less than 20 years are considered medium to high risk, and testing for gonorrhoea and syphilis should be considered in addition to chlamydia, following a risk assessment.²² Although the overall notification rates remained higher in males than females, our study revealed that when taking into account remoteness, females in major cities had a greater increase than males in the same remoteness category. The bridging of sexual networks between MSM and heterosexuals was described as a potential factor that contributed to the increase in notifications seen among females. A study in Victoria utilised genomic analyses to identify clusters among gonorrhoea notifications reported in 2017. After linking epidemiological characteristics to identified-clusters, 11 major clusters containing 30 or more cases were found, and female cases were identified in six of the major MSM-associated clusters. The researchers also believed that men who have sex with men and women (MSMW) play a role in facilitating transmission of gonorrhoea between men who have sex with men only (MSMO) and females.²³ The proportion of females with oropharyngeal gonorrhoea has also substantially increased between 2006 and 2018. A change in sexual practices among females could have contributed to the observed increases. This postulation is supported

by the findings in the Second Australian Study of Health and Relationships conducted between 2012 and 2013.²⁴ Compared to the First Australian Study of Health and Relationships conducted between 2001 and 2002, the Second Australian Study of Health and Relationships found a statistically significant increase (15 percentage points) in the proportion of women aged 16–59 years who have ever had oral sex.²⁴

Gonorrhoea notification rates remain highest among Aboriginal and Torres Strait Islander peoples, particularly those residing in the Northern Territory and in very remote areas of Australia. Although high rates persisted in the Aboriginal population, the increase in rates was less than that of the non-Indigenous population. The high notification rates may be a reflection of the population groups' inability to access culturally and socially appropriate healthcare services, indicating either a change in service delivery, and/or additional tailored services are required to reduce the persistently high infection rates.²⁵ We had similar findings to a study that examined trends in gonorrhoea notification and testing in a remote district of the Northern Territory.²⁶ Among Aboriginal and Torres Strait Islander peoples, the gonorrhoea notification rates have been highest in the 15–19, 20–24 and 25–29 years age groups. This finding corresponds to the screening recommendations by the Royal Australian College of General Practitioners where annual gonorrhoea screening is recommended for all sexually active Aboriginal and Torres Strait Islander peoples aged 15–30 years.²⁷ Our study also revealed higher gonorrhoea notification rates in female Aboriginal and Torres Strait Islander peoples than their male counterparts. A study conducted at a remote community health clinic in the Northern Territory found that men accessed the clinic less than women, and were less likely to receive testing for sexually transmissible infections. Low health literacy and perceived shame associated with clinic visits were identified as common barriers to accessing services in the community health clinic.²⁸ Higher testing rates among Aboriginal and Torres Strait Islander people may be an explanation of the higher notification rates observed, however we were unable to explore that hypothesis as testing data exported from Medicare Australia Statistics did not provide a breakdown by Aboriginal and Torres Strait Islander status. While we are unable to determine whether higher testing rates among Aboriginal and Torres Strait Islander people play a role, the continuing high infection rates in Aboriginal and Torres Strait Islander people, particularly in young women of childbearing age, are concerning. Untreated gonorrhoea during pregnancy is associated with miscarriage, preterm birth, and low birth weight. The infection can also be transmitted from mother to baby during delivery.²⁹

An increase in gonorrhoea notification rates may be attributed to a combination of a real increase in disease prevalence, and to improved diagnosis and increased laboratory testing leading to an

increase in diagnosis. The introduction of the dual NAAT for the detection of *Neisseria gonorrhoeae* and *Chlamydia trachomatis* is likely to have contributed to the increased laboratory testing, thereby identifying additional gonorrhoea cases that may have otherwise remained undetected under previous testing practices. While culture-based testing is regarded as the gold standard for the diagnosis of gonorrhoea due to its high specificity, several advantages associated with NAATs may have led to the transition from culture-based testing. NAATs show improved sensitivity compared to culture-based testing, and transport requirements are less stringent as viable organisms are not required for detection.^{30,31} However, a decrease in culture-based testing will lead to a reduction of clinical isolates available for antimicrobial resistance surveillance in Australia. Increased laboratory testing in recent years may also be partially driven by the introduction of HIV pre-exposure prophylaxis (PrEP) as PrEP users are recommended to test for sexually transmissible infections (i.e. syphilis, gonorrhoea, chlamydia) every 3 months.³² While increased laboratory testing may have led to an increase in diagnosis, Chow and Mannion argued that positive NAAT tests in low-risk populations should be interpreted with caution. In populations with low disease prevalence, the positive predictive value decreases even if a test with high sensitivity and specificity was used, such as NAAT, resulting in a substantial amount of false-positives.^{33,34} As suggested by Chow, confirmatory cultures should be performed to minimise false-positive notifications.³³

Our analyses on gonorrhoea notifications by sex, site of infection – used as a proxy measure for sexual exposure, and test positivity together suggest a real increase in disease prevalence, particularly in the MSM population. During our study period, males recorded higher age-standardised rates than females, as well as having a large magnitude of increase in notification rates. Between 2016 and 2017, infections of the pharynx and rectum in males have almost doubled. Rectal infections in males are more likely to be in the MSM population given the low transmission probability from females to males.³⁵ Additionally, a study has estimated a probability as high as 84% for urethral-to-rectal transmission among a modelled MSM population.³⁶ The increase seen in the overall male-to-female ratio during our study period further supports our argument that gonorrhoea infections are increasing the MSM population. A recent study conducted in 2019, using data from 47 publicly funded sexual health clinics in Australia, found that the overall incidence of gonorrhoea among gay and bisexual men attending Australian sexual health clinics increased significantly between 2010 and 2017. The study also highlighted that the increase in incidence was higher overall among those aged less than 30 years.¹⁰ This is consistent with our findings that a large increase in test positivity was observed among males aged 25–34 years. Geospatial networking applications, particularly among MSM, may have played an important role in the rising STI rates. Applications are thought to facilitate transmission of

gonorrhoea through the development and bridging of large sexual networks. However, further research utilising a representative sample is warranted.³⁷

Gonorrhoea is best prevented by practicing safe sex which includes using condoms when having vaginal, anal or oral sexual intercourse.³⁸ Yet, recent studies have demonstrated a decrease in consistent condom use after PrEP initiation among gay and bisexual men with casual partners, presumably due to changes in risk perception.³⁹⁻⁴¹

8.1 Limitations

Data incompleteness is one of the limitations of this study. Aboriginal and Torres Strait Islander status and site of infection fields are not well recorded. Study results should therefore be interpreted with caution. NSW is the only jurisdiction excluded from the analyses by Aboriginal and Torres Strait Islander status. The difference in data completeness seen between NSW and other jurisdictions is likely associated with the difference in the notification and follow up processes. Poor data completeness in NSW is likely due to gonorrhoea being notifiable by the diagnosing laboratories only, and that cases are generally not followed up by the public health units, therefore demographics details are not routinely collected.⁴² The only exception is when the public health unit routinely conducts enhanced STI surveillance. In other jurisdictions with higher degree of data completeness, diagnoses of gonorrhoea are generally notified by the diagnosing laboratory, the referring clinician, hospital or a combination of these.

MBS testing data do not include services provided in sexual health clinics or public hospitals, or services that qualify for a benefit provided by the Australian Government Department of Veteran's Affairs. This is a major limitation as Australian sexual health clinics are known to attract higher proportions of priority populations compared with their proportion in the wider general population. We have, therefore, potentially excluded a large proportion of the MSM population from our denominator in the test positivity analysis. As a result, we will have undercounted the total number of gonorrhoea tests performed and overestimated the test positivity. Pathology services subsidised through the MBS are subject to episode coning, which means an upper limit applies to the number of services that are eligible for Medicare benefits in a single patient episode. In general, Medicare pays for the three most expensive items.⁴³ Therefore, we may have again overestimated the test positivity. Testing data obtained directly from public and private laboratories would serve as a more accurate denominator.

9 Conclusions

Gonorrhoea remains a public health challenge in Australia, where the national notification rates have continued to increase in recent years, partially attributed to increased testing. Obtaining gonorrhoea test counts directly from pathology laboratories would assist public health officials to better interpret changes in disease notification trends and the impact of increased testing. Further efforts are required to decrease the increasing infection rates.

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11 Appendices

11.1 Appendix 1: Advanced draft article for submission to the Sexual Health journal

Epidemiology of gonorrhoea in Australia, 1999–2018

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Summary text for the Table of Contents

We described the epidemiology of gonorrhoea in Australia between 1999 and 2018. Analyses revealed that notification rates for gonorrhoea have continued to increase in recent years.

Abstract

Background: Despite the availability of treatment, notification rates for gonococcal infection have continued to increase in recent years. This study aimed to describe the epidemiology of gonorrhoea in Australia between 1999 and 2018 and review trends in gonorrhoea testing subsidised through Medicare Benefit Schedule (MBS) in Australia between 2012 and 2018.

Methods: Gonorrhoea notifications reported to the Australian Government Department of Health between 1 January 1999 and 31 December 2018 were extracted from the National Notifiable Diseases Surveillance System (NNDSS) and analysed using Stata/SE 13.1 (StataCorp, Texas, USA). Time trend analyses were performed by sex, age group, notifying state or territory, Aboriginal and Torres Strait Islander status, remoteness area and site of infection. Gonorrhoea tests subsidised through the MBS between 1 January 2012 and 31 December 2018 were extracted from the Medicare Australia Statistics website were used as the denominator to estimate test positivity. **Results:** Nationally, the gonorrhoea notification rate was 4.4 times higher in 2018

(126.9 per 100,000) than in 1999 (29.1 per 100,000). Infection rates remained high among the Aboriginal and Torres Strait Islander peoples, particularly those residing in the Northern Territory. The number of gonorrhoea tests subsidised through the MBS increased by a factor of 1.4 from 2012 (1,094,913 tests) to 2018 (1,548,438 tests). Test positivity increased from 1.27% to 1.99%.

Conclusions: Gonorrhoea remains a public health challenge in Australia. Prevention and control strategies tailored to population groups with high or increasing rates of gonorrhoea are essential to tackling this public health threat in Australia.

Additional keywords: *Neisseria gonorrhoeae*

Introduction

Gonorrhoea is the second most common bacterial sexually transmissible infection, and is caused by a Gram-negative intracellular diplococci bacterium, *Neisseria gonorrhoeae*.^(1,2) Sexually transmissible infections remain a public health challenge globally. The World Health Organization (WHO) estimated that 87 million new gonorrhoea cases occurred in people aged 15–49 years in 2016.⁽³⁾ Gonorrhoea is a nationally notifiable disease in Australia and notification rates have continued to increase since 1993.⁽⁴⁾ The highest notification rates for gonorrhoea are seen in Aboriginal and Torres Strait Islander peoples living in remote and very remote communities.^(4,5) Notifications among females, and males in major cities have also been increasing.^(4,6)

In 2007, a duplex nucleic acid amplification test (NAAT) for *Neisseria gonorrhoeae* and *Chlamydia trachomatis* was introduced in Australia. By 2012, the majority of Australian laboratories started routinely performing the duplex NAAT, even if only a test for *Chlamydia trachomatis* was requested. However, these laboratories reported only billing Medicare if a test for *Neisseria gonorrhoeae* was requested by the clinician.⁽⁷⁾

The key objective of the study was to describe the epidemiology of gonorrhoea in Australia between 1999 and 2018. The secondary objective was to review trends in gonorrhoea tests subsidised through Medicare Benefit Schedule (MBS) in Australia between 2012 and 2018.

Methods

A retrospective case series was conducted on gonorrhoea notifications reported to the NNDSS between 1 January 1999 and 31 December 2018. Notifications were summarised by year of infection, sex, age group, notifying state or territory, Aboriginal and Torres Strait Islander status, remoteness area and site of infection. Analyses by Aboriginal and Torres Strait Islander status were only reported from 2009 and restricted to states and territories in which Aboriginal and Torres Strait Islander status was reported for at least 50% of notifications for each year. Analyses by site of infection included data from all jurisdictions (the Australian Capital Territory (ACT), New South Wales (NSW), Queensland (Qld), South Australia (SA), Tasmania (Tas), Victoria (Vic) and Western Australia (WA)) except the Northern Territory (NT) which do not report these data to the NNDSS. Analyses by site of infection were restricted to years 2006 to 2017 as the sexually transmissible infection enhanced surveillance fields were only endorsed by the Communicable Disease Network Australia in December 2005. Site of infection data from 2018 were not included due to poor data completeness from the majority of the jurisdictions.

Mid-year resident population estimates were used to calculate annual notification rates per 100,000 population.⁽⁸⁾ The direct method was used to calculate age-standardised rates, with 2001 Australian census data as the standard population. Age-standardised rates by Aboriginal and Torres Strait Islander status were calculated by year using estimated and projected populations from 2001 to 2026.⁽⁹⁾ Age-standardised rates by remoteness areas were calculated by year using estimated resident population from 2001 to 2018 by Statistical Area Level 1 and Statistical Area Level 1-derived areas of Australia, according to the 2016 edition of the Australian Statistical

Geography Standard. Estimates were final for 2001 to 2016, revised for 2017, and preliminary for 2018.

Remoteness area is a geographical classification defined by the Australian Bureau of Statistics (ABS) which divides Australia into five categories of remoteness on the basis of a measure of relative access to services. The five categories are: major cities, inner regional, outer regional, remote and very remote. Cases notified to the NNDSS were mapped to a category of remoteness using the reported postcode of residence, which may not necessarily represent the place where the infection was acquired.

Item number 69316 (chlamydia testing alone) in addition to 69317 and 69319 (duplex NAAT for chlamydia and a second or third organism, which typically reflects the duplex NAAT for chlamydia and gonorrhoea) were used as a proxy for gonorrhoea tests. Gonorrhoea tests (using item numbers 69316, 69317 and 69319) subsidised through the MBS between 1 January 2012 and 31 December 2018 were extracted from the Medicare Australia Statistics website. To estimate gonorrhoea test positivity, we used the MBS testing data as the denominator, and the number of gonorrhoea cases notified to the NNDSS as the numerator. Test positivity was estimated by year, sex and state and territory.

Ethics approval was obtained from the Australian National University Human Research Ethics Committee (protocol no. 2019/310).

Results

Gonorrhoea notifications increased steadily since 1999 except for a decrease in 2007 (Figure 1). The gonorrhoea notification rate was 4.4 times higher in 2018 (126.9 per 100,000) than in 1999 (29.1 per 100,000). The most substantial annual increases observed were in 2010 and 2016.

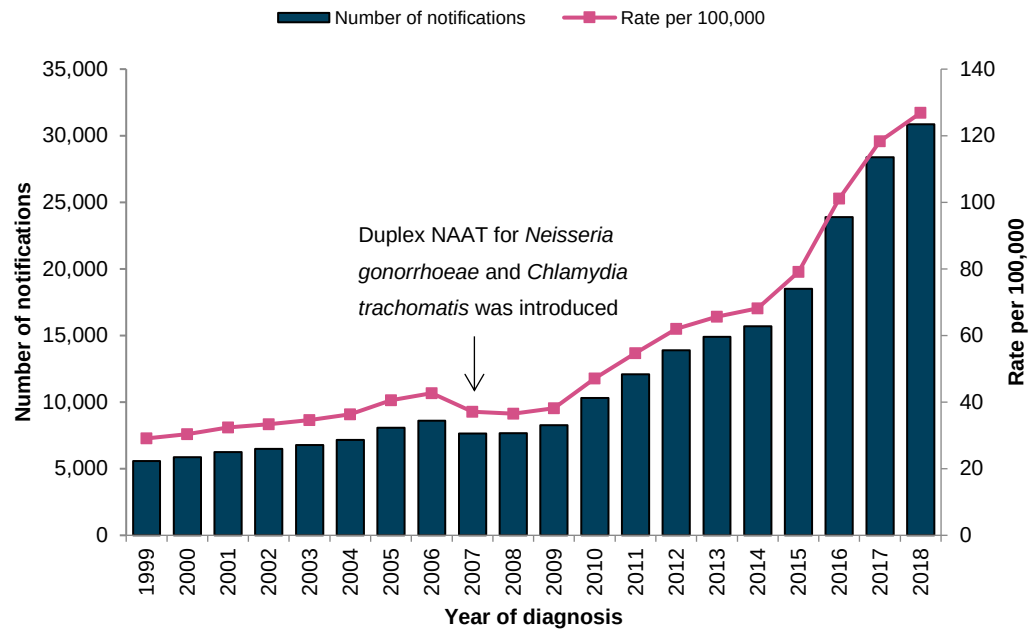


Figure 1. Gonorrhoea notifications and notification rate per 100,000 population, Australia, 1999–2018

Rate by notifying state and territory

Gonorrhoea notification rates increased between 1999 and 2018 in all states and territories (Figure 2). Notification rates were highest in NT, followed by WA in the past 20 years (1999–2018). In NT, notification rates fluctuated across the study period, and the most recent decrease occurred between 2015 (702.9 per 100,000) and 2017 (676.8 per 100,000), followed by a rapid increase in 2018 (823.9 per 100,000). In WA, a sharp increase in notification rates was observed in 2016, followed by rates stabilising between 2016 and 2018. Although NT and WA had the highest notification rates in the past 20 years, both jurisdictions had the smallest increase in notifications during the study period. The largest increase occurred in ACT and Vic where notification rates rose from 6.1 per 100,000 in 1999 to 73.0 per 100,000 in 2018, and from 14.5 per 100,000 in 1999 to 123.7 per 100,000 respectively.

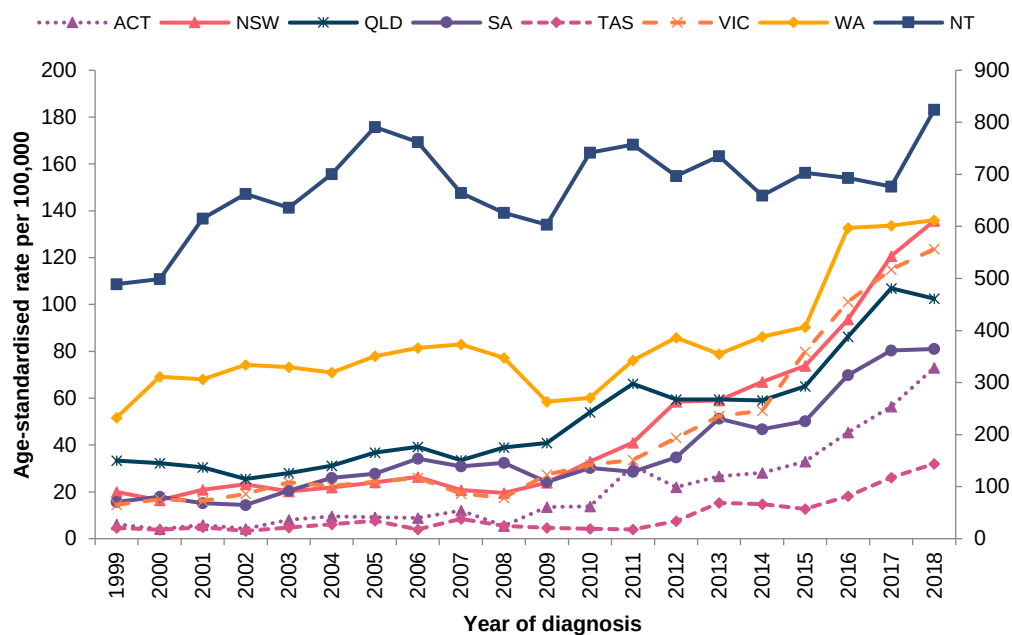


Figure 2: Gonorrhoea notification rate per 100,000 population, Australia, 1999–2018, by state and territory

Rate by age and sex

Gonorrhoea notification rates increased in all age groups between 1999 and 2017, with the highest notification rates seen in the age group 20–24 years. In 2018, notification rate fell by 7% in the age group 20–24 years (341.6 per 100,000), and the notification rate in the age group 25–29 years (367.0 per 100,000) surpassed that of the age group 20–24 years.

Age-standardised rates have been higher in males than females in the past 20 years (1999–2018) (Figure 3). Notification rates in males increased by a factor of 4.7 from 39.5 per 100,000 in 1999 to 186.0 per 100,000 in 2018. A similar trend was observed among females although a lesser magnitude where notification rates increased by a factor of 3.6 from 18.7 per 100,000 in 1999 to 67.5 per 100,000 in 2018. A sharp increase in notifications was observed in 2016 for both males and females. The proportion of notification by sex varied during the study period, however males consistently accounted for the majority of notifications. In 1999, males accounted for

approximately 68% of notifications, and by 2018, this increased to 74%. Male to female ratio increased from 2.2:1 in 1999 to 2.8:1 in 2018.

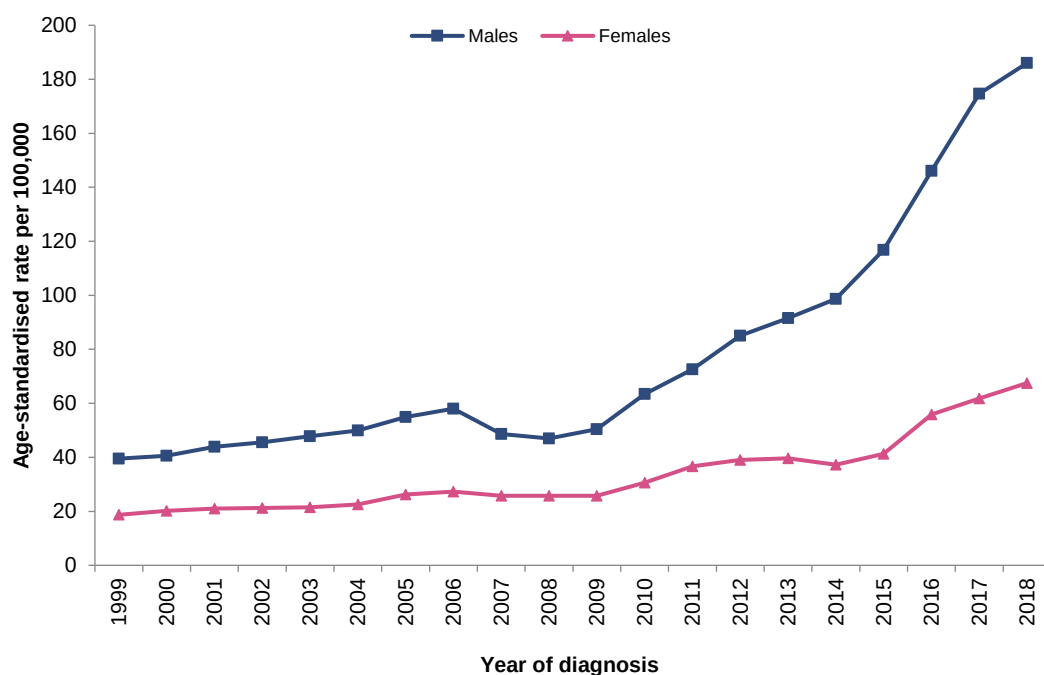


Figure 3. Gonorrhoea notification rate per 100,000 population, Australia, 1999–2018, by sex

Rate by Aboriginal and Torres Strait Islander status

Of the gonorrhoea cases notified to the NNDSS in 2009, the non-Indigenous population accounted for approximately 32% of notifications. This proportion continued to increase and by 2018, accounted for almost 55% of notifications.

Nationally, the age-standardised notification rates per 100,000 population among Aboriginal and Torres Strait Islander peoples were higher than the rates in the non-Indigenous population in over the past 10 years (2009–2018). In 2009 the notification rate in the Aboriginal population was 25 times as high as in the non-Indigenous population (589.6 per 100,000 compared with 23.9 per 100,000). By 2018, this disparity between the two population groups has decreased. The notification rate in 2018 was 7 times higher in the Aboriginal population (709.3 per 100,000) compared to the non-Indigenous population (98.8 per 100,000).

Among Aboriginal and Torres Strait Islander peoples, notification rates continued to rise from 2009 (589.6 per 100,000) to 2011 (785.1 per 100,000). Between 2012 and 2015, notification rates began to fall with sharp declines in 2012 (10% decrease), and 2014 (19% decrease). Notification rate started trending upwards again in 2016 and by 2018, notification rate reached 709.3 per 100,000. In the non-Indigenous population, gonorrhoea notification rates continued to increase from 2009. Notification rates between 2009 and 2018 increased fourfold from 23.9 per 100,000 in 2009 to 98.8 per 100,000 in 2018, in contrast to the 1.2-fold increase observed in the Aboriginal and Torres Strait Islander peoples.

Between 2009 and 2018, the age-standardised notification rates among the Aboriginal and Torres Strait Islander peoples was highest in the NT (2,085.6 per 100,000), followed by WA (958.6 per 100,000) (Figure 4). In the non-Indigenous population, highest notification rates were also observed in the NT (137.4 per 100,000), followed by Vic (123.6 per 100,000). In 2018, the age-standardised notification rates were higher among Aboriginal and Torres Strait Islander peoples than the non-Indigenous populations in all jurisdictions except Tasmania.

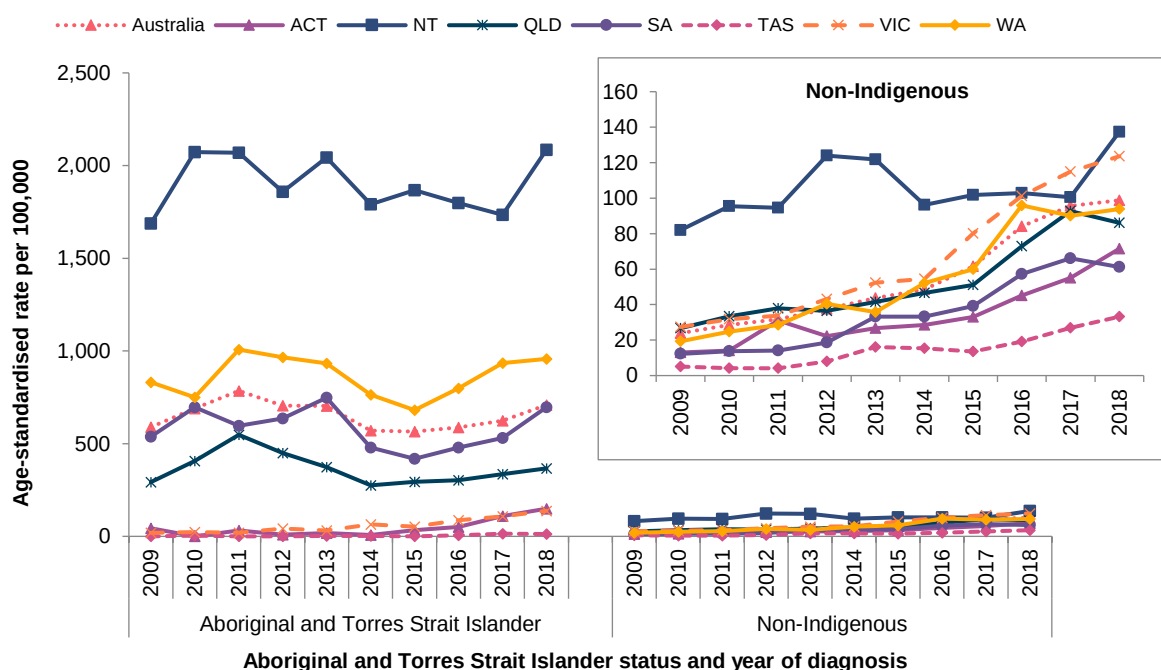


Figure 4. Gonorrhoea notification rate per 100,000 population, Australia, 2009–2018, by Aboriginal and Torres Strait Islander status and jurisdiction

The overall male to female ratio was 0.9:1 and 3.3:1 for Aboriginal and non-Indigenous populations respectively. Among the Aboriginal and Torres Strait Islander peoples, the gonorrhoea notification rates were higher in females than males. In 2018, the highest rate was seen in female Aboriginal and Torres Strait Islander peoples aged 15–19 years (2,683.4 per 100,000), followed by those aged 20–24 years (2,342.6 per 100,000). In the non-Indigenous population, the opposite was observed. Gonorrhoea notification rates were higher in males than females over the study period. In 2018, the highest rate was seen in non-Indigenous males aged 25–29 years (458.5 per 100,000), followed by those aged 30–34 years (384.9 per 100,000).

Rate by remoteness

Between 2001 and 2018, gonorrhoea notification rates increased in all categories of remoteness. While highest rates of gonorrhoea were in remote and very remote areas of Australia, the greatest increase in rate was in major cities. Between 2001 and 2018, notification rates increased by a factor of 6.7 in major cities from 18.5 per 100,000 to 123.2 per 100,000, and by a factor of 3 in regional areas from 20.2 per 100,000 to 63.1 per 100,000.

Notifications by Aboriginal and Torres Strait Islander status differed by remoteness category. For gonorrhoea notifications reported in remote and very remote areas of Australia between 2009 and 2018, more than 90% of notifications were in Aboriginal and Torres Strait Islander peoples. While the majority of gonorrhoea notification in major cities were in the non-Indigenous population, almost 40% of cases had unknown Aboriginal and Torres Strait Islander status.

The sex distribution of gonorrhoea cases differed by remoteness category. Females from major cities had a greater increase in number of gonorrhoea notifications between 2001 and 2018 than males. Age-standardised rates increased by a factor of 12 from 4.5 per 100,000 population in 2001 to 53.5 per 100,000 in 2018. For males, age-standardised rates increased by a factor of 6 from 34.1 per 100,000 in 2001 to 200.2 per 100,000 in 2018. Males still accounted for the

majority of notification reported in major cities during the study period, but the proportion of female cases has increased from 12% in 2001 to 21% in 2018. The male to female ratio among cases reported in major cities decreased correspondingly from 7.3:1 in 2001 to 3.7:1 in 2018. The overall male to female ratios among cases reported in inner and outer regional areas, and remote and very remote areas during the study period were 1.5:1 and 0.9:1 respectively.

Site of infection

The urogenital tract remained the most commonly reported site of infection in both males and females. The proportion of males with urogenital gonorrhoea decreased during the study period, despite a threefold increase in the number of urogenital infections between 2006 (n=3,439) and 2017 (n=10,188). While a similar trend was observed among females, the magnitude was much less profound than males. Between 2006 and 2017, an increase in the proportion of males and females with rectal gonorrhoea was observed. In males, the proportion increased from 12% in 2006 to almost 30% in 2017. In females, the proportion with rectal gonorrhoea increased threefold from slightly less than 1% in 2006 to 2.4% in 2017. A similar trend was observed in the proportion of males and females with oropharyngeal gonorrhoea. In males, the proportion with oropharyngeal gonorrhoea increased more than threefold from 8.2% in 2006 to 30% in 2017. In females, the proportion with oropharyngeal gonorrhoea increased substantially from 1.2% in 2006 to 8.5% in 2017. Nationally, the proportion of notifications with gonorrhoea isolated from more than one known site increased from 2.0% (n=115) in 2006 to 10.3% (n=2,570) in 2017. The proportion increased from 2.3% (n=97) to 12.4% (n=2,312) in males, and from 0.4% (n=6) to 3.6% (n=218) in females.

Test positivity

There was a 1.4-fold increase in the number of gonorrhoea tests performed from 1,094,913 in 2012 to 1,548,438 in 2018 (Figure 5). Gonorrhoea positivity also increased from 1.3% in 2012 to

2.0% in 2018. Whilst more gonorrhoea tests were performed in females than males between 2012 and 2018, the proportion of tests that were positive were higher in males (Figure 6).

Males also had a greater increase in gonorrhoea tests than females across all age groups between 2012 and 2018. Gonorrhoea testing increased by a factor of 1.7–1.9 among males aged 25–54 years, and by a factor of 2.1–2.4 for males aged over 55 years. A similar trend was observed in females where the magnitude of increase in testing was higher among older age groups. Gonorrhoea testing increased by a factor of 1.5–1.9 among females aged 25–64 years, and by a factor of 2.4 for females aged over 65 years. The smallest increase in the number of gonorrhoea tests performed in both males and females was among those aged 15–24 years. During the same period, gonorrhoea positivity increased across all age groups in both males and females.

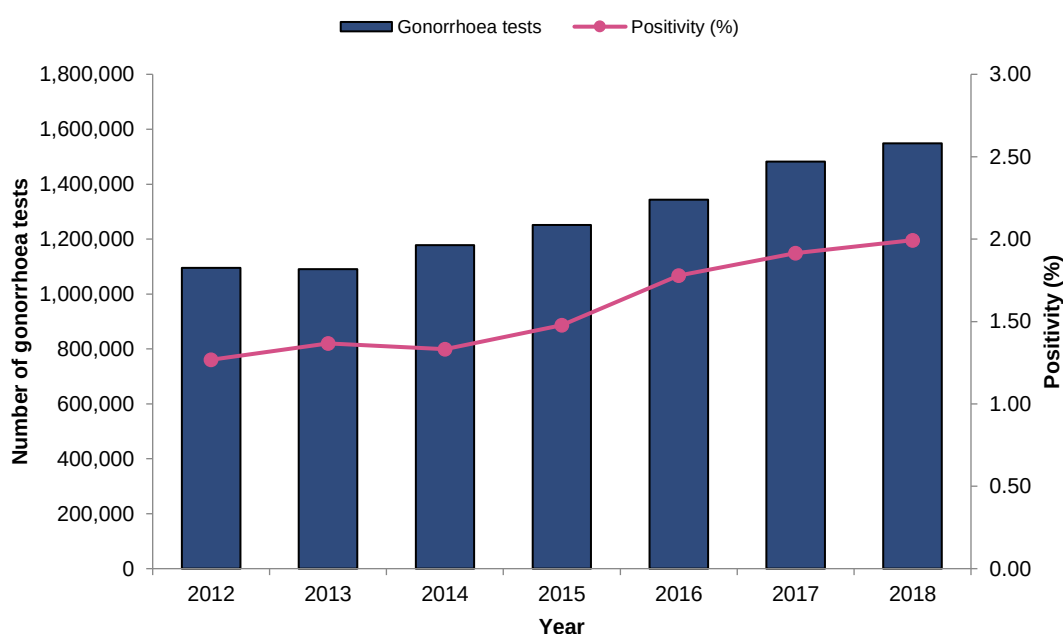


Figure 5. Number of gonorrhoea tests and positivity (%), Australia, 2012–2018

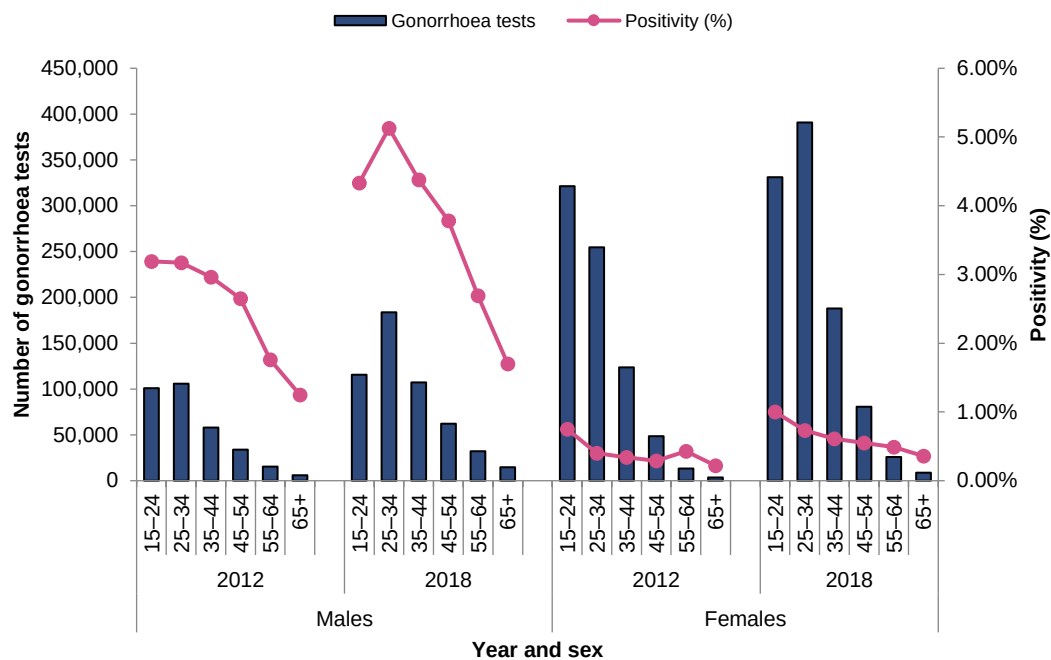


Figure 6. Number of gonorrhoea tests and positivity (%), Australia, 2012 and 2018, by sex and age group

Discussion

This study describes the epidemiology of gonorrhoea in Australia between 1999 and 2018. Nationally, the gonorrhoea notification rate increased by a factor of 4.4 between 1999 (29.1 per 100,000) and 2018 (126.9 per 100,000). Similar trends are observed in the United States and Europe.(10,11) The increased routine use of the duplex nucleic acid amplification tests for *Neisseria gonorrhoeae* and *Chlamydia trachomatis* may partially explain the increase in gonorrhoea notifications. In addition, the increased testing was likely to have identified asymptomatic cases that would otherwise remain undetected.

Our findings on the distribution of gonorrhoea notifications by geographical location, sex, Aboriginal and Torres Strait islander status, and site of infection were broadly comparable with those reported in the last national epidemiological review published in 2014.(4) High notification rates persisted in NT and we hypothesise that this is a reflection of the jurisdiction population structure where Aboriginal and Torres Strait Islander peoples comprised 30% of the NT

population. This hypothesis also applies to other sexually transmissible infections in NT, and may explain the jurisdiction's substantially higher notification rates for chlamydia and infectious syphilis.(5)

Although the overall notification rates remained higher in males than females, our study revealed that when taking into account remoteness, females in major cities had a greater increase than males in the same remoteness category. The bridging of sexual networks between MSM and heterosexuals was described as a potential factor that contributed to the increase in notifications seen among females. A study in Victoria utilised genomic analyses to identify clusters among gonorrhoea notifications reported in 2017. After linking epidemiological characteristics to identified-clusters, 11 major clusters containing 30 or more cases were found, and female cases were identified in six of the major MSM-associated clusters. The researchers also believed that men who have sex with men and women (MSMW) play a role in facilitating transmission of gonorrhoea between men who have sex with men only (MSMO) and females.(12) The proportion of females with oropharyngeal gonorrhoea has also substantially increased between 2006 and 2018. A change in sexual practices among females could have contributed the observed increases. This postulation is supported by the findings in the Second Australian Study of Health and Relationships conducted between 2012 and 2013.(13) Compared to the First Australian Study of Health and Relationships conducted between 2001 and 2002, the Second Australian Study of Health and Relationships found a statistically significant increase (15 percentage points) in the proportion of women aged 16–59 years who have ever had oral sex.(13)

Gonorrhoea notification rates remain high among Aboriginal and Torres Strait Islander peoples, particularly those residing in the Northern Territory and in very remote areas of Australia. Although high rates persisted in the Aboriginal population, the increase in rates was less than that of the non-Indigenous population. Among Aboriginal and Torres Strait Islander peoples, the gonorrhoea notification rates have been highest in the 15–19, 20–24 and 25–29 years age groups.

These findings corresponds to the screening recommendations by the Royal Australian College of General Practitioners where annual gonorrhoea screening is recommended for all sexually active Aboriginal and Torres Strait Islander peoples aged 15–30 years.(14) Our study also revealed higher gonorrhoea notification rates in female Aboriginal and Torres Strait Islander peoples than their male counterparts. A study conducted at a remote community health clinic in the Northern Territory found that men accessed the clinic less than women, and were less likely to receive testing for sexually transmissible infections. Low health literary and perceived shame associated with clinic visits were identified as common barriers to accessing services in the community health clinic.(15) Higher testing rates among Aboriginal and Torres Strait Islander people may be an explanation of the higher notification rates observed, however we were unable to explore this hypothesis as testing data exported from Medicare Australia Statistics did not provide a breakdown by Aboriginal and Torres Strait Islander status.

An increase in gonorrhoea notification rates may be attributed to a combination of a real increase in disease prevalence, and to improved diagnosis and increase laboratory testing leading to an increase in diagnosis. The introduction of the dual NAAT for the detection of *Neisseria gonorrhoeae* and *Chlamydia trachomatis* is likely to have contributed to the increase laboratory testing, thereby identifying additional gonorrhoea cases that may have otherwise remained undetected under previous testing practices. Increased laboratory testing in recent years may also be partially driven by the introduction of HIV pre-exposure prophylaxis (PrEP) as PrEP users are recommended to test for sexually transmissible infections (i.e. syphilis, gonorrhoea, chlamydia) every 3 months.(16) While increasing laboratory testing may have led to an increase in diagnosis, Chow and Mannion argued that positive NAAT tests in low-risk populations should be interpreted with caution. In populations with low disease prevalence, positive predictive value decreases even if a test with high sensitivity and specificity was used, such as NAAT, resulting in a substantial amount of false-positive.(17,18) As suggested by Chow, confirmatory cultures should be performed to minimise false-positive notifications.(17) Performing culture-based

testing also has the additional benefit of contributing to antimicrobial resistance surveillance in Australia.

Analyses by site of infection are often used as a proxy measure for sexual exposure. Between 2016 and 2017, infections of the pharynx and rectum in males have almost doubled. Rectal infections in males are likely to be in the MSM population given the low transmission probability from females to males.⁽¹⁹⁾ Additionally, a study has estimated a probability as high as 84% for urethral-to-rectal transmission among a modelled MSM population.⁽²⁰⁾ This hypothesis is supported by the increase seen in the overall male to female ratio during the study period. Geospatial networking applications, particularly among MSM, may have played an important role in the rising STI rates. Applications are thought to facilitate transmission of gonorrhoea through the development and bridging of large sexual networks.⁽²¹⁾ However, further research utilising a representative sample is warranted.

Limitations

Data incompleteness is one of the limitations of the study. Aboriginal and Torres Strait Islander status and site of infection fields were not well recorded. NSW is the only jurisdiction excluded from the analyses by Aboriginal and Torres Strait Islander status due to poor data completeness, which is likely due to gonorrhoea being notifiable by pathology laboratories only, therefore demographic details were not routinely collected. Study results should therefore be interpreted with caution.

There are several limitations with using MBS testing data as the denominator when estimating gonorrhoea test positivity rates. MBS testing data do not include services provided in sexual health clinics or public hospitals, or services that qualify for a benefit provided by the Australian Government Department of Veteran's Affairs. As a result, we would have undercounted the total number of gonorrhoea tests performed and overestimated the test positivity. Pathology services

subsidised through the MBS are subject to episode coning, which means an upper limit applies to the number of services that are eligible for Medicare benefits in a single patient episode. In general, Medicare pays for the three most expensive items.(22) Therefore, we may have again overestimated the test positivity. Testing data obtained directly from public and private laboratories would serve as a more accurate denominator.

Conclusions

Gonorrhoea remains a public health concern in Australia, where the national notification rates have continued to increase in recent years. Obtaining gonorrhoea test counts directly from pathology laboratories would assist public health official to better interpret changes in disease notification trends and the impact of increased testing. Further efforts are required to decrease the increasing infection rates.

Conflicts of interest

The authors declare no conflicts of interest.

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11.2 Appendix 2: Abstract submitted for oral presentation at the 2020 HIV&AIDS and Sexual Health Conference

Title: Epidemiology of gonorrhoea in Australia, 2012–2018

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Background: Despite the availability of treatment, notification rates for gonorrhoea have continued to increase in recent years. This study aimed to describe the epidemiology of gonorrhoea in Australia and review trends in gonorrhoea tests subsidised through the Medicare Benefit Schedule (MBS) between 2012 and 2018.

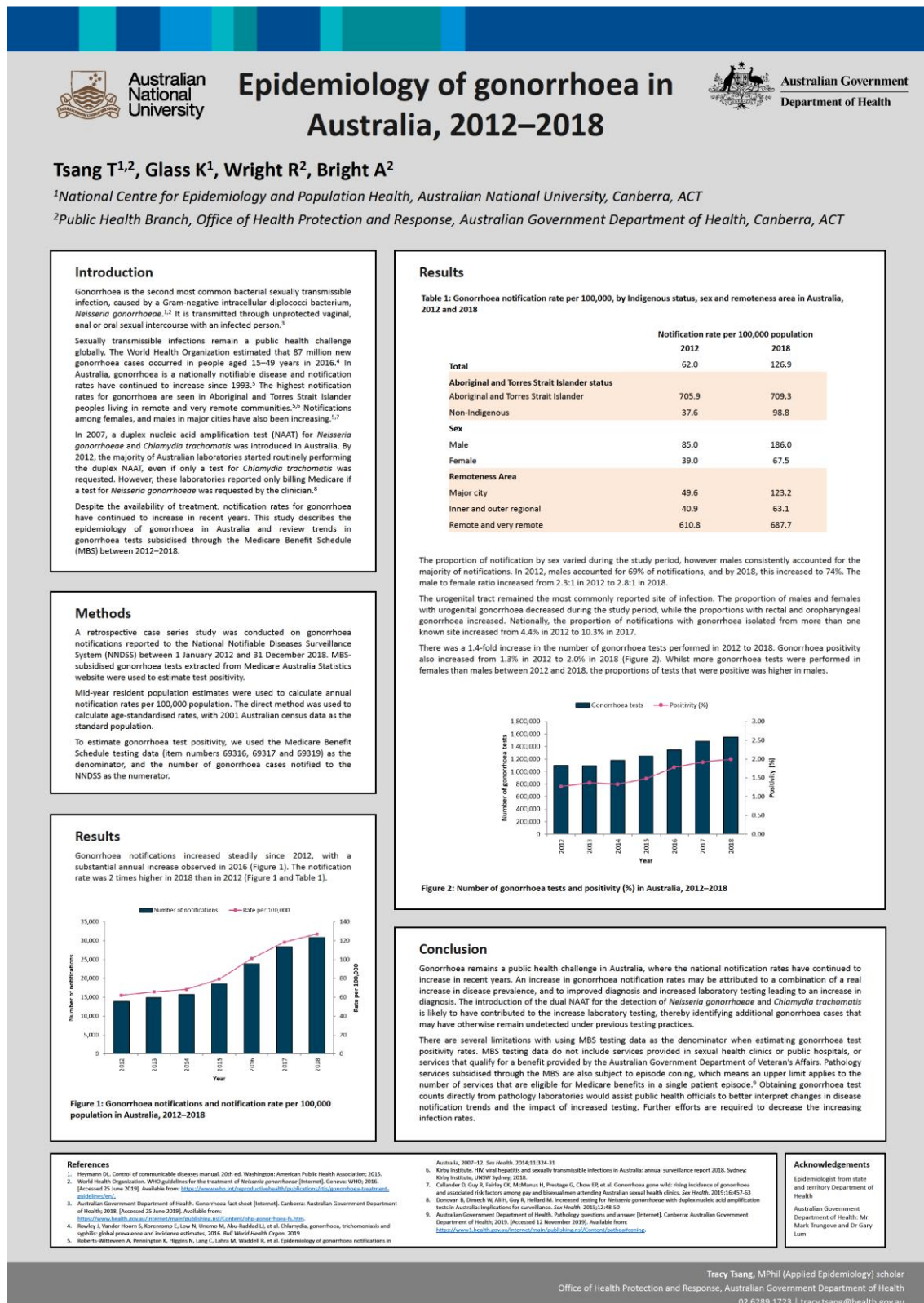
Methods: A retrospective case series study was conducted on gonorrhoea notifications reported to the National Notifiable Diseases Surveillance System between 1 January 2012 and 31 December 2018. Time trend analyses were performed by sex, age group, state/territory, Aboriginal and Torres Strait Islander status, remoteness areas and site of infection. MBS-subsidised gonorrhoea tests extracted from Medicare Australia Statistics website were used to estimate test positivity.

Results: Nationally, the gonorrhoea notification rate in 2018 (126.9 per 100,000) was twice that of 2012 (62.0 per 100,000). Infection rates remain high among Aboriginal and Torres Strait Islander peoples. While gonorrhoea notification rates increased in all categories of remoteness, the largest increase was observed in major cities. The number of gonorrhoea tests performed and subsidised through the MBS increased by a factor of 1.4 from 2012 (1,094,913 test) to 2018 (1,548,438 tests). Test positivity increased from 1.27% to 1.99%.

Conclusion: Gonorrhoea remains a public health challenge. Prevention and control strategies tailored to population groups with persistently high or increasing rates of gonorrhoea are essential to tackling this public health threat.

Disclosure of Interest Statement: This research is supported by a Master of Philosophy in Applied Epidemiology Scholarship.

11.3 Appendix 3: 2020 HIV&AIDS and Sexual Health Conference poster presentation



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Chapter 5

Epidemiology of coronavirus disease (COVID-19) in
Australia, 2020

Abbreviations used in this chapter

CDI	<i>Communicable Diseases Intelligence</i>
CI	confidence interval
COVID-19	coronavirus disease 2019
ECDC	European Centre for Disease Control and Prevention
ICU	intensive care unit
NSW	New South Wales
NIR	National Incident Room
NNDSS	National Notifiable Diseases Surveillance System
NT	Northern Territory
OR	odds ratio
PIMS-TS	Paediatric Inflammatory Multisystem Syndrome Temporally associated with SARS-CoV-2
SARS-CoV-2	severe acute respiratory syndrome coronavirus 2
Tas	Tasmania
Vic	Victoria

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1 Prologue

The epidemiological study that I initially planned to conduct was to establish reinfection periods for the national surveillance of enteric diseases. Reinfection periods (i.e. for what period should an enteric disease notification for the same person be considered as an ongoing infection as opposed to a new infection) are currently not consistently applied across states and territories for enteric disease notifications transmitted to the National Notifiable Diseases Surveillance System. The primary aim of the study was to improve consistency in national enteric disease surveillance, by seeking consensus on proposed reinfection periods among OzFoodNet epidemiologists using the Delphi technique (multiple-round surveys). However, the coronavirus disease 2019 (COVID-19) outbreak occurred when the project was due to commence. States and territories OzFoodNet epidemiologists were called upon to assist the local coronavirus disease 2019 (COVID-19) outbreak response. As a result, the project was suspended as it was unlikely that the states and territories OzFoodNet epidemiologists would have the capacity to complete the online surveys whilst responding to a major public health event. After discussions with my MAE supervisors, we decided to conduct an epidemiological study based on tasks I performed in the National Incident Room (NIR) during the initial phase of the COVID-19 pandemic.

1.1 My role

Between February and April 2020, I was part of the Epidemiology Reporting Team within the Epidemiology and Surveillance Section in the NIR. The Epidemiology Reporting Team is primarily responsible for producing the COVID-19 weekly/fortnightly epidemiology report, published in the *Communicable Diseases Intelligence* (CDI) journal. The team followed a rotating roster and I had the opportunity to undertake the following tasks:

- cleaned, analysed and interpreted NNDSS COVID-19 notification data using Microsoft Excel and Stata
- wrote reports
- conducted literature reviews.

1.2 Lessons learnt

During the COVID-19 pandemic, timely analysis of COVID-19 notifications was needed to inform surveillance and enable a nationally coordinated public health response. However, due to the amount of case investigation and contact tracing faced by public health units in states and territories, data completeness was low for certain data fields. This study provided me with a whole new appreciation of datasets that are complete.

I found performing the multivariable analysis of this study quite rewarding as it was a topic of interest that I never had the time to explore while I was in the NIR. However, I also found the interpretation of the study results quite challenging as it required multiple literature searches and lots of reading to understand the postulated mechanisms between the identified risk factors and severe COVID-19 disease.

1.3 Public health implications

This study identifies pre-existing comorbidities that are associated with poor COVID-19 clinical outcomes among cases in Australia, and contributes to existing knowledge gaps. Findings of this study can be used to direct future research studies examining risk factors and COVID-19 disease severity, and to improve allocation of resources to better protect those most vulnerable.

1.4 Acknowledgements

I would like to thank my academic supervisor, A/Prof Kathryn Glass, for her patience in answering my endless Stata questions.

I would like to also thank the Assistant Data Manager in the Communicable Diseases Epidemiology and Surveillance Section, for sharing his knowledge on the data caveats around the COVID-19 notifications.

1.5 Master of Philosophy in Applied Epidemiology core requirements

- ✓ Design and conduct an epidemiological study
- ✓ Conduct a targeted literature search

2 Abstract

Introduction: COVID-19 first appeared as a cluster of pneumonia cases of unknown causes in Wuhan City, Hubei Province of China in December 2019. By the end of January 2020, exported cases were reported. The key objective of this study was to describe the epidemiology of coronavirus disease (COVID-19) in Australia between 1 January 2020 and 26 April 2020, and to explore pre-existing health conditions that were associated with severe illness and fatal outcome.

Methods: Confirmed COVID-19 notifications reported to the National Notifiable Diseases Surveillance System (NNDSS) between 1 January 2020 and 26 April 2020 were extracted and analysed using Stata/SE 13.1 (StataCorp, Texas, USA). Descriptive analyses were conducted to examine demographics, clinical characteristics and outcomes of notified COVID-19 cases. Univariable and multivariable logistic regression analyses were conducted to identify pre-existing health conditions that were associated with hospitalisation, intensive care unit (ICU) admission, and death.

Results: A total of 6,763 confirmed COVID-19 cases (50.5% males), including 97 COVID-19 associated deaths, were notified to the NNDSS between 1 January and 26 April 2020. The median age of all cases was 48 years (interquartile range: 30–63 years). The most common symptoms were cough (70%) and fever (48%). Among cases with a hospitalisation status recorded ($n=4,794$), 18% ($n=853$) were hospitalised. Of those who were hospitalised and had a known ICU admission status ($n=560$), 28% ($n=155$) were admitted to an ICU. Hospitalisation and death rates were mostly higher in males than in females across all age groups. Multivariable analysis revealed a statistically significant association between ICU admission and obesity among all COVID-19 cases (aOR 2.79, 95% CI 1.54–5.04, $p=0.001$) and among those that were hospitalised (aOR 2.74, 95% CI 1.32–5.71, $p=0.007$). Our analysis also revealed a statistically significant association between COVID-19 associated death and neurological disorder (aOR 7.36, 95% CI 3.84–14.13, $p<0.001$).

Conclusions: Our findings support existing literature that COVID-19 generally presents as mild illness in the majority of cases. The study also highlights comorbidities that are associated with severe COVID-19 disease. However, further research is needed to confirm these results and to better understand the mechanisms between identified risk factors and severe COVID-19 disease.

3 Introduction

On 31 December 2019, the Chinese authorities notified the World Health Organization of a cluster of cases of pneumonia of unknown aetiology in Wuhan City, Hubei Province of China. A novel coronavirus was subsequently isolated and identified on 7 January 2020. By 20 January 2020, exported cases from Wuhan City were reported in Thailand, Japan and Republic of Korea.¹ The World Health Organization declared the outbreak a Public Health Emergency of International Concern on 30 January 2020.² Due to the alarming levels of spread and severity, COVID-19 was characterised as a pandemic on 11 March 2020.³ The situation continued to rapidly evolve, and as of 5 June 2020, over six million COVID-19 confirmed cases and at least 380,000 confirmed deaths were reported in 216 regions.⁴

COVID-19 is caused by the virus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) which is thought to have originated from bats, and transmitted to humans via an unknown intermediate animal host.⁵⁻⁷ SARS-CoV-2 is primarily transmitted between humans via respiratory droplets and contact routes such as direct contact with an infected person or indirect contact through fomites around the infected person. There have been reports of SARS-CoV-2 RNA detection in stool samples of COVID-19 cases, suggesting potential transmission of SARS-CoV-2 via the faecal-oral route, however current evidence does not support this as a major transmission route.^{8,9} The mean incubation period is estimated to be 5–6 days (range 1–14 days).⁹ People with COVID-19 generally develop mild symptoms with fever and cough being most commonly reported. Preliminary findings indicated that the median time from disease onset to symptom resolution was two weeks for cases with mild disease and three to six weeks for cases with severe or critical disease. People of older age and those with underlying health conditions are most at risk of severe disease and fatal outcomes. Whilst cases of COVID-19 are reported in all age groups, children appear to be less affected and make up a small proportion of all cases.⁹

4 Objectives

The key objective of the study was to describe the epidemiology of COVID-19 in Australia, up to 26 April 2020, and to identify pre-existing comorbidities that were associated with severe COVID-19 illness.

5 Methods

5.1 Study type

A retrospective case series was conducted on confirmed COVID-19 notifications reported to the National Notifiable Diseases Surveillance System (NNDSS) between 1 January 2020 and 26 April 2020, based on data extracted on 11 May 2020.

5.2 Case definitions

As at 6 July 2020, the national case definition for a confirmed COVID-19 case is a person who:¹⁰

1. tests positive to a validated specific SARS-CoV-2 nucleic acid test, **OR**
2. has the virus isolated in cell culture, with PCR confirmation using a validated method, **OR**
3. undergoes a seroconversion to or has a significant rise in SARS-CoV-2 neutralising or IgG antibody level (e.g. four-fold or greater rise in titre).

5.3 Data analysis

Confirmed COVID-19 cases notified to the NNDSS between 1 January 2020 and 26 April 2020 were summarised by notifying state or territory, age at onset, sex, Aboriginal and Torres Strait Islander status, remoteness area derived from postcode of residence, hospitalisation status, ICU admission status, death status, symptoms experienced, and pre-existing comorbidities. Mid-year resident population estimates were used to calculate year-to-date notification rates per 100,000 population.¹¹ Due to inconsistent reporting by states and territories, probable COVID-19 cases were excluded.

Symptoms recorded on the NNDSS were based on a pre-defined list adapted from the World Health Organization COVID-19 case report form. The list included the following symptoms: fever, cough, sore throat, runny nose, shortness of breath, diarrhoea, nausea/vomiting, headache, irritability/confusion, muscular pain, chest pain, abdominal pain, joint pain, pneumonia, and acute respiratory disease. Additionally, there was a free-text field to capture additional symptoms not listed above.

Univariable analysis was conducted using Stata/SE 13.1 (StataCorp, Texas, USA) to calculate odds ratios (ORs), 95% confidence intervals (CIs) and *p*-values for each reported comorbidity. Comorbidities with *p*<0.25 in the univariable analysis were included in an initial multivariable logistic regression model. The model was refined by removing comorbidities that were not statistically significant (*p*>0.05). The final model was used to calculate adjusted odds ratios, 95% confidence interval and *p*-values. A *p*<0.05 was considered statistically significant for all analyses.

In the multivariable logistic regression models used to assess association between comorbidities and ICU admission and death, collinearity was detected and as a result, Stata automatically omitted the age group >60 years from the model. To overcome this, age was therefore included in the model as a continuous variable.

Graphs presented in this chapter were created using Microsoft Excel.

6 Ethics

Ethics approval was obtained from the Australian National University Human Research Ethics Committee (protocol no. 2020/251).

7 Results

Between 1 January 2020 and 26 April 2020, 6,763 confirmed COVID-19 cases were notified to the NNDSS. Of those, 179 were overseas residents. The first COVID-19 case recorded on the NNDSS reported an illness onset date of 13 January 2020. During the study period, the outbreak peaked on 20 March 2020 (Figure 1).

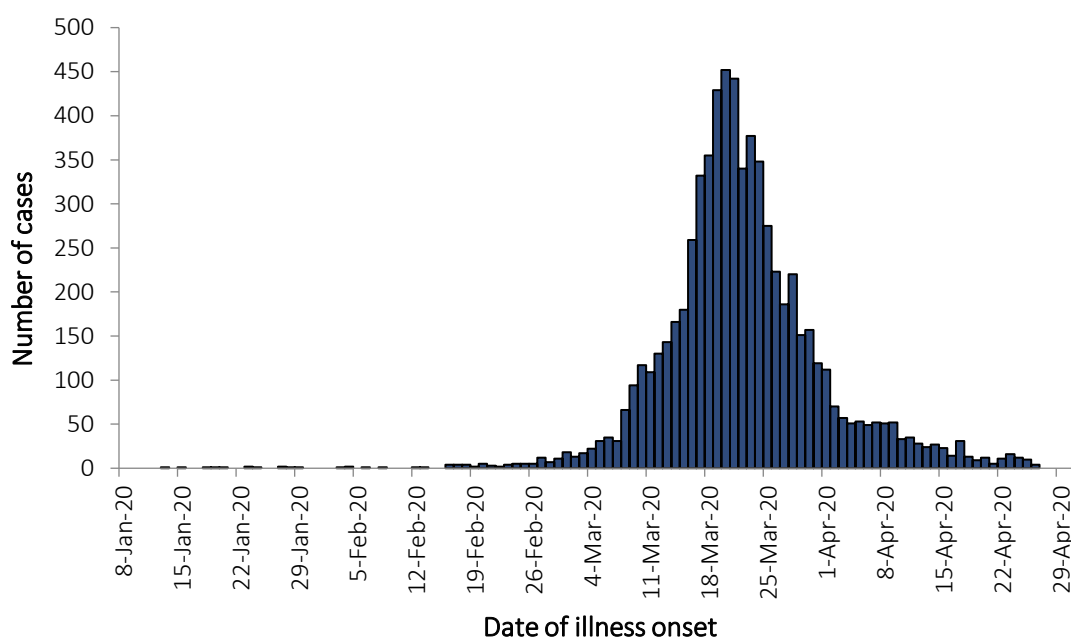


Figure 1. Epidemic curve of confirmed COVID-19 cases, Australia, 1 January 2020–26 April 2020

7.1 COVID-19 notifications by jurisdiction

Confirmed cases of COVID-19 were reported in all states and territories. Approximately 45% of total COVID-19 notifications until 26 April 2020 were reported in New South Wales (NSW) (Table 1). Tasmania (Tas) had the highest year-to-date rate (41.7 per 100,000), followed by NSW (37.4

per 100,000) while the Northern Territory (NT) had the lowest year-to-date rate (11.8 per 100,000). The majority of cases were reported in areas classified as major cities (79%) and only a small proportion of cases were reported in remote and very remote areas of Australia (0.5%).

Notifications by state/territory differed by place of acquisition (Figure 2). Most states and territories had a greater proportion of cases who acquired their infection overseas than in Australia, except Tasmania where more than half of the cases acquired their infection locally.

Table 1. Notifications of COVID-19 by state and territory, Australia, 1 January 2020–26 April 2020

State/Territory	Notifications		Year-to-date rate per 100,000
	n	%	
New South Wales	3,027	44.8	37.4
Victoria	1,381	20.4	20.9
Queensland	1,039	15.4	20.4
Western Australia	532	7.9	20.3
South Australia	425	6.3	24.5
Tasmania	223	3.3	41.7
Australian Capital Territory	107	1.6	25.1
Northern Territory	29	0.4	11.8
Australia	6,763	100	26.7

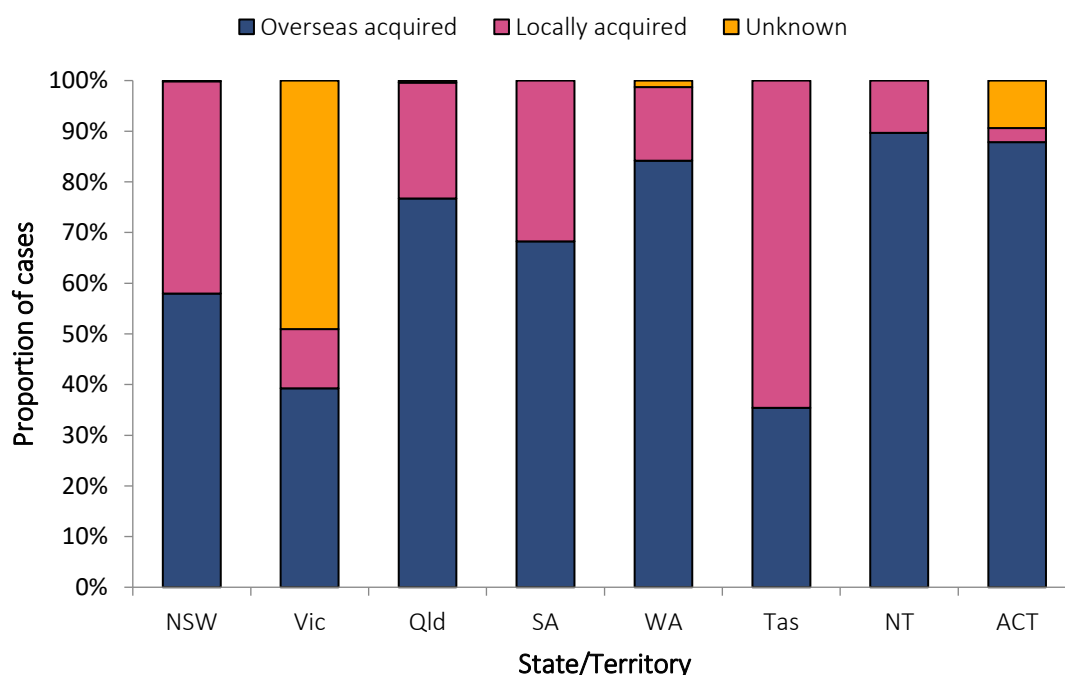


Figure 2. Proportion of COVID-19 cases by state/territory and place of acquisition, Australia, 1 January 2020–26 April 2020

7.2 COVID-19 notifications by age and sex

Cases of COVID-19 were reported in all age groups. The median age of all cases was 48 years (interquartile range: 30–63 years), with the highest proportion of cases aged 20–29 years (Table 2). The highest COVID-19 notification rate was in the 60–69 years age group (42.9 per 100,000), followed by 70–79 years (40.2 per 100,000) and 20–29 years (38.6 per 100,000). The lowest COVID-19 notification rate was in the 0–9 years age group (2.3 per 100,000) (Figure 3).

Table 2. Notifications of COVID-19 by age group, Australia, 1 January 2020–26 April 2020

Age group (years)	Notifications		Year-to-date rate per 100,000
	n	%	
0–9	74	1.1	2.3
10–19	201	3.0	6.6
20–29	1,414	20.9	38.6
30–39	1,061	15.7	28.9
40–49	864	12.8	26.4
50–59	1,079	16.0	35.0
60–69	1,120	16.6	42.9
70–79	720	10.7	40.2
80–89	183	2.7	22.4
90+	47	0.7	23.2

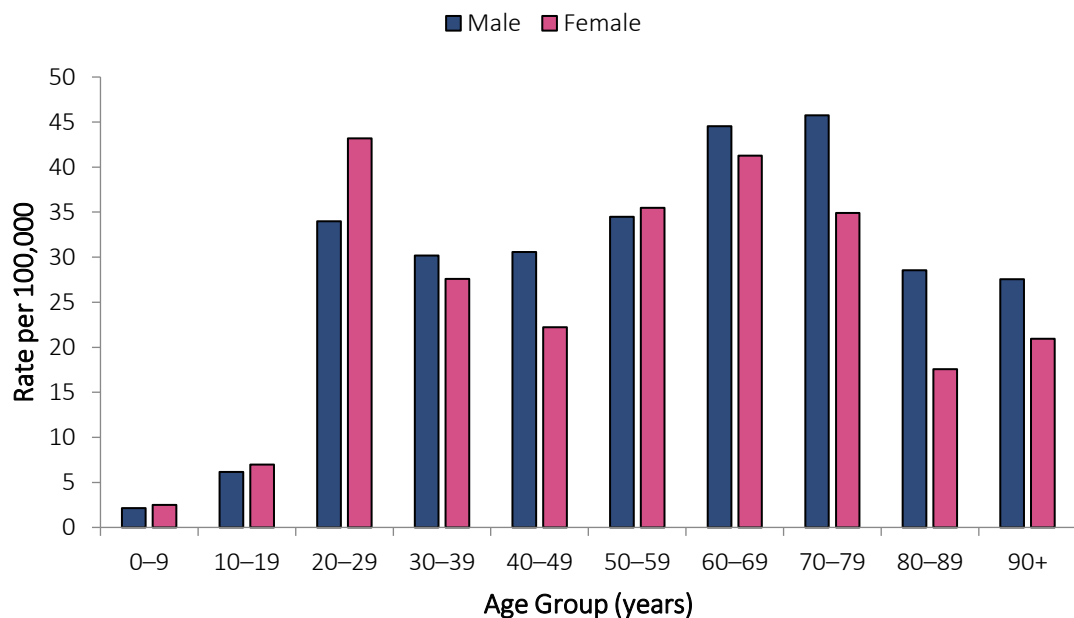


Figure 3. COVID-19 notification rates per 100,000 population by age and sex, Australia, 1 January 2020–26 April 2020

Whilst the number of COVID-19 cases in males (50.5%) and females (49.5%) were similar nationally, variations were seen across age groups. Females in the 20–29 years age group had a higher notification rate than their male counterparts; and males in the 40–49 years and ≥60 years age groups had a higher notification rate than their female counterparts.

7.3 COVID-19 notifications by Aboriginal and Torres Strait Islander status

Of the total COVID-19 cases notified to the NNDSS, 0.8% (n=55) were among Aboriginal and Torres Strait Islander peoples. Approximately 40% of these cases (n=22) were reported in major cities of New South Wales and no cases were reported in remote and very remote areas of Australia. The median age of cases among Aboriginal and Torres Strait Islander peoples was 34 years (interquartile range: 21–55 years), with the highest proportion of cases aged 20–29 years. Of the COVID-19 cases among Aboriginal and Torres Strait Islander peoples with a known hospitalisation status, 14% were hospitalised. No cases were reported as requiring an ICU admission.

Among cases with a known place of acquisition, 51% (n=26) acquired their infection overseas and 49% (n=25) acquired their infection locally. Of those who acquired their infection overseas, the most commonly reported place of acquisition was at sea including on cruise ships. Four cases (7%) were classified as under investigation.

7.4 COVID-19 notifications by place of acquisition

Of the total confirmed COVID-19 cases notified to the NNDSS, 60% (n=4,030) acquired their infection overseas, 30% (n=2,031) acquired their infection locally and 10% (n=702) were classified as unknown. As the pandemic continued, a shift in the cases' place of acquisition was observed (Figure 4). Cases with an illness onset between weeks 1 and 3 (weeks since the first case in Australia) all acquired their infection overseas. Despite some minor fluctuations in weeks 4 and 5, people who acquired their infection overseas continued to make up the majority of confirmed COVID-19 cases in Australia until week 11. Between weeks 11 and 15, the proportion of cases who acquired their infection locally continued to increase.

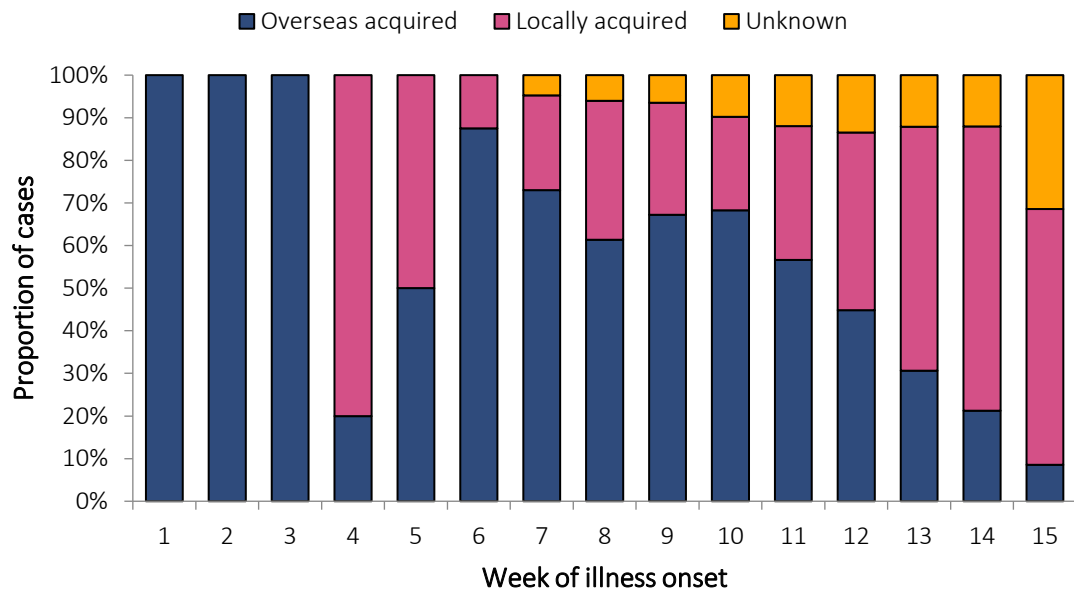


Figure 4. Proportion of cases by place of acquisition and week of illness onset, Australia, 1 January 2020–26 April 2020

The majority of overseas-acquired cases reported a recent travel history to the European region (34%), followed by recent sea travel including on board cruise ships (29%) and travel to the Americas region (22%). Approximately 51% of cases with a recent travel history to the European region were aged between 20 and 39 years, and approximately 58% of cases that acquired their infection on board cruise ships were aged between 60 and 79 years.

7.5 COVID-19 notifications by symptom

Of the total COVID-19 cases notified to the NNDSS, 93% (n=6,323) had symptoms recorded. Cough (70%) was the most commonly reported symptom, followed by fever (48%), headache (46%), sore throat (42%), and runny nose (30%). Loss of taste or smell was also reported for a small proportion of cases (9%).

While minor differences were observed, symptom profile was largely consistent across age groups, with cough and fever being the most commonly symptoms (Figure 5). Headache and runny nose were more common among younger cases, while shortness of breath was more common among older cases, particularly those aged ≥ 80 years.

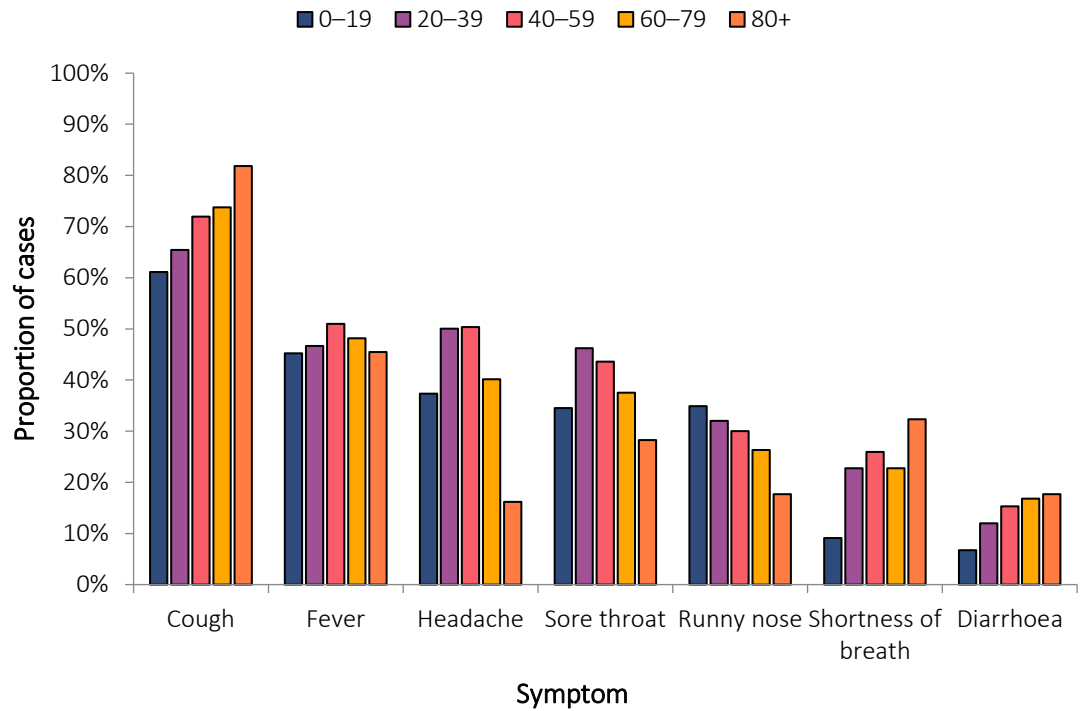


Figure 5. Proportion of COVID-19 cases by age group and symptom, Australia, 1 January 2020–26 April 2020

7.6 COVID-19 notifications by severity

Of the total COVID-19 cases notified to the NNDSS, 71% (n=4,794) had hospitalisation status recorded. Among those, 18% (n=853) were admitted to a hospital. The median age of hospitalised cases was 61 years (interquartile range: 42–72 years).

The 70–79 years age group had the highest hospitalisation rate (10.3 per 100,000) followed by the 80–89 years age group (8.8 per 100,000). Males had higher rates of hospitalisation across all age groups except in the 20–29 years (Figure 6).

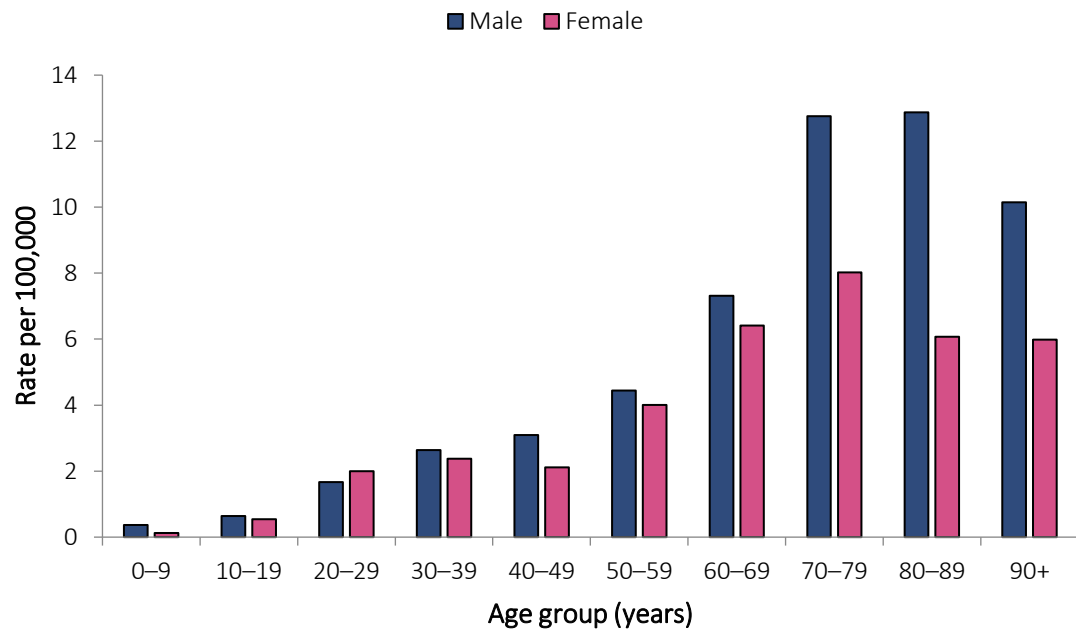


Figure 6. COVID-19 hospitalisation rates per 100,000 population by age and sex, Australia, 1 January 2020–26 April 2020

Of the hospitalised COVID-19 cases, 66% (n=560) had ICU admission status recorded. Among those, 28% (n=155) required an intensive care unit (ICU) admission, with 45 cases receiving ventilation. No cases aged less than 10 years were admitted to the ICU. ICU admissions were also uncommon among cases aged 10–19 years (1.3% of total cases requiring an ICU admission).

During the study period, 97 COVID-19 associated deaths were notified to the NNDSS. The median age of cases that died was 80 years (interquartile range: 74–86 years). No deaths were reported among cases aged less than 40 years. The death rate increased with age, with the highest rate seen in males aged over 90 years (13.0 per 100,000) (Figure 4). Similarly, the case fatality rate also increased with age, with the highest case fatality rate (40%) seen in cases aged over 90 years. Of the cases that died and had a known region of acquisition, 63% (n=50) acquired their infection locally, and 31% (n=25) acquired their infection on board cruise ships.

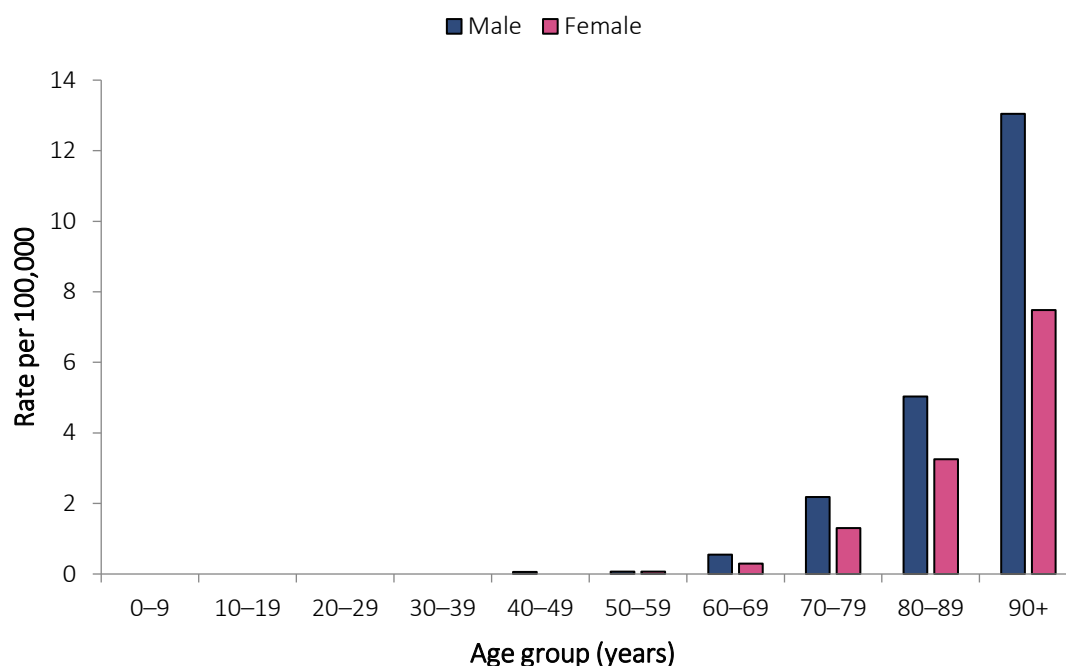


Figure 7. COVID-19 death rates per 100,000 population by age and sex, Australia, 1 January 2020–26 April 2020

7.7 Comorbidities and COVID-19 disease severity

Of the total COVID-19 cases notified to the NNDSS, 68% ($n=4,587$) had comorbidities recorded. Cardiac disease (excluding hypertension) and diabetes were the most commonly reported comorbidities across the disease severity spectrum (Table 3). The proportion of COVID-19 cases with cardiac disease (excluding hypertension), diabetes, an immunosuppressive condition or a neurological disorder increased with disease severity. The proportion of COVID-19 cases with obesity followed a largely similar trend and increased with disease severity. Approximately 4.3% of all COVID-19 cases with comorbidities recorded reported obesity. This proportion increased to approximately 7.8% among hospitalised cases, and 14.7% among cases admitted to an ICU, before a decrease to 8.6% among cases that died. The proportion of COVID-19 cases with at least one reported comorbidity also increased with disease severity.

Table 3. Commonly reported comorbidities for all cases, hospitalised cases and cases admitted to an ICU, Australia, 1 January 2020–26 April 2020

Comorbidity	All cases (n=4,587)*		Hospitalised cases (n=565)*		Cases admitted to ICU (n=116)*		Deaths (n=70)*	
	n	%	n	%	n	%	n	%
Asthma	455	9.9	67	11.9	12	10.3	4	5.7
Cardiac disease**	436	9.5	114	20.2	25	21.6	25	35.7
Diabetes	352	7.7	105	18.6	28	24.1	19	27.1
Obesity	196	4.3	44	7.8	17	14.7	6	8.6
Chronic respiratory condition***	172	3.8	74	13.1	15	12.9	16	22.9
Immunosuppressive condition/therapy	147	3.2	39	6.9	14	12.1	13	18.6
Neurological disorder	109	2.4	23	4.1	5	4.3	16	22.9

* Cases with missing data on comorbidities were excluded.

**Hypertension excluded

*** Asthma excluded

7.7.1 Hospitalisation

A number of comorbidities were found to have a significant association with hospital admission in the univariable analysis (Table 4). This included: age groups 60–79 years and ≥80 years, male sex, chronic respiratory condition, cardiac disease, immunosuppressive condition, diabetes, obesity, renal disease and neurological disorder. All comorbidities listed above were included in an initial multivariable logistic regression model. In the final multivariable analysis, age group ≥60 years (aOR 2.43, 95% CI 1.31–4.51, $p=0.005$), chronic respiratory condition (aOR 3.86, 95% CI 2.71–5.50, $p<0.001$), cardiac disease (aOR 1.56, 95% CI 1.18–2.05, $p=0.002$), immunosuppressive condition (aOR 2.31, 95% CI 1.51–3.57, $p<0.001$), diabetes (aOR 2.17, 95% CI 1.63–2.89, $p<0.001$) and renal disease (aOR 2.14, 95% CI 1.16–3.95, $p=0.02$) were significant predictors (Table 5).

Table 4. Univariable analysis of risk factors for hospitalisation among all COVID-19 cases, Australia, 1 January 2020–26 April 2020

	n/N*	OR	95% CI	P-value
Age				
0–19	26/194	1		
20–39	159/1,713	0.66	0.42–1.03	0.07
40–59	215/1,345	1.23	0.79–1.91	0.36
60–79	364/1,377	2.32	1.51–3.57	<0.001
80+	89/165	7.57	4.53–12.65	<0.001
Sex				
Female	384/2,384	1		
Male	469/2,410	1.26	1.08–1.46	0.002
Aboriginal and Torres Strait Islander status				
Non-Aboriginal	799/4,562	1		
Aboriginal	6/44	0.74	0.31–1.77	0.50
Asthma	67/400	0.97	0.74–1.29	0.85
Chronic respiratory condition	74/151	5.21	3.74–7.28	<0.001
Cardiac disease	114/338	2.84	2.22–3.64	<0.001
Immunosuppressive condition	39/103	3.10	2.06–4.67	<0.001
Diabetes	105/274	3.48	2.67–4.52	<0.001
Obesity	44/170	1.75	1.23–2.50	0.002
Liver disease	6/33	1.08	0.44–2.63	0.87
Renal disease	20/49	3.43	1.93–6.12	<0.001
Neurological disorder	23/74	2.24	1.36–3.69	0.002
Number of comorbidities				
0	234/2,109	1		
1	218/903	2.55	2.08–3.13	<0.001
2	78/226	4.22	3.11–5.74	<0.001
3+	35/70	8.02	4.92–13.05	<0.001

*COVID-19 cases with missing hospitalisation status excluded

Table 5. Multivariable analysis of risk factors for hospitalisation among all COVID-19 cases, Australia, 1 January 2020–26 April 2020

	Initial model			Final model		
	aOR	95% CI	P-value	aOR	95% CI	P-value
Age						
0–19	1			1		
20–39	0.88	0.47–1.66	0.70	0.88	0.47–1.66	0.70
40–59	1.32	0.71–2.48	0.38	1.34	0.72–2.51	0.36
60+	2.39	1.29–4.44	0.006	2.43	1.31–4.51	0.005
Sex						
Female	1					
Male	1.12	0.93–1.37	0.24			
Chronic respiratory condition	3.83	2.68–5.46	<0.001	3.86	2.71–5.50	<0.001
Cardiac disease	1.51	1.15–1.99	0.003	1.56	1.18–2.05	0.002
Immunosuppressive condition	2.25	1.46–3.47	<0.001	2.31	1.51–3.57	<0.001
Diabetes	2.15	1.61–2.86	<0.001	2.17	1.63–2.89	<0.001
Obesity	1.13	0.76–1.68	0.53			
Renal disease	2.08	1.12–3.87	0.02	2.14	1.16–3.95	0.02
Neurological disorder	1.53	0.90–2.63	0.12			

7.7.2 ICU admission

Being aged 60 years and over, male sex, chronic respiratory condition, cardiac disease, immunosuppressive condition, diabetes, obesity and renal disease were significantly associated with ICU admission in the univariable analysis (Table 6). In the multivariable analysis, only age (aOR 1.05, 95% CI 1.04–1.07, $p<0.001$), immunosuppressive condition (aOR 2.82, 95% CI 1.47–5.41, $p=0.002$) and obesity (aOR 2.79 95% CI 1.54–5.04, $p=0.001$) were significant predictors (Table 7).

Table 6. Univariable analysis of risk factors for ICU admission among all COVID-19 cases, Australia, 1 January 2020–26 April 2020

	n/N*	OR	95% CI	P-value
Age				
0–19	2/84	1		
20–39	7/678	0.43	0.09–2.09	0.30
40–59	44/600	3.24	0.77–13.64	0.11
60–79	93/662	6.70	1.61–27.72	0.01
80+	9/81	5.13	1.07–24.50	0.04
Sex				
Female	58/1,001	1		
Male	97/1,104	1.57	1.12–2.19	0.01
Asthma	12/172	0.82	0.44–1.53	0.54
Chronic respiratory condition	15/82	2.74	1.51–4.97	0.001
Cardiac disease	25/187	1.93	1.21–3.10	0.01
Immunosuppressive condition	14/60	3.75	2.00–7.06	<0.001
Diabetes	28/152	3.03	1.90–4.81	<0.001
Obesity	17/80	3.38	1.90–6.00	<0.001
Renal disease	6/23	4.13	1.59–10.68	0.003
Neurological disorder	5/39	1.68	0.64–4.38	0.29
Number of comorbidities				
0	38/833	1		
1	50/421	2.81	1.82–4.38	<0.001
2	17/126	3.26	1.78–5.98	<0.001
3+	11/39	8.22	3.81–17.74	<0.001

* COVID-19 cases with missing ICU admission status excluded

Table 7. Multivariable analysis of risk factors for ICU admission among all COVID-19 cases, Australia, 1 January 2020–26 April 2020

	Initial model			Final model		
	aOR	95% CI	P-value	aOR	95% CI	P-value
Age*	1.05	1.04–1.07	<0.001	1.05	1.04–1.07	<0.001
Sex						
Female	1					
Male	1.46	0.97–2.22	0.07			
Chronic respiratory condition	1.78	0.94–3.39	0.08			
Cardiac disease	0.88	0.52–1.47	0.62			
Immunosuppressive condition	2.62	1.35–5.08	0.004	2.82	1.47–5.41	0.002
Diabetes	1.52	0.92–2.51	0.10			
Obesity	2.47	1.32–4.60	0.004	2.79	1.54–5.04	0.001
Renal disease	2.55	0.92–7.05	0.07			

* Stata automatically omitted the age group ≥ 60 years from the model due to collinearity, therefore age was included as a continuous variable in this model

7.7.3 ICU admission among those hospitalised

Being aged 60 years and over, male sex, immunosuppressive condition and obesity were significantly associated with ICU admission among hospitalised cases in the univariable analysis (Table 8). In the multivariable analysis, age (aOR 1.04, 95% CI 1.02–1.06, $p < 0.001$) and obesity (aOR 2.74, 95% CI 1.32–5.71, $p = 0.007$) were significant predictors (Table 9).

Table 8. Univariable analysis of risk factors for ICU admission among hospitalised COVID-19 cases, Australia, 1 January 2020–26 April 2020

	n/N*	OR	95% CI	P-value
Age				
0–19	2/19	1		
20–39	7/103	0.62	0.12–3.24	0.57
40–59	44/143	3.78	0.84–17.06	0.08
60+	102/295	4.49	1.01–19.83	0.05
Sex				
Female	58/250	1		
Male	97/310	1.51	1.03–2.19	0.03
Asthma	12/45	0.85	0.42–1.71	0.65
Chronic respiratory condition	15/52	0.96	0.50–1.83	0.90
Cardiac disease	25/82	1.06	0.62–1.79	0.84
Immunosuppressive condition	14/28	2.57	1.18–5.58	0.02
Diabetes	28/71	1.72	1.01–2.95	0.05
Obesity	17/34	2.62	1.28–5.33	0.008
Renal disease	6/12	2.45	0.77–7.78	0.13
Neurological disorder	5/17	0.99	0.34–2.88	0.99
Number of comorbidities				
0	38/166	1		
1	50/146	1.75	1.07–2.89	0.03
2	17/54	1.55	0.78–3.05	0.21
3+	11/26	2.47	1.05–5.83	0.04

Table 9. Multivariable analysis of risk factors for ICU admission among hospitalised COVID-19 cases, Australia, 1 January 2020–26 April 2020

	Initial model			Final model		
	aOR	95% CI	P-value	aOR	95% CI	P-value
Age*	1.04	1.02–1.05	<0.001	1.04	1.02–1.06	<0.001
Sex						
Female	1					
Male	1.43	0.89–2.30	0.14			
Immunosuppressive condition	2.12	0.94–4.79	0.07			
Diabetes	1.18	0.66–2.14	0.57			
Obesity	2.77	1.30–5.93	0.009	2.74	1.32–5.71	0.007
Renal disease	1.43	0.42–4.84	0.57			

* Stata automatically omitted the age group ≥ 60 years from the model due to collinearity, therefore age was included as a continuous variable in this model

7.7.4 Death

Chronic respiratory condition, cardiac disease, immunosuppressive condition, diabetes, liver disease, renal disease and neurological disorder were significantly associated with COVID-19 death in the univariable analysis (Table 10). In the final multivariable analysis, age (aOR 1.17, 95% CI 1.09–1.25, $p < 0.001$), chronic respiratory condition (aOR 4.21, 95% CI 2.25–7.90, $p < 0.001$), immunosuppressive condition (aOR 3.99, 95% CI 1.99–8.01, $p < 0.001$), diabetes (aOR 2.19, 95% CI 1.24–3.88, $p = 0.007$) and neurological disorder (aOR 7.36, 95% CI 3.84–14.13, $p < 0.001$) were significant predictors (Table 11). Our analysis also revealed a strong association between those reported three or more comorbidities and death (aOR 10.68, 95% CI 4.66–24.49, $p < 0.001$) (Table 12).

Table 10. Univariable analysis of risk factors for death among all COVID-19 cases, Australia, 1 January 2020–26 April 2020

	n/N	OR	95% CI	P-value
Age	97/6,763	1.19	1.13–1.26	<0.001
Sex				
Female	42/3,346	1		
Male	55/3,414	1.29	0.86–1.93	0.22
Asthma	4/455	0.55	0.20–1.51	0.24
Chronic respiratory condition	16/172	8.23	4.64–14.80	<0.001
Cardiac disease	25/436	5.55	3.36–9.14	<0.001
Immunosuppressive condition	13/147	7.46	3.99–13.96	<0.001
Diabetes	19/352	4.68	2.73–8.02	<0.001
Obesity	6/196	2.14	0.91–4.99	0.08
Liver disease	2/39	3.56	0.84–15.07	0.04
Renal disease	3/56	3.77	1.15–12.37	0.03
Neurological disorder	16/109	14.09	7.78–25.54	<0.001
Number of comorbidities				
0	15/3,085	1		
1	23/1,149	4.18	2.17–8.04	<0.001
2	21/274	16.99	8.65–33.36	<0.001
3+	11/79	33.11	14.67–74.74	<0.001

Table 11. Multivariable analysis of risk factors for death among all COVID-19 cases, Australia, 1 January 2020–26 April 2020

	Initial model			Final model		
	aOR	95% CI	P-value	aOR	95% CI	P-value
Age	1.17	1.09–1.25	<0.001	1.17	1.09–1.25	<0.001
Sex						
Female	1					
Male	0.99	0.59–1.65	0.97			
Asthma	0.61	0.21–1.77	0.37			
Chronic respiratory condition	3.87	2.02–7.41	<0.001	4.21	2.25–7.90	<0.001
Cardiac disease	1.62	0.93–2.82	0.09			
Immunosuppressive condition	3.97	1.97–8.04	<0.001	3.99	1.99–8.01	<0.001
Diabetes	1.98	1.10–3.56	0.02	2.19	1.24–3.88	0.007
Obesity	1.22	0.47–3.15	0.68			
Liver disease	1.63	0.30–8.79	0.57			
Renal disease	1.61	0.43–6.05	0.48			
Neurological disorder	6.75	3.48–13.10	<0.001	7.36	3.84–14.13	<0.001

Table 12. Multivariable analysis of the association between the number of comorbidities and death among all COVID-19 cases, Australia, 1 January 2020–26 April 2020

	Initial model			Final model		
	aOR	95% CI	P-value	aOR	95% CI	P-value
Age*	1.17	1.09–1.25	<0.001	1.17	1.09–1.25	<0.001
Sex						
Female	1					
Male	1.01	0.61–1.65	0.98			
Number of comorbidities						
0	1					
1	2.08	1.07–4.04	0.03	2.08	1.08–4.04	0.03
2	6.17	3.10–12.26	<0.001	6.17	3.11–12.25	<0.001
3+	10.68	4.65–24.52	<0.001	10.68	4.66–24.49	<0.001

* Stata automatically omitted the age group >60 years from the model due to collinearity, therefore age was included as a continuous variable in this model

8 Discussion

This study describes the epidemiology of COVID-19 in Australia between 1 January 2020 and 26 April 2020. During the study period, 6,763 COVID-19 cases were notified to the NNDSS, representing a national year-to-date notification rate of 26.7 per 100,000 population. Among all states and territories, Tasmania had the highest year-to-date COVID-19 notification rate (41.7 per 100,000). The high year-to-date notification rate was likely driven by the outbreak in the Northwest Regional Hospital in Tasmania.¹² On the other hand, the Northern Territory had the lowest year-to-date COVID-19 notification rate (11.8 per 100,000). In addition to that, approximately 90% of all confirmed COVID-19 cases reported in NT acquired their infection overseas, suggesting limited community transmission. We hypothesise that additional border control measures in place played a role in limiting the spread of COVID-19, including a 14-day mandatory quarantine in a designated facility for all international and domestic arrivals to the Territory, restriction of non-essential travel to remote communities, and a 14-day mandatory quarantine for community residents wishing to return home from regional centres.^{13–15} The small proportion of annual short-term visitors (less than 1%) intending to stay in the Northern Territory may also have assisted in limiting the spread of COVID-19 in the region.¹⁶

Unlike seasonal influenza, evidence suggests that children appear to be less affected by COVID-19.^{17,18} In Australia, cases aged less than 20 years accounted for 4.1% of all COVID-19 cases notified to the NNDSS during the study period. Low hospitalisation and ICU admission rates also suggest that children and adolescents have a milder clinical course compared to adults. While severe illness among children is rare, recent reports in the United Kingdom and other European

countries have identified critically ill children presenting with a mix of symptoms resembling Kawasaki Disease and Toxic Shock Syndrome, provisionally named Paediatric Inflammatory Multisystem Syndrome Temporally associated with SARS-CoV-2 (PIMS-TS).¹⁹ Although Australian experts believed that the overall risk for severe outcomes among Australian children remains low as no increase in Kawasaki Disease cases has been observed since the onset of the COVID-19 epidemic, development of surveillance for PIMS-TS is still warranted. This will allow rapid detection of new PIMS-TS cases, and will bridge the knowledge gap by gathering more epidemiological and clinical information about the syndrome.^{20,21} While children appeared to be less affected by COVID-19, our findings revealed a significant association between older age group (aged 60 years and over) and COVID-19 hospitalisation.

During the early phase of the COVID-19 epidemic in Australia, the majority of cases notified to the NNDSS were among travellers returning from overseas. Despite minor fluctuations, this trend persisted into mid-March 2020. By late-March 2020, the proportion of cases that acquired their infection overseas declined sharply, likely due to a reduction in international travel as foreign nationals were banned from entering Australia, and Australian citizens and permanent residents restricted from travelling overseas. The decline was accompanied by an increase in the proportion of cases that acquired their infection domestically. This increase was likely driven by local clusters and outbreaks associated with aged care, healthcare facilities and private functions.²²

The majority of COVID-19 cases in Australia presented with a mild respiratory infection. Our findings were largely consistent with reports published by the United States Centers for Disease Control and Prevention and the European Centre for Disease Control and Prevention (ECDC), which found cough being the most commonly reported symptoms, followed by fever.^{17,23} In addition to the symptoms typically associated with respiratory infections, two new distinctive symptoms, taste and smell dysfunction, have been identified and shown to be prevalent among COVID-19 cases.^{24,25} Cases with such symptoms were also identified in our study but at a lower prevalence of approximately 9% of all cases reporting taste and smell dysfunction. The prevalence was likely under-estimated as a change in taste or smell was not a standard option under the 'symptoms' field on the NNDSS.

Disparities in COVID-19 disease severity between males and females have been observed worldwide.^{9,23} Our study found that hospitalisation and death rates were mostly higher in males than females, with differences more marked in the older age groups. This may partly be explained by the fact that males, compared to females, generally have higher rates of diabetes and cardiovascular disease, both of which have displayed an association with COVID-19 associated

hospitalisation or death. When comorbidities were factored into our multivariable analysis, sex was no longer found to be a significant risk factor for severe COVID-19 disease or fatal outcomes. Interestingly, this is in contrast to findings reported by ECDC and some published literature.^{23,26,27}

Published preliminary reports have linked obesity to severe COVID-19 disease.^{26,28-30} Results from our analyses were largely consistent, where obesity was found to be associated with severe COVID-19 disease requiring ICU admission. However, obesity was not found to be a significant risk factor for hospitalisation or fatal outcomes. We suspect the increased odds of being obese among cases admitted to ICU may be related to the need for ventilation assistance as obese patients generally have an increased oxygen demand, which may be unmet due to diminished lung capacity, resulting in low oxygen saturation.³¹ While our analyses did not find an association between obesity and COVID-19 associated deaths, several mechanisms between obesity and poor clinical outcomes have been postulated. Researchers believe the chronic low-grade inflammation that accompanies obesity triggers a heightened inflammatory response, thereby increasing the risk of a cytokine storm that can cause acute respiratory distress syndrome, severe organ damage and death.³²⁻³⁴

Neurological disorder was the third most common comorbidity reported in COVID-19 associated deaths in our study. While neurological disorder was not well-defined in the NNDSS COVID-19 dataset field specifications, we suspect Alzheimer's disease and other dementias may have made up the majority of this field, given its high prevalence in Australia.³⁵ Similar preliminary findings were reported in England and Wales where Alzheimer's disease and dementia were the most common comorbidity in deaths involving COVID-19 in March and April 2020.³⁶ Our analysis revealed a strong association between neurological disorder and COVID-19 related deaths (aOR 7.38, 95% CI 3.84–14.16, $p < 0.001$). At the time of writing, literature on neurological disorder and severe COVID-19 disease is limited. The US Centers for Disease Control and Prevention acknowledged this knowledge gap but also recognised that people with neurologic conditions such as dementia may be at increased risk for severe illness from COVID-19.²⁸ In Australia, dementia, including Alzheimer's disease, was the second leading cause of death in 2018.³⁷ It is possible that COVID-19 played a role in accelerating the dementia disease progression, partially explaining the strong association observed between neurological disorder and COVID-19 associated deaths. However, further research is needed to confirm this hypothesis. Our results also demonstrated a positive dose-response relationship between the number of reported comorbidities and COVID-19 related death. This positive relationship may have contributed to the strong association between neurological disease and COVID-19 related death as people with dementia reported an average of 5.4 comorbidities, with stroke, diabetes, heart disease and

diseases of the nervous system being the most common.³⁸ Further research is again needed to confirm this hypothesis.

8.1 Limitations

Poor data completeness is one of the limitations of this study. The data fields on hospitalisation, intensive care admission and pre-existing comorbidities were not well recorded. A range of factors may have contributed to the poor data completeness observed. Poor data flow between a hospital system and the jurisdiction's central management system can potentially explain the poor completeness of the hospitalisation and intensive care admission fields. We suspect an unprecedented workload experienced by public health officials may have also contributed to poor data completeness. In addition, due to time restraints, we only allowed a two-week period between the end of our study period and data extraction. Early studies from China suggests that it takes approximately one week to develop severe COVID-19 disease from symptom onset, and about two to eight weeks for fatal outcome to occur.⁹ Early studies from Australia suggested similar findings with a median time of six to seven days from symptom onset to first hospitalisation.^{39,40} We acknowledge that the two-week period in our study was insufficient for jurisdictions to perform data cleaning, and for outcomes to be adequately assessed, in particular for cases with illness onset in mid to late April 2020.

Due to smaller numbers of deaths and cases requiring ICU admission in this dataset, confidence intervals around estimates of risk factors for death and ICU admission are fairly wide. Study results should therefore be interpreted with caution. We acknowledge that a larger sample size would improve the precision of our results. We also found that most of the comorbidities in our study were highly correlated to each other. While we have included all comorbidities listed on NNDSS in our initial multivariable logistic regression model to adjust for confounding, there may be other potential confounders such as frailty, which was not recorded and therefore we were unable to adjust for. The strong correlation between comorbidities also made it difficult to conclude with confidence which comorbidities are true independent risk factors for severe COVID-19 disease and fatal outcome.

Information bias may have been introduced into the study as variables were not well-defined, particularly for the variable on pre-existing comorbidities. The COVID-19 dataset field specifications should ideally provide a list of diseases that each comorbidity includes. This will ensure consistent data collection across interviewers in all states and territories. As comorbidities were self-reported, bias may have also been introduced.

9 Conclusions

Our study identified comorbidities that were associated with severe COVID-19 disease among Australian cases notified between 1 January and 26 April 2020. While we recognise the limitations of our study, we hope the findings of the study can be used to direct future research studies. Larger cohort studies are needed to confirm our findings, and to better understand the mechanisms between identified risk factors and severe COVID-19 disease.

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Chapter 6

Teaching experience

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1 Teaching requirements

The ability to teach public health concepts is recognised to be an important skill for all public health professionals including field epidemiologists. As a result, the MAE program includes two teaching requirements. Each MAE scholar must:

- prepare at least one “Lessons from the field”
- prepare and conduct a teaching session for first year MAE scholars (or another epidemiology training program), as part of the second year subject POPH8914 *Issues in Applied Epidemiology*.

1.1 Master of Philosophy in Applied Epidemiology core requirements

- ✓ Teach topics in field epidemiology

2 Lessons from the field

MAE scholars are asked to develop a case study based on real-life challenges and present it to their peers as a problem-solving exercise. The primary objective of my Lessons from the Field (LFF) was for participants to gain expertise in performing advanced searches using the MEDLINE (via OVID) database (Appendix 1).

During the MAE, I participated in two LFFs, including:

- Data visualisation using Tableau (Liz Walker – Immunisation Registers Section, Australian Government Department of Health)
- Surveys in epidemiology and how to create a survey using Research Electronic Data Capture (REDCap) (Genevieve O’Neill – Communicable Diseases Epidemiology & Surveillance Section, Australian Government Department of Health)

The feedback from my LFF group was that the session was relevant and useful. The group also suggested including a table of popular shortcut commands that can be entered in the search box, which was incorporated in the final version of my LFF.

3 First year MAE teaching

To fulfil one of the two teaching requirements of the MAE program, second year MAE scholars are often given an afternoon session at the end of their third courseblock to teach the first year MAE scholars. However, due to the coronavirus disease 2019 pandemic, our third courseblock was postponed to August 2020. The MAE teaching team also had to modify the delivery mode of the third courseblock in order to comply with physical distancing rules and current travel

restrictions. As a result, the third courseblock was not delivered face-to-face on campus, but a combination of online learning, and videoconferencing. The MAE teaching team also recognised the pressure placed on our cohort. As a result, we have been asked to take the LFF of one of our team members and deliver it via a 25 minute live Zoom session, instead of developing new teaching material. Our group decided to present my LFF on advanced literature search technique to the first year MAEs (Appendix 2). Nine first year MAEs completed the evaluation survey and most agreed that the session met its objectives and that the content was useful (Appendix 3).

4 Appendices

4.1 Appendix 1: Advanced literature search using the Medline (via OVID) database

Lessons from the Field

Instructions

In this LFF, we will work through some advanced search technique using the MEDLINE(via OVID) database.

Learning Objectives

After this session, you should be able to:

- use MEDLINE (via OVID) to perform an advanced search
- use truncation, wild cards and Boolean operators
- export search results from MEDLINE to Microsoft Word
- set up AutoAlerts in MEDLINE
- perform a cited reference search using Web of Science

Accessing the Medline (via OVID) Database

You can access the Medline (via OVID) database from the [ANU library homepage](#).

1. Select “M” under E-resources & databases.



2. Select “Medline (via OVID)”.

1. [Macquarie dictionary online](#) [\[show details\]](#)
2. [Magazine Plus \(Nichigai\)](#) [\[show details\]](#)
3. [MagazinePlus](#) [\[show details\]](#)
4. [MAIS - Multicultural Aust. & Immigration Studies](#) [\[show details\]](#)
5. [Majalah Tempo](#) [\[show details\]](#)
6. [Malaysian Insight](#) [\[show details\]](#)
7. [Manhal](#) [\[show details\]](#)
8. [Mass Observation](#) [\[show details\]](#)
9. [MathsciNet: Mathematics Literature](#) [\[show details\]](#)
10. [Max Planck Encyclopedias of International Law](#) [\[show details\]](#)
11. [Medieval and Early Modern Studies](#) [\[show details\]](#)
12. [Medieval Travel Writing](#) [\[show details\]](#)
13. [Medline \(via OVID\)](#) [\[show details\]](#)
14. [Medline: Medical and Healthcare Literature](#) [\[show details\]](#)
15. [Mekong review](#) [\[show details\]](#)
16. [Middle East and Africa Database](#) [\[show details\]](#)

3. When prompted to select resource(s) to search, select “Ovid MEDLINE (R) ALL” and click “OK”.

Select Resource(s) to search:

☐ **All Resources**

☐ Australian National University Library Full Text Journals@Ovid	i
☐ Journals@Ovid (Full Text and abstracts)	i
☐ Books@Ovid April 27, 2020	i
☐ APA PsycArticles Full Text	i
☐ CAB Abstracts 1973 to 2020 Week 15	i
☒ Ovid MEDLINE(R) ALL 1946 to April 24, 2020	i
☐ APA PsycBooks 1806 to March 2020	i
☐ APA PsycInfo 2002 to April Week 3 2020	i
☐ APA PsycInfo 1806 to April Week 3 2020	i
☐ Zoological Record 1978 to 2016	i

OK **Add Group** **Delete Group**

You are the new MAE working in the National Incident Room (NIR) at the Australian Government Department of Health. The NIR Director has asked you to conduct a literature search on the transmissibility of the coronavirus disease (COVID-19).

Truncation, Wild Cards and Boolean Operators

You remember that you attended the digital literacy training during the MAE course block and learnt that you can use:

- Boolean operators AND, OR and NOT to narrow your topic
- Enter shortcut commands into the command line to bypass the use of the icon bar (see tables below for description and common shortcut commands)

Command	Description
<term>.xy.	Runs a search for the word or phrase (term) through the field indicated by the two-letter short code (xy).
<term>.xy,yz.	Runs a search for the word or phrase (term) through the fields indicated by the two-letter short code (xy,yz).
limit n to <dblimit>	Limits the results of set number (n) to the database-specific limit indicated.

Examples	Description
novel coronavirus.tw.	Runs a search for novel coronavirus through the abstract and title fields of the database (tip: tw = text word)
novel coronavirus.ab,ti.	Runs a search for novel coronavirus through the abstract and title fields of the database
limit 5 to English	Restricts results to articles written in English. Foreign language articles with English abstracts will be eliminated.
limit 5 to humans	Restricts results to articles that are about human subjects.
limit 5 to yr=2020 limit 5 to yr=2000–2020	Restricts results to articles published in the specified year or range.

Below is the initial search strategy you came up with.

Advanced Search | [Basic Search](#) | [Find Citation](#) | [Search Tools](#) | [Search Fields](#) | [Multi-Field Search](#)

1 Resource selected | [Hide](#) | [Change](#)

Ovid MEDLINE(R) ALL 1946 to April 24, 2020

Enter keyword or phrase
(* or \$ for truncation)

☒ **Keyword** ☐ Author ☐ Title ☐ Journal

Search

▼ **Limits** (close)

☐ Include Multimedia

☒ Map Term to Subject Heading

☐ Abstracts

☐ Structured Abstracts

☐ English Language

☐ No Language Specified

☐ Full Text

☐ Review Articles

☐ Humans

☐ Core Clinical Journals (AIM)

☐ Latest Update

☐ Pharmacologic Actions

☐ COVID-19

Publication Year - -

[Additional Limits](#)

[Edit Limits](#)

▼ **Search History** (5)

[View Saved](#)

☐	# ▲	Searches	Results	Type	Actions	Annotations
☐	1	novel coronavirus.tw.	1663	Advanced	Display Results More ▼	Contract
☐	2	(2019-nCoV or COVID-19 or SARS-CoV-2).tw.	6604	Advanced	Display Results More ▼	Contract
☐	3	1 or 2	7209	Advanced	Display Results More ▼	Contract
☐	4	transmission.tw.	355163	Advanced	Display Results More ▼	Contract
☐	5	3 and 4	771	Advanced	Display Results More ▼	Contract

[Save](#) [Remove](#) Combine with: [AND](#) [OR](#)

[Save All](#) [Edit](#) [Create RSS](#) [View Saved](#)

1. You identified a few abstracts referring to coronavirus disease as:

- novel beta coronavirus
- novel 2019 coronavirus disease
- novel human coronavirus

How would you modify line #1 in your search strategy to capture these abstracts?

You could use the Boolean operator "ADJn". ADJn allows you to retrieve records that contain your search terms (in any order) within a specified number (n-1) of words from each other.

☐	1	(novel adj2 coronavirus).tw.	1771	Advanced	Display Results More ▼
--------------------------	---	------------------------------	------	----------	--

The ADJn operator is useful when you are not sure of the exact terminology used in the literature. ADJ1 operator finds two terms next to each other in any order. ADJ2 operator finds two terms in any order, with one word (or none) between them.

TIP: Depending on the database used, words such as “a”, “the” and “or” may or may not be counted.

2. You realised the search term “transmission” may be too narrow.

How would you modify line #4 of your search strategy so the search will retrieve records that will include words such as transmissible, transmissibility or transmittable?

*You can use truncation (\$ or *).*

Truncation allows you to find variations of a specified term. For example, “transmi\$” will retrieve records that include words such as transmissible, transmissibility, transmittable, transmitted and transmission etc.

☐	1	transmi\$.tw.	501770	Advanced	Display Results More ▼
--------------------------	---	---------------	--------	----------	--

3. After adding “World Health Organization” as a search term, you managed to narrow down the results but you also realised you may be missing records that refer to World Health Organization as “World Health Organisation”.

How would you modify line #6 of your search strategy so that the search will retrieve records with either spelling?

▼ Search History (7)						View Saved	⋮
☐	# ▲	Searches	Results	Type	Actions	Annotations	
☐	1	novel coronavirus.tw.	1663	Advanced	Display Results More ▼		Contract
☐	2	(2019-nCoV or COVID-19 or SARS-CoV-2).tw.	6604	Advanced	Display Results More ▼		
☐	3	1 or 2	7209	Advanced	Display Results More ▼		
☐	4	transmission.tw.	355163	Advanced	Display Results More ▼		
☐	5	3 and 4	771	Advanced	Display Results More ▼		
☐	6	World Health Organization.tw.	52048	Advanced	Display Results More ▼		
☐	7	5 and 6	69	Advanced	Display Results More ▼		

Combine with:

You can use wildcard (?).

Wildcard is useful for retrieving records with British and American spelling variations. It stands for zero or one character within a word or at the end of a word. For example, “organi?ation” finds occurrences of organisation and organization, and “colo?r” finds occurrence of colour and color.

Exporting search results

You did not find any relevant material in the 69 abstracts you reviewed. You now plan to review the 771 abstracts retrieved from your original search, however you have previously been warned by a colleague that Ovid times out after a certain period. In addition, you understand the importance of good record-keeping, and would like to save a copy of your search.

How do you export the 771 results? What are some pros and cons for your chosen method?

Select the box next to “All” and click “Export”.

The screenshot shows the Ovid search results interface. On the left, there is a sidebar with 'Search Information' and 'Filter By' sections. The 'Search Information' section shows 'You searched: 3 and 4', 'Search terms used: 2019-ncov, covid-19, novel, coronavirus, sars-cov-2, transmission', 'Search Returned: 771 text results', and 'Sort By: -'. The 'Filter By' section has 'Add to Search History' and 'Selected Only (771)' with a 'Years' filter set to 'All Years'. The main area displays a list of results. The first result is 'Presymptomatic SARS-CoV-2 Infections and Transmission in a Skilled Nursing Facility.' by Arons MM, Hatfield KM, Reddy SC, et al. The 'All' checkbox is highlighted in red, and the 'Export' button is also highlighted in red.

You will then be prompted to choose the desired format, fields and citation style for your export.

My personal preference is to export citations with selected custom fields to Microsoft Word, and include the search history.

By exporting citations to Microsoft Word, I can easily insert comments, highlight abstracts of interest, share document with colleagues and keep a record of the search terms used and results retrieved.

Under “Fields”, the option “Citation” includes irrelevant fields such as author’s full name, therefore I like to use custom fields.

ab = abstract

au = author (not authors full name)

so = source (name of journal)

ti = title

Export Citation(s)

Selected: 1-771
Total: 771

Format:
Microsoft Word

Fields:
Custom [Edit](#)

Selected Fields: ab, au, so, ti

Citation Style:
Ovid Labeled Citation

Include:
☐ Link to External Resolver
☐ URL
☒ Search History

[Cancel](#) [Export](#)

Setting up AutoAlerts

Your Director advised you that she would like an update on the transmissibility of the coronavirus disease once a month. What can you do to avoid reviewing the initial 771 abstracts?

You can set up an AutoAlert for your search.

You will first need to create an account to use this function.

▼ Search History (5) [View Saved](#)

#	Searches	Results	Type	Actions	Annotations
1	novel coronavirus.tw.	1663	Advanced	Display Results More	Contract
2	(2019-nCoV or COVID-19 or SARS-CoV-2).tw.	6604	Advanced	Display Results More	
3	1 or 2	7209	Advanced	Display Results More	
4	transmission.tw.	355163	Advanced	Display Results More	
5	3 and 4	771	Advanced	Display Results More	

[Save](#) [Remove](#) Combine with: [AND](#) [OR](#)

[Save All](#) [Edit](#) [Create RSS](#) [View Saved](#)

Select the box next to search you would like to create an auto alert for and click “Save”.

Under “Type”, select “AutoAlert (SDI)”.

You can personalise how often you receive the auto alerts under “Scheduling Options”.

You can choose how you want to receive the alerts. Delivering alerts via email can be quite useful.

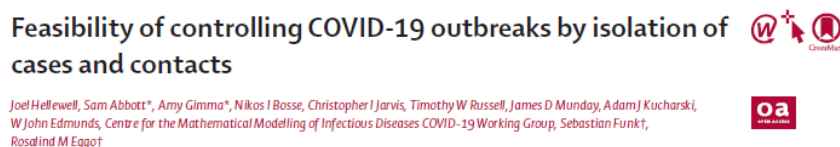
For example, in one of my previous jobs, the organisation has a librarian who performs the literature searches. She has auto alerts set up where new articles are automatically sent to the relevant epidemiologists once a month.

Once you are done with personalising the AutoAlert options, click “Save”.

Search Name	Comment (Optional)	Type	
		AutoAlert (SDI)	Save
AutoAlert Options			
Scheduling Options ☒ On Database Update[?] ☐ Quarterly ☐ Monthly - on day 1 ☐ Every other week - on Monday ☐ Weekly - on Monday		Deduping Options ☐ 90 Days	
☒ Include Open Access Results			
Delivery Options ☒ Email ☐ RSS ☐ My Projects <input checked="" type="button" value="Email"/> RSS My Projects			
Email Address & Subject Separate multiple email addresses with commas. Do not use any spaces between the addresses. Recipient's Email Address: tracy.tsang@health.gov.au Email Subject: Ovid Results			
Email Options ☒ Inline ☐ As an Attachment (Ovid Result Format only)		Output Type ☐ HTML (Ovid Result Format only) ☒ ASCII ☐ EXCEL (Ovid Result Format only) ☐ XML	
☒ Include Strategy			
☐ Include external resolver link			

Cited reference search

You found a key article describing the feasibility of controlling COVID-19 outbreaks by isolation of cases and contacts.



You are interested in identifying other published articles that cite this key paper. What would you do?

You can use the cited references search in Web of Science.

Access the Web of Science database from the ANU library homepage.

1. Select “W” under E-resources & databases.



2. Select “Web of Science”.

1. [Wan Qing qi kan guan wen shu ju ku \(1833-1911\)](#) [\[show details\]](#)
2. [WDI online](#) [\[show details\]](#)
3. [Web of Knowledge \(see Web of Science\)](#) [\[show details\]](#)
4. [Web of Science](#) [\[show details\]](#)
5. [Wellesley index to Victorian periodicals](#) [\[show details\]](#)
6. [Westlaw](#) [\[show details\]](#)
7. [Westlaw - Canadian materials](#) [\[show details\]](#)

Select a database Web of Science Core Collection

Basic Search Author Search^{BETA} **Cited Reference Search** Advanced Search Structure Search

Find the articles that cite a person's work.

Step 1: Enter information about the cited work. Fields are combined with the Boolean AND operator.

* Note: Entering the title, volume, issue, or page in combination with other fields may reduce the number of cited reference variants found.

Hellewell J	Cited Author
Select from Index	
2020	Cited Year(s)
feasibility	Cited Title

Search [View our Cited Reference Search tutorial.](#)

[+ Add row](#) | [Reset](#)

Timespan

[More settings](#)

3. Click “Cited Reference Search”.
4. Enter information about the cited work.
5. Select the relevant cited references and click “Finish Search”.

TIP: Look for cited reference variants.

Select	Cited Author	Cited Work [Expand Titles]	Title [Hide Expanded Titles]	Early Access Year ***	Year	Volume	Issue	Page
☒	Hellewell, J + [Show all authors]	LANCET GLOB HLTH	Feasibility of controlling COVID-19 outbreaks by isolation of cases and contacts URL: http://dx.doi.org.virtual.lanu.edu.au/10.1016/S2214-109X(20)30074-7		2020	8	4	E488
☒	Hellewell, J + [Show all authors]	LANCET GLOB HEALTH	Feasibility of controlling Covid-19 outbreaks by isolation of cases and contacts URL: https://doi-org.virtual.lanu.edu.au/10.1016/S2214-109X(20)30074-7		2020			
☒	Hellewell, J + [Show all authors]	LANCET GLOB HLTH	Feasibility of controlling COVID-19 outbreaks by isolation of cases and contacts		2020			
☐	Hellewell, J + [Show all authors]	FEASIBILITY CONTROLL	Feasibility of controlling 2019-nCoV outbreaks by isolation of cases and contacts		2020			
☐	Hellewell, J + [Show all authors]	FEASIBILITY CONTROLL	Feasibility of controlling 2019-nCoV outbreaks by isolation of cases and contacts		2020			
☐	Hellewell, J + [Show all authors]	FEASIBILITY CONTROLL	Feasibility of controlling 2019-nCoV outbreaks by isolation of cases and contacts URL: https://www.medrxiv.org/content/10.1101/2020.02.28.20055555		2020		20	

6. Using the Web of Science Core Collection, the cited reference search retrieved 151 records that cited the article by Hellewell et al.

Web of Science

Clarivate Analytics

Search

Tools ▾ Searches and alerts ▾ Search History Marked List

Results: 151
(from Web of Science Core Collection)

You searched for: CITED AUTHOR: (Hellewell J) AND CITED YEAR: (2020) AND CITED TITLE: (feasibility) ...[More](#)

Create an alert

Refine Results

Search within results for...

Filter results by:

☐ Highly Cited in Field (1)

☐ Open Access (141)

[Refine](#)

Publication Years

Sort by: [Date](#) [Times Cited](#) [Usage Count](#) [More ▾](#)

1 of 16

☐ Select Page [A Export...](#) [Add to Marked List](#)

1. SARS-CoV-2 infection and air pollutants: Correlation or causation?
By: Ricco, Matteo; Ranzieri, Silvia; Balzarini, Federica; et al.
SCIENCE OF THE TOTAL ENVIRONMENT Volume: 734
Article Number: 139489 Published: SEP 10 2020
[Find it at ANU](#) [Free Published Article From Repository](#)

2. COVID-19: Transmission, prevention, and potential therapeutic opportunities
By: Lotfi, Melika; Hamblin, Michael R.; Rezaei, Nima
CLINICA CHIMICA ACTA Volume: 508 Pages: 254-266
Published: SEP 2020
[Find it at ANU](#) [Free Full Text from Publisher](#)

[View Abstract ▾](#)

[Analyze Results](#)
[Create Citation Report](#)

Times Cited: 0
(from Web of Science Core Collection)

Usage Count ▾

Times Cited: 2
(from Web of Science Core Collection)

Usage Count ▾

4.2 Appendix 2: Teaching first year MAEs – Presentation

Advanced search technique using the MEDLINE (via OVID) database

Genevieve O'Neill
Liz Walker
Tracy Tsang

1

Objectives

- ▶ Use MEDLINE (via OVID) to perform an advanced search
- ▶ Use truncation, wild cards and Boolean operators
- ▶ Export search results from MEDLINE to Microsoft Word
- ▶ Set up AutoAlerts in MEDLINE
- ▶ Perform a cited reference search using Web of Science

2

Why would I use MEDLINE?

- ▶ MEDLINE comprises more than 26 million references to journal articles in life sciences.
- ▶ MEDLINE is the primary component of PubMed.



3

Info to get you started...

- ▶ Entering shortcut commands into the command line will allow you to bypass the use of the icon bar.

Advanced Search | Basic Search | Find Citation | Search Tools | Search Fields | Multi-Field Search

1 Resource selected | [Hide](#) | [Change](#)

📌 Ovid MEDLINE(R) ALL 1946 to August 05, 2020

Enter keyword or phrase
(* or \$ for truncation)

☒ Keyword ☐ Author ☐ Title ☐ Journal

▼ Limits (close) ☐ Include Multimedia ☒ Map Term to Subject Heading

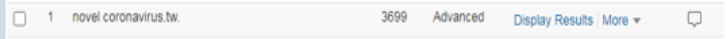
☐ Abstracts	☐ Structured Abstracts	☐ English Language
☐ No Language Specified	☐ Full Text	☐ Review Articles
☐ Humans	☐ Core Clinical Journals (AIM)	☐ Latest Update
☐ Pharmacologic Actions	☐ COVID-19	

Publication Year -

[Additional Limits](#) [Edit Limits](#)



4

Command	Description
<term>.xy.	Runs a search for the word or phrase (term) through the field indicated by the two-letter short code (xy).  <i>Tip: tw = text word</i> <i>(runs a search for the term through the abstract and title fields of the database)</i>
<term>.xy,yz.	Runs a search for the word or phrase (term) through the fields indicated by the two-letter short code (xy, yz).

5

Scenario

- ▶ You are the new MAE working in the National Incident Room (NIR) at the Australian Government Department of Health.
- ▶ The NIR Director has asked you to conduct a literature search on the transmissibility of the coronavirus disease (COVID-19).



6

Initial search strategy

▼ Search History (5) View Saved

☐	# ▲	Searches	Results	Type	Actions	Annotations
☐	1	novel coronavirus.tw.	3699	Advanced	Display Results More ▼	Contract
☐	2	(2019-nCoV or COVID-19 or SARS-CoV-2).tw.	37632	Advanced	Display Results More ▼	
☐	3	1 or 2	38368	Advanced	Display Results More ▼	
☐	4	transmission.tw.	363631	Advanced	Display Results More ▼	
☐	5	3 and 4	3061	Advanced	Display Results More ▼	

Combine with:

7

Exercise 1

- ▶ You identified a few abstracts referring to coronavirus disease as:
 - novel beta coronavirus
 - novel 2019 coronavirus disease
 - novel human coronavirus
- ▶ How would you modify your search strategy to capture these abstracts?

8

Exercise 1 – Answers

- ▶ You can use the Boolean operator “ADJn”.
- ▶ ADJn allows you to retrieve records that contain your search terms (in any order) within a specified number (n-1) of words from each other.



▼ Search History (2)		View Saved			
#	Searches	Results	Type	Actions	Annotations
1	novel coronavirus.tw.	3699	Advanced	Display Results More ▾	
2	(novel adj2 coronavirus).tw.	3876	Advanced	Display Results More ▾	

Save Remove Combine with: AND OR

9

- ▶ The ADJn operator is useful when you are not sure of the exact terminology used in the literature.
- ▶ ADJ1 operator finds two terms next to each other in any order.
- ▶ ADJ2 operator finds two terms in any order, with one word (or none) between them.
- ▶ *TIP: Depending on the database used, words such as “a”, “the”, and “or” may or may not be counted.*

10

Exercise 2

- ▶ You realised the search term “transmission” may be too narrow.
- ▶ How would you modify your search strategy so the search will retrieve records that will include words such as transmissible, transmissibility or transmittable?



11

Exercise 2 – Answers

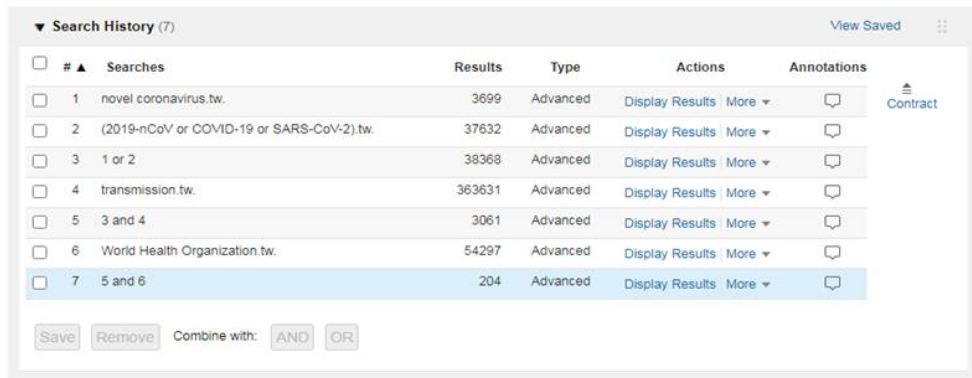
- ▶ You can use truncation (* or \$).
- ▶ Truncation allows you to find variations of a specified term.
- ▶ For example, “transmi\$” will retrieve records that include words such as transmissible, transmissibility, transmittable, transmitted and transmission etc.

A screenshot of a search history interface. It features a table with two columns: 'Searches' and 'Results'. The first row shows the search 'transmission.tw.' with 363631 results. The second row, which is highlighted in blue, shows the search 'transmi\$.tw.' with 512720 results. Below the table are buttons for 'Save', 'Remove', and 'Combine with: AND OR'.

12

Exercise 3

- ▶ You added “World Health Organization” as a search term to narrow down the results.



▼ Search History (7) View Saved

☐	# ▲	Searches	Results	Type	Actions	Annotations
☐	1	novel coronavirus.tw.	3699	Advanced	Display Results More ▼	Contract
☐	2	(2019-nCoV or COVID-19 or SARS-CoV-2).tw.	37632	Advanced	Display Results More ▼	
☐	3	1 or 2	38368	Advanced	Display Results More ▼	
☐	4	transmission.tw.	363631	Advanced	Display Results More ▼	
☐	5	3 and 4	3061	Advanced	Display Results More ▼	
☐	6	World Health Organization.tw.	54297	Advanced	Display Results More ▼	
☐	7	5 and 6	204	Advanced	Display Results More ▼	

[Save](#) [Remove](#) Combine with: [AND](#) [OR](#)

13

- ▶ Would “World Health Organization” capture citations that referred it as “World Health Organisation”? If not, what modification would you make so your search will retrieve records with either spelling?

14

Exercise 3 – Answers

- ▶ You can use wildcard (?).
- ▶ Wildcard is useful for retrieving records with British and American spelling variations. It stands for zero or one character within a word or at the end of a word.
- ▶ For example, “organi?ation” finds occurrences of organisation and organization, and “colo?r” finds occurrences of colour and color.



15

Exercise 4

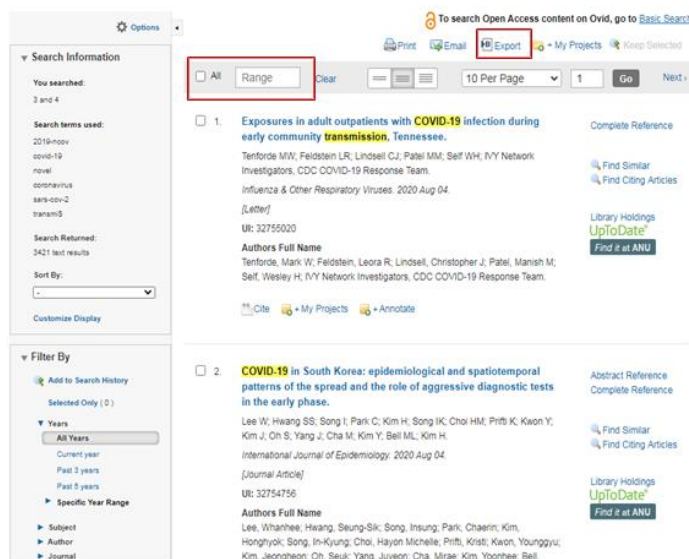
- ▶ You now plan to review all the abstracts retrieved from your original search (3000+ results).
 - You have been warned by a colleague that Ovid times out after a certain period. In addition, you understand the importance of good record-keeping, and would like to save a copy of your search strategy.
- ▶ How do you export the results? What are some pros and cons for your chosen method?



16

Exercise 4 – Answers

- You can export your searches.



17

The option "Citation" includes fields that may not be relevant to you.

Here, I selected abstract (ab), author (au), source (so) and title (ti).

Export Citation(s)

Selected: 1-100
Total: 100

Format: Microsoft Word

Fields: Custom

Selected Fields: ab, au, so, ti

Citation Style: Ovid Labeled Citation

Include:

☐ Link to External Resolver

☐ URL

☒ Search History

Cancel Export

You can choose your desired format.

Exporting citations to MS Word allows you to insert comments, highlight abstracts of interest, share document with colleagues that may not have specific software like EndNote and keep a record of the search terms used.

18

Exercise 5

- ▶ Your Director advised you that she would like an update on the transmissibility of COVID-19 once a month.
- ▶ What can you do to avoid reviewing the same abstracts that you have reviewed from the initial search?



19

Exercise 5 – Answers

- ▶ You can set up an AutoAlert for your search.
- ▶ *TIP: You will need to create an account to use this function.*



20

▼ Search History (5) View Saved

☐	# ▲	Searches	Results	Type	Actions	Annotations
☐	1	novel coronavirus.tw.	3699	Advanced	Display Results More ▼	
☐	2	(2019-nCoV or COVID-19 or SARS-CoV-2).tw.	37632	Advanced	Display Results More ▼	
☐	3	1 or 2	38368	Advanced	Display Results More ▼	
☐	4	transmi\$.tw.	512720	Advanced	Display Results More ▼	
☒	5	3 and 4	3421	Advanced	Display Results More ▼	

Combine with:

21

Give your search a name.

You can personalise how often you receive the auto alerts.

Search Name Comment (Optional) Type ☒ AutoAlert (SDI) ☐ Save

AutoAlert Options

Scheduling Options

☒ On Database Update[?]
 ☐ Quarterly
 ☐ Monthly - on day
☐ Every other week - on
☐ Weekly - on

Deduping Options

☐ 90 Days

☒ Include Open Access Results

Delivery Options

☒ Email
 ☐ RSS
 ☐ My Projects

22

23

Exercise 6

- ▶ You found a key article describing the feasibility of controlling COVID-19 outbreaks by isolation of cases and contacts.

Feasibility of controlling COVID-19 outbreaks by isolation of cases and contacts

Joel Hellewell, Sam Abbott*, Amy Gimma*, Nikos I Bosse, Christopher I Jarvis, Timothy W Russell, James D Munday, Adam J Kucharski, W John Edmunds, Centre for the Mathematical Modelling of Infectious Diseases COVID-19 Working Group, Sebastian Funk†, Rosalind M Eggo†



- ▶ You are interested in identifying other published articles that cite this key paper. What would you do?

24

Exercise 6 – Answers

- ▶ You can use the cited reference search in Web of Science.



25

Web of Science Clarivate Analytics

Tools ▾ Searches and alerts ▾ Search History Marked List

Select a database Web of Science Core Collection ▾

Basic Search Author Search Cited Reference Search Advanced Search Structure Search

Find the articles that cite a person's work.

Step 1: Enter information about the cited work. Fields are combined with the Boolean AND operator.

* Note: Entering the title, volume, issue, or page in combination with other fields may reduce the number of cited reference variants found.

Hellewell J ✕	Cited Author ▾
Select from Index	
2020 ✕	Cited Year(s) ▾
feasibility ✕	Cited Title ▾

Search [View our Cited Reference Search tutorial.](#)

[+ Add row](#) | [Reset](#)



26

Select	Cited Author	Cited Work [Expand Titles]	Title [Hide Expanded Titles]	Early Access Year ***	Year	Volume	Issue	Page
☒	Hellewell, J + [Show all authors]	LANCET GLOB HLTH	Feasibility of controlling COVID-19 outbreaks by isolation of cases and contacts URL: http://dx.doi.org/10.1016/S2214-109X(20)30074-7		2020	8	4	E488
☒	Hellewell, J + [Show all authors]	LANCET GLOB HEALTH	Feasibility of controlling Covid-19 outbreaks by isolation of cases and contacts URL: https://doi.org/10.1016/S2214-109X(20)30074-7		2020			
☒	Hellewell, J + [Show all authors]	LANCET GLOB HLTH	Feasibility of controlling COVID-19 outbreaks by isolation of cases and contacts		2020			
☐	Hellewell, J + [Show all authors]	FEASIBILITY CONTROLL	Feasibility of controlling 2019-nCoV outbreaks by isolation of cases and contacts		2020			
☐	Hellewell, J + [Show all authors]	FEASIBILITY CONTROLL	Feasibility of controlling 2019-nCoV outbreaks by isolation of cases and contacts		2020			
☐	Hellewell, J + [Show all authors]	FEASIBILITY CONTROLL	Feasibility of controlling 2019-nCoV outbreaks by isolation of cases and contacts URL: https://www.medrxiv.o		2020		20	

27

☒	Hellewell, J + [Show all authors]	LANCET GLOB HEALTH	Feasibility of controlling COVID-19 outbreaks by isolation of cases and contacts		2020			488
☒	Hellewell, J. + [Show all authors]	LANCET GLOBAL HLTH	Feasibility of controlling COVID-19 outbreaks by isolation of cases and contacts		2020			
☒	Hellewell, Joel + [Show all authors]	LANCET GLOB HEALTH	Feasibility of controlling COVID-19 outbreaks by isolation of cases and contacts		2020	8	4	E488

↑ Select Page
Select All *
Clear
Export Table
Finish Search

28

Web of Science

Clarivate Analytics

Search Tools Searches and alerts Search History Marked List

Results: 151
(from Web of Science Core Collection)

You searched for: CITED AUTHOR:
(Hellewell J) AND CITED YEAR: (2020)
AND CITED TITLE: (feasibility) ...More

Create an alert

Refine Results

Search within results for...

Filter results by:

☐ Highly Cited In Field (1)

☐ Open Access (141)

Refine

Publication Years

Sort by: Date Times Cited Usage Count More

1 of 16

Select Page Export... Add to Marked List

Analyze Results
Create Citation Report

1. SARS-CoV-2 infection and air pollutants: Correlation or causation?
By: Ricco, Matteo; Ranzieri, Silvia; Balzarini, Federica; et al.
SCIENCE OF THE TOTAL ENVIRONMENT Volume: 734
Article Number: 139489 Published: SEP 10 2020
Find it at ANU Free Published Article From Repository

Times Cited: 0
(from Web of Science Core Collection)

Usage Count

2. COVID-19: Transmission, prevention, and potential therapeutic opportunities
By: Lotfi, Melika; Hamblin, Michael R.; Rezaei, Nima
CLINICA CHIMICA ACTA Volume: 508 Pages: 254-266
Published: SEP 2020
Find it at ANU Free Full Text from Publisher

Times Cited: 2
(from Web of Science Core Collection)

Usage Count

View Abstract

29

Useful shortcut commands

▼ Search History (10) View Saved

#	Searches	Results	Type	Actions	Annotations
1	novel coronavirus.tw.	3699	Advanced	Display Results More	
2	(2019-nCoV or COVID-19 or SARS-CoV-2).tw.	37632	Advanced	Display Results More	
3	1 or 2	38368	Advanced	Display Results More	
4	transmission.tw.	363631	Advanced	Display Results More	
5	3 and 4	3061	Advanced	Display Results More	
6	limit 5 to english	2934	Advanced	Display Results More	
7	limit 6 to humans	1211	Advanced	Display Results More	
8	limit 7 to yr=2019-2020	1152	Advanced	Display Results More	
9	limit 7 to yr="2020"	1150	Advanced	Display Results More	
10	novel coronavirus.ab.ti.	3699	Advanced	Display Results More	

Save Remove Combine with: AND OR

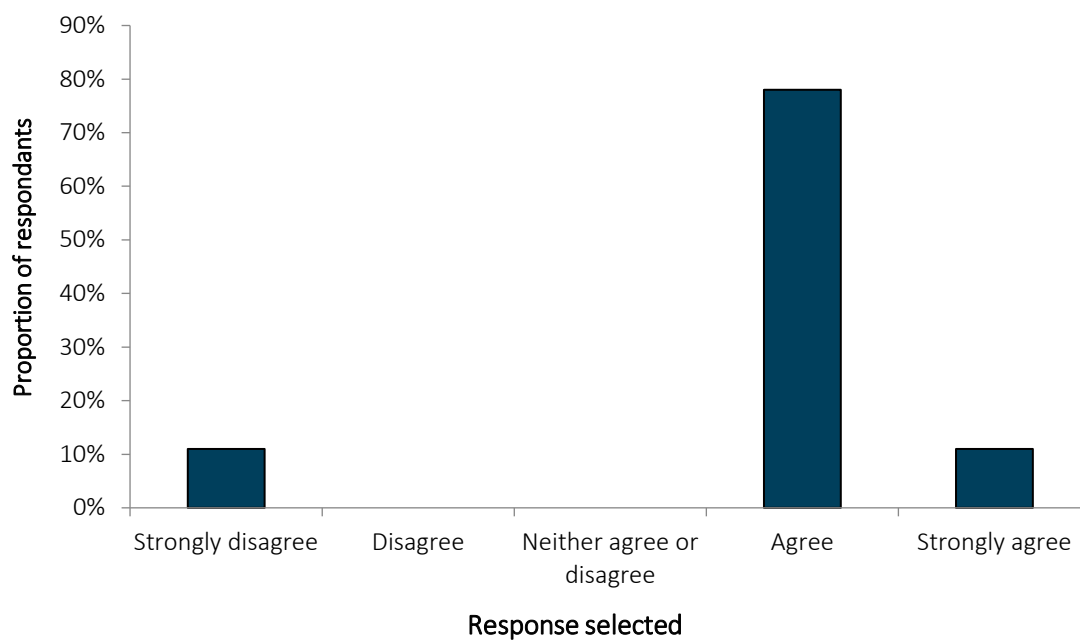
30

Thank you!

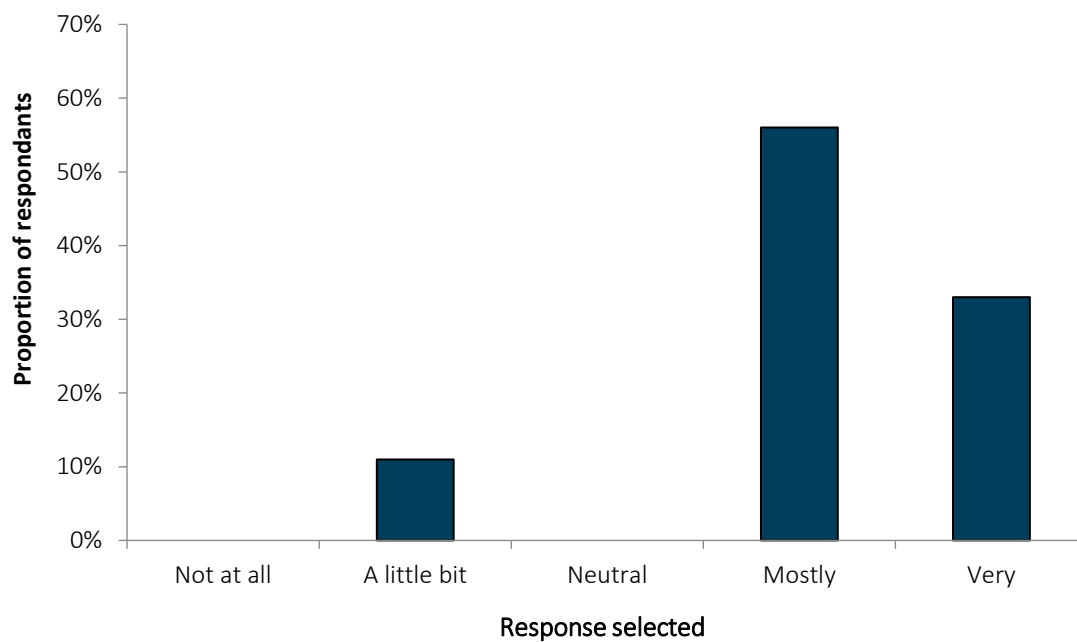


4.3 Appendix 3: Evaluation of first year MAE teaching

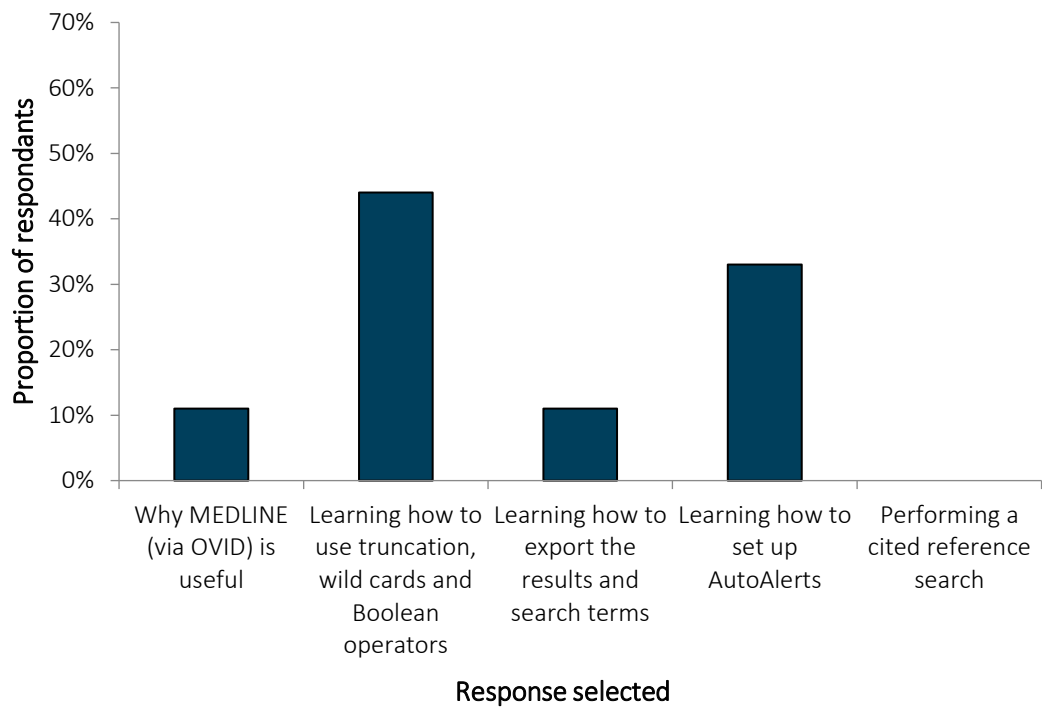
The session met its objectives.



Was the content useful?



Which component of the session did you find the most useful?



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