Chapter V
Outbreak investigation

SARS-CoV-2 outbreak at a metropolitan restaurant in South Australia

We do need to take this very, very seriously – it can run like wildfire.

Chief Public Health Officer, Professor Nicola Spurrier, 18 July 2021

Table of contents

List of figures

List of tables

Abbreviations

AIR	Australian Immunisation Registry
CCTV	Closed-circuit television
CDCB	Communicable Disease Control Branch
COVID-19	Coronavirus Disease 2019
Ct	Cycle threshold
DPC	Department of Premier and Cabinet
NDSS	Notifiable disease surveillance systems
PCR	Polymerase chain reaction
PHSM	Public Health and Social Measures
QR	Quick Response
SA	South Australia
TGA	Therapeutic Goods Administration
TTQI	Test, trace, quarantine and isolate
VOC	Variant of Concern
WHO	World Health Organization

Prologue

Between March 2020 and December 2021, Australia pursued an elimination strategy in response to the COVID-19 pandemic. Despite these efforts, several small COVID-19 outbreaks occurred. This chapter describes a COVID-19 outbreak at a restaurant in South Australia (SA) in July 2021. The following Master of Applied Epidemiology course requirements have been accomplished with this chapter: investigation of an acute public health problem and conference presentation (Appendix I).

Role

In July 2021, I was seconded to the SA Health Communicable Disease Control Branch (CDCB) COVID Operations during the State's first significant outbreak of the SARS-CoV-2 Delta variant. During this time, I worked within the Outbreak Control Team, whose primary role was identifying and managing exposure sites. I was responsible for reviewing closed-circuit television (CCTV) footage from a transmission site and cleaning and validating data. I also had the opportunity to prepare a transmission map, data on vaccination coverage and attack rates for the media and the South Australian Chief Public Health Officer, Professor Nicola Spurrier. In addition, I attended daily COVID-19 Operations meetings and risk assessments, completed the Health Rapid Response Training, and presented my outbreak findings at the 2021 South Australian Population Health Conference.

Lessons Learned

1. Field epidemiologists must provide timely and concise information to stakeholders, particularly in a constantly evolving outbreak situation. In this outbreak, I determined the vaccination coverage and attack rates for close contacts at the exposure site within an hour for the South Australian Chief Public Health Officer in advance of a press conference.

2. Notifiable disease surveillance systems (NDSS) are a critical source of information in an outbreak investigation. However, the timeliness and quality of data can be compromised in a significant and rapidly evolving outbreak. In the context of this outbreak, I verified data from multiple locations within the state NDSS, for example, comparing interview notes with Disease Case Report Forms entries to address data completeness and validity.
3. The COVID-19 pandemic has evolved rapidly. In preparing this outbreak investigation report, I learned the importance of clearly contextualising the outbreak within the disease control measures implemented at the time, such as immunisation requirements and public health and social measures, to ensure its future usefulness.

Public Health Impact

This investigation has contributed to the evidence base on the transmission of the SARS-CoV-2 Delta variant within indoor environments. It details the use of check-ins and hotel quarantine to manage COVID-19 outbreaks and effectively break chains of transmission in the absence of high immunisation coverage levels. It also illustrates airborne transmission of SARS-CoV-2 in a public bathroom, possibly for the first time.

Acknowledgements

I want to acknowledge Emma Denehy, Emma Northcote and Professor Caroline Miller for their mentoring and oversight; Tom Freeman and Brian Yam for data extraction and interpretation; and Mitchell Acland, Sam Damant and the SA Health COVID-19 Operations Outbreak Control Team for answering an endless number of questions.

Abstract

Introduction

Between March 2020 and December 2021, Australia pursued an elimination strategy in response to the COVID-19 pandemic. Despite these efforts, several small COVID-19 outbreaks occurred, one of which was the Modbury outbreak in South Australia in 2021. This study characterises an outbreak at one of the transmission sites during the Modbury outbreak.

Methods

A descriptive epidemiological study was undertaken to investigate the outbreak. Close contacts were identified via routine contract tracing, including auditing of electronic Quick Response check-in and electronic financial record, as well as self-identification to the state COVID-19 hotline. Epidemiological data related to cases and close contacts were collected from the state's notifiable disease surveillance system. Closed-Circuit Television (CCTV) footage was obtained to determine exposure status and interactions between primary cases and close contacts. New cases were identified via active surveillance of close contacts during mandatory quarantine, including regular SARS-CoV-2 polymerase chain reaction (PCR) testing. Phylogenetic relatedness of cases was confirmed using whole genome sequencing.

Results

Eight people tested positive for SARS-CoV-2 by PCR; all were confirmed to be the Delta variant (B.1.617.2). Two were identified as co-primary cases and six as secondary cases. Half of the secondary cases had face-to-face exposure, defined as at least 15 minutes within 1.5 meters of a confirmed case or greater than two hours within the same room, without a mask or face covering. The attack rate was 33.3% for face-to-face exposure and 2.5% for those not exposed. The relative risk of becoming

a COVID-19 case was 13.22 times higher (95% CI: 3.10–56.36; $p = 0.004$) among close contacts with face-to-face exposure than those with no face-to-face exposure.

Conclusions

This study found evidence of possible airborne transmission of COVID-19, highlighting the importance of indoor ventilation and mask use in reducing the burden of COVID-19 in a population. It also demonstrates the impact of rapid contact tracing and quarantine in suppressing a COVID-19 outbreak. Furthermore, it illustrates the utility of CCTV footage in determining the transmission dynamics of a novel respiratory virus.

Introduction

COVID-19 pandemic

SARS-CoV-2, the virus that causes Coronavirus Disease 2019 (COVID-19), has rapidly spread worldwide since its emergence in Wuhan, China, in December 2019 (1). Like most viruses, viral replication of SARS-CoV-2 causes mutations in the genetic material and allows new virus variants to arise (2). Sharing SARS-CoV-2 genetic sequence data has enabled the tracking of virus mutations and facilitated near-real-time global surveillance of the pandemic (2, 3). Since January 2021, the World Health Organization (WHO) and a network of international experts have monitored the virus's evolution and characterised specific Variants of Concern (VOC) (4). VOC are virus variants with evidence of the following: increased transmissibility; increased virulence; changes in clinical disease; decreased effectiveness of public health measures, available diagnostics, vaccines or therapeutics (4).

As of December 2021, five SARS-CoV-2 variants had met the VOC criteria, one of which is the B.1.617.2 Delta variant (4). The Delta variant emerged in India in October 2020 and caused a devastating nationwide outbreak. At the outbreak's peak, India witnessed over 400,000 daily cases and 7,300 deaths (5). Compared to earlier variants, B.1.617.2 has a shorter incubation period and higher viral loads (6), resulting in increased transmissibility (6). The basic reproductive number (R_0) of the Delta variant is estimated to be >5.0 in immunologically naïve populations, compared to >3.0 in ancestral strains, giving it greater epidemic potential (7). Unvaccinated persons infected with the Delta variant, compared to earlier variants, also have higher odds of hospitalisation (8), severe disease, ICU admission and death (9). Between July 2021 and January 2022, Delta was the dominant variant circulating in most countries (10).

Australia pursued an elimination strategy from the pandemic's beginning until the end of 2021 (11, 12). Defined as 28 days of no community transmission of SARS-CoV-2 (11), elimination was achieved in all states and territories via a wide range of non-pharmaceutical interventions, including social distancing, mask-wearing, lockdowns, international and state border closures, and a robust test, trace, isolate, and quarantine (TTIQ) plan (12, 13). The approach successfully contained the first wave of COVID-19 infections between March and April 2020 (13). However, the emergence of the Delta variant in December 2020 challenged this strategy. The first community-acquired infection of the Delta variant occurred in Sydney in May 2021, leading to outbreaks across Australia and resulting in New South Wales and Victoria moving from an elimination strategy to a suppression strategy.

SARS-CoV-2 is transmitted via large respiratory droplets, >5–10 μm in diameter, during close contact with asymptomatic, pre-symptomatic and symptomatic individuals (14). Consistent with other respiratory viruses, such as SARS-CoV-1, Middle Eastern respiratory syndrome coronavirus (MERS-CoV), and influenza (15, 16), a growing body of evidence strongly supports airborne transmission of SARS-CoV-2 (17-19). This occurs when an infectious person ejects microdroplets or aerosols, <5 μm in diameter, containing the virus. In poorly ventilated spaces, these aerosols can remain suspended in the air and infectious over long periods and distances (20). Strategies to prevent droplet transmission, such as physical distancing, are less effective for airborne transmission. The prevention of airborne transmission requires introducing engineering controls, for example, improving ventilation and increasing air exchange, which are more effective than administrative controls or personal protective equipment in the infection control hierarchy (20). Early in the pandemic, fomite transmission was also considered a risk factor. However, emerging evidence suggests the risk of fomite transmission is negligible (21).

Globally, herd immunity via whole-population COVID-19 vaccination is deemed the only viable path out of the pandemic and opportunity to return to life as usual with minimal requirements for public health and social measures. The vaccination rollout commenced in Australia following the provisional approval by the Therapeutic Goods Administration (TGA) of Comirnaty (Pfizer) vaccine on 25 January, and Vaxzevria (AstraZeneca) vaccine on 15 February 2021. As of 25 July 2021, five months into the rollout, only 12.9% of the Australian population were fully vaccinated (13), compared to more than 50% in Canada, the United Kingdom, Portugal, Denmark, Singapore and Ireland (18). Between July and August 2021, following the outbreak of the Delta variant in NSW, the rollout of COVID-19 vaccines was fast-tracked. During this period, the daily number of COVID-19 vaccinations per 100,000 persons across Australia doubled, from 500 to 1,000 (22).

Management of COVID-19 in South Australia

In South Australia, a Declaration of a Major Emergency, under the *Emergency Management Act 2004*, was made on 22 March 2020 to manage the COVID-19 pandemic. Under the Declaration and the leadership of the State Controller (Police Commissioner Grant Stevens) and State Control Centre Health, numerous associated directions were made. Theses directions aimed to limit public activities, restrict entry into South Australia and enforce public health and social measures (PHSM), including social distancing and mask-wearing. These directions were implemented in parallel to a robust TTIQ public health strategy to break chains of COVID-19 transmission. Notably, under the *Isolation Following Diagnosis or Close Contact Direction 2020* close contacts and COVID-19 cases could be directed to a health facility, including a medihotel for supervised quarantine, preventing opportunities for household transmission. On 21 July 2021, the *Emergency Management (Activities—General No 3) (COVID-19) Direction* also enforced the use of approved contact tracing systems and check-in by individuals at public venues, events and large private gatherings (23). The Direction aimed to provide contact tracing teams with rapid access to contact details of anyone at a known COVID-19 exposure site.

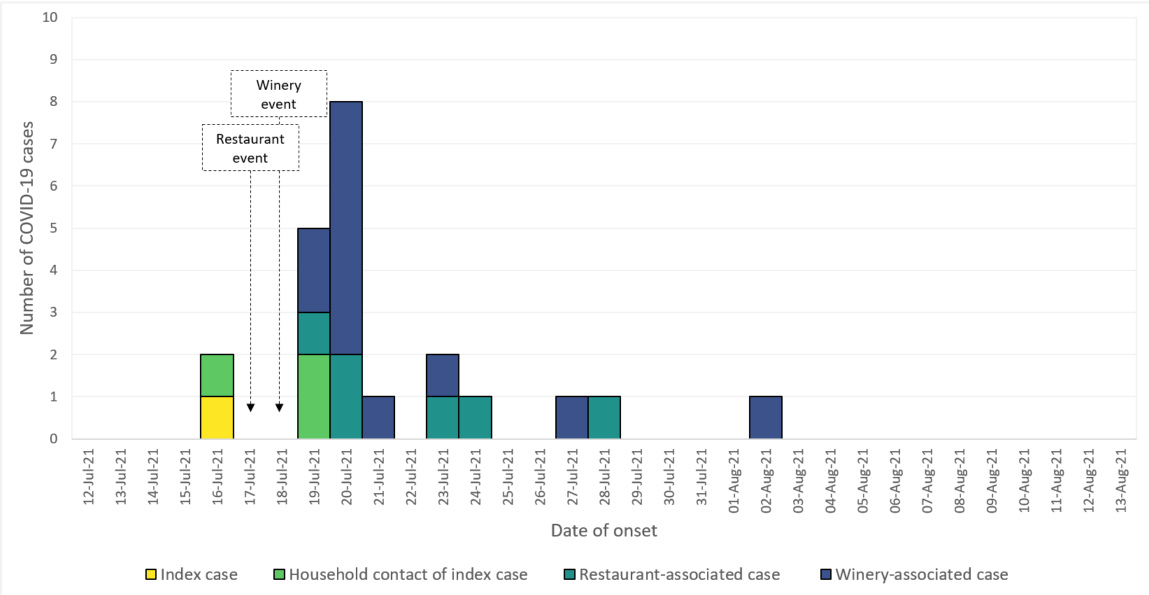
The strategies employed during the elimination period in South Australia were largely effective. Between 1 January 2020, and 23 November 2021 - when the state opened its borders following 76.1% double-dose vaccination - only 922 COVID-19 cases (75.2% (*n*= 693) of which were overseas-acquired) had been recorded and four deaths, and the state had undergone ten days in lockdown. Despite these efforts, several small COVID-19 outbreaks occurred (Appendix II), including one in Modbury in July 2021.

Modbury COVID-19 Outbreak

On 19 July 2021, the SA Health Communicable Disease Control Branch (CDCB) received a medical notification for a male aged >80 years who tested positive for SARS-CoV-2 by PCR – the index case and primary case of what became known as the Modbury Outbreak. In response, level five restrictions were initiated from 18.00 hours on 21 July 2021, and a 7-day statewide lockdown was declared. Under the restrictions, South Australian residents were only allowed to leave their home for five reasons - care and compassion, essential work, purchase of essential goods or services, medical reasons (including COVID-19 testing and vaccination) and exercise (limited to members of the same household). A mask mandate was also introduced, requiring masks to be worn outside the home.

Twenty-two cases and 92 public exposure sites, including two transmission sites at hospitality venues, were linked to the Modbury outbreak, which was declared over on 30 August 2021. This chapter describes the epidemiology of the outbreak at one of the transmission sites in the Modbury outbreak, Restaurant X. To provide context, an epidemic curve of the outbreak at Restaurant X in the broader Modbury outbreak is illustrated in Figure 1 below, and further details can be found in Appendix III.

Figure 1. COVID-19 cases, onset date and source, Modbury, South Australia, July 2021



Methods

Epidemiological investigation

Close contacts from Restaurant X were identified via auditing QR check-in information, financial transactions and self-identification to the state COVID-19 hotline. Information relating to person, place and time for the cases and close contacts related was collected retrospectively from electronic Disease Case Report Forms and Close Contact Report Forms stored in the state notifiable disease surveillance system. Clinical data, including symptom onset, specimen collection and laboratory results, were accessed from electronic Notifiable Condition Report forms. COVID-19 vaccination status was extracted from the Australian Immunisation Registry (AIR), and where data was missing, self-reported status in case and contact report forms was used.

In collaboration with the Department of Premier and Cabinet (DPC) and SA Police, QR check-in data, financial transactions, floorplans and Closed-Circuit Television (CCTV) footage were obtained to determine exposure status and interactions between primary cases and close contacts. New cases were identified via active surveillance of close contacts including SARS- CoV-2 PCR testing on days one, five and 13 of mandatory quarantine. Periodic bulk short message services (SMS) were sent to remind contacts of their testing requirements. Daily symptom checks were performed for all close contacts via SMS or daily phone calls. Additional testing was initiated for symptomatic contacts who were not due for a routine test.

A person was a primary case if they met the following definition:

> A person with a positive RT-PCR test for SARS- CoV-2 AND had attended Restaurant X between 18.00 and 23.00 on Saturday, 17 July, during their infectious period.

A person was a secondary case if they met the following definition:

> A person with a positive RT-PCR test for SARS- CoV-2 AND had attended Restaurant X between 18.00 and 23.00 on Saturday, 17 July.

A person was a close contact if they met the following definition:

> Any person that attended Restaurant X between 18.00 and 23.00 on Saturday, 17 July 2021.

Face-to-face exposure was defined as at least 15 minutes within 1.5 meters of a confirmed case or greater than two hours within the same room[15], without a mask or

[15] An indoor room $<100m^2$

face covering. Attack rates were calculated for all restaurant patrons and staff in attendance during the exposure period and disaggregated by face-to-face exposure status. Relative risk and associated 95% confidence intervals (95% CI) were calculated to examine the risk between face-to-face exposure and becoming COVID-19 positive.

Laboratory investigation

All laboratory analyses were performed at SA Pathology as part of standard clinical investigation. Phylogenetic relatedness of cases was confirmed using whole genome sequencing (WGS) with SARS-CoV-2 variant lineage performed using pangolin (v3.1.11) with pangoLEARN database (date 2021-08-09). Phylogenetic analysis was conducted using MAFFT (v7.487, 2021/July/26) and FastTree (v2.1.10) and cases were considered to be genomically linked at less than two single nucleotide polymorphisms (SNPs) difference.

Ethics

This study was conducted within the South Australian jurisdiction as a public health outbreak investigation under the *South Australian Public Health Act, 2011* and the powers as an authorised officer under the *South Australian Emergency Management Act, 2004.* The Australian National University Human Research Ethics Committee approved the ethical aspects of this project under protocol 2017/909 – request for waiver of consent for the use of data in research for Masters in Applied Epidemiology students for '*Outbreak Investigation'* project.

Results

On 19 July 2021, CDCB received three medical notifications for SARS-CoV-2. Subsequent case interviews identified that two of the three cases had attended a function at a metropolitan restaurant, Restaurant X, on 17 July, during their infectious period, so the restaurant was deemed an outbreak transmission site. Authorised

Officers immediately directed all three cases to isolate for 14 days, and an outbreak investigation and public health response commenced.

Close contacts

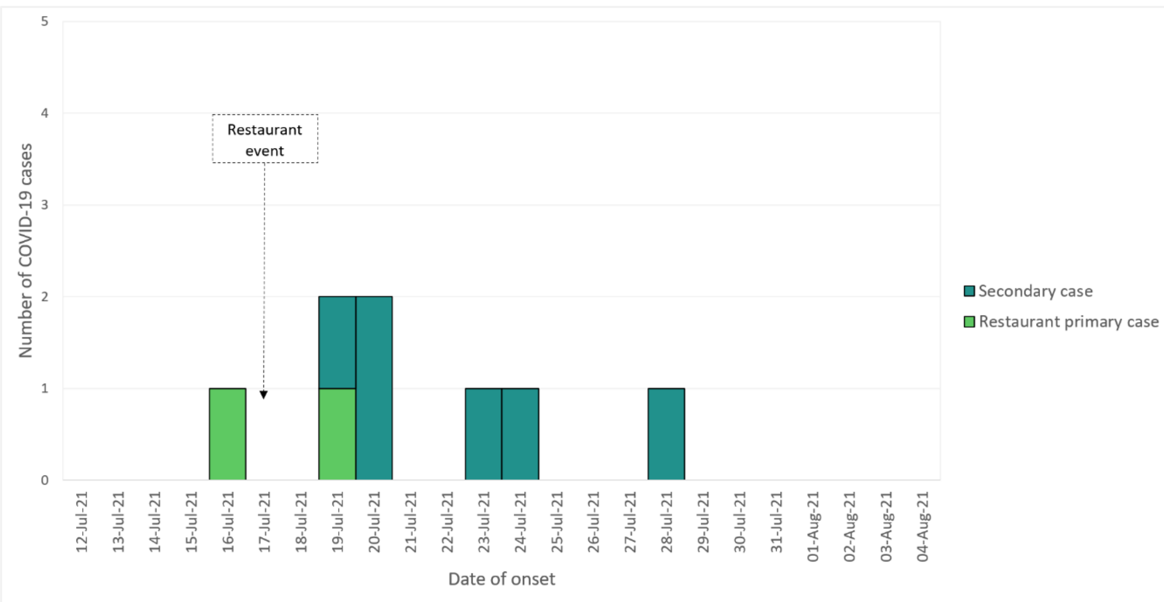
CDCB contact tracers identified 128 people who attended the restaurant during the exposure period 18.00 and 23.00 on Saturday, 17 July. Of the 128 close contacts, nine had attended the function in a private dining room with the two cases notified on 19 July. Most contacts were found via QR check-in (*n*=85, 66.4%) or a family member's QR check-in (*n*=13, 10.2%). Only one person had manually checked in (0.8%), and 22.7% (*n*=29) did not check in and were identified during contact tracing interviews. All close contacts were directed by Authorised Officers over the phone or via SMS to immediately quarantine and informed of testing requirements, COVID-19 signs and symptoms and where to seek healthcare if required. The median number of days between exposure on 17 July and Authorised Officer direction was 3 (IQR: 3–4.5 days) for those who checked in using QR code or manually and 3 days (IQR: 3–6 days) for those that did not check in. Critically, 90% (*n*=116) of close contacts were identified by contact tracers and directed to quarantine before the statewide lockdown at 18.00 hours on 21 July.

The COVID-19 vaccination status of 122 (95.3 %) close contacts was identified via the Australian Immunisation Registry, and 6 (4.7%) self-reported their status during case interviews. Of the 128 close contacts, 21 (16.4%) had received two doses of a TGA-approved COVID-19 vaccine, 31 (24.2%) had received one dose, and 76 (59.4%) were unvaccinated. Among unvaccinated close contacts, 20 (26.3%) were in the eligible age range (≥40 years of age) for a COVID-19 vaccination and had failed to vaccinate.

COVID-19 cases

Eight people that attended Restaurant X on 17 July tested positive for SARS-CoV-2 by PCR. Two cases, a male aged 65–74 years and female aged 55–64 years, were household contacts of the Modbury outbreak index case, and both tested positive by PCR on 19 July. During case interviews, the male case reported a symptom onset of 16 July. The reported symptom onset for the female case was 20 July, a day after testing positive by PCR. Given both cases were in their infectious period on 17 July, they were considered co-primary outbreak cases. Six other close contacts tested positive for SARS-CoV-2 by PCR during the 14-day quarantine period (Figure 2), thus becoming secondary cases. Of these six cases, five were restaurant patrons, and one was a staff member.

Figure 2. COVID-19 cases by date of onset, Restaurant X, South Australia, July 2021.



The median age of cases was 60 years (IQR: 36–71 years); three were male (35.7%), and two had received one dose of a TGA-approved COVID-19 vaccine greater than 14 days before their exposure and were considered partially vaccinated. Five cases were required to complete their isolation within a state government medihotel.

Seven cases (87.5%) reported being symptomatic. Reported symptoms included rhinorrhoea, shortness of breath, cough, sore throat, anosmia, dysgeusia, diarrhoea, myalgia, arthralgia and fever (Table 1). The most frequently reported symptom was rhinorrhoea (*n*=4), which was also the single symptom reported by one of the partially vaccinated cases. The other partially vaccinated was asymptomatic. The median incubation period, which is the time between virus exposure to symptom onset, was 4.5 days (IQR: 3.0–6.3). A female case, aged 35–44 years, reported their earliest symptom on 19 July however had negative COVID-19 PCR tests on July 20 and 22. As an extended respiratory panel test was not performed, it was unclear whether these symptoms resulted from infection with SARS-CoV-2 or with another respiratory virus. Given that they had also attended multiple indoor public venues while symptomatic with no onward transmission of COVID-19, their COVID-19 symptom onset was considered the date of their first positive test, taken on 23 July.

Table 1. Symptoms reported by symptomatic COVID-19 cases (*n*=7), Restaurant X, South Australia, July 2021

Symptom	*n*	%
Abdominal pain	1	14%
Anosmia	2	29%
Arthralgia	2	29%
Cough	2	29%
Diarrhoea	2	29%
Dysgeusia	2	29%
Fever	1	14%
Myalgia	1	14%
Shortness of breath	2	29%
Sore throat	1	14%
Rhinorrhoea	4	57%
Headache	2	29%

Three close contacts tested positive on their first test, two to three days following exposure. Based on the infectious period occurring 24–72 hours before symptom onset (24, 25), these cases spent a maximum of three to four days in the community while infectious. Viral loads from day one tests were considered low for all three cases, with polymerase chain reaction (PCR) assay cycle threshold (Ct E gene) values ranging from 33.7 to 38. 7. Viral loads in these cases increased on test 2 (Ct E gene values range: 17.7–30.1) and decreased again on test 3 (Ct E gene values range: 33.0–37.40). The 0–5 year old female case spent more than seven hours in childcare while symptomatic and infectious on 19 July. All close contacts from this exposure were quarantined for 14 days and provided with information regarding testing, COVID-19 signs and symptoms and when and where to seek healthcare if required. No close contacts from this setting became a COVID-19 case. All other secondary cases were more than three days into their quarantine period before testing positive and spent no time in the community while infectious. WGS was performed on samples from the eight outbreak cases. All were confirmed to be the Delta variant (B.1.617.2) and genomically linked (1–2 SNPs difference) to the Modbury outbreak index case and the ongoing outbreak in NSW.

A summary of the eight outbreak cases, including exposure and onset dates, incubation and quarantine periods, is reported in Table 2 below. This table summarises all of the information presented above.

Table 2. COVID-19 cases, Restaurant X outbreak, South Australia, July 2021

Case	Age group	Sex	Case type	Vaccine doses	Earliest known exposure	Face-to-face exposure	Symptom onset	First positive test (by PCR)	Infection onset*	Incubation period (days)	Quarantine or isolation start date	Days infectious in the community
A	55–64	F	P	0	13/07	-	20/07	19/07	19/07	6	19/07	3
B	65–74	M	P	0	13/07	-	16/07	19/07	16/07	3	19/07	6
C	55–64	M	S	0	17/07	Y	19/07	19/07	19/07	2	19/07	2
D	15–24	F	S	0	17/07	N	20/07	20/07	20/07	3	20/07	3
E	0–5	F	S	0	17/07	N	20/07	20/07	20/07	3	21/07	4
F	35–44	F	S	0	17/07	N	19/07	23/07	23/07	6	20/07	0
G	80+	M	S	1	15/07	Y	NA	24/07	24/07	7	19/07	0
H	80+	F	S	1	15/07	Y	29/07	27/07	27/07	10	19/07	0

*Date of infection onset = Date of symptom onset or date of the first positive test by PCR if asymptomatic. P = Primary, S = Secondary.

Exposure status and transmission pathways

The co-primary cases (cases A and B) spent most of the evening seated in a private dining room. They sat at the head of the table, furthermost from the doorway (Figure 3, panel A). During the evening, the female primary case left the dining room between 20:32–20:34 to attend the bathroom (Figure 3, panel D), and the male primary case paid the bill at the bar at 21:49 (Figure 3, panel F). They did not move around the restaurant at any other time.

Three secondary cases (C, G and H) attended the function, with the two primary cases in the private dining room. All three cases spent >15 minutes with both primary cases and were physically seated within one metre (Figure 3). Two cases (G and H) also travelled to and from the venue with the co-primary cases for a total of 1 hour and 20 minutes and visited their house two days prior for one hour during the infectious period of the male primary case. CCTV footage and interview records support respiratory droplet and/or airborne transmission for cases C, G and H.

Case D, a female aged 15–24 years, worked as a waiter at the restaurant. While not the allocated waiter for the private dining room, CCTV footage captured them serving food and beverages in the private dining room on four occasions (Figure 3, panel C). The total time spent in the room was no longer than two minutes. Case interview records indicated that they attended the private dining room once more at the end of the night to clear the table after the primary cases had departed. No CCTV footage was available to validate this potential exposure.

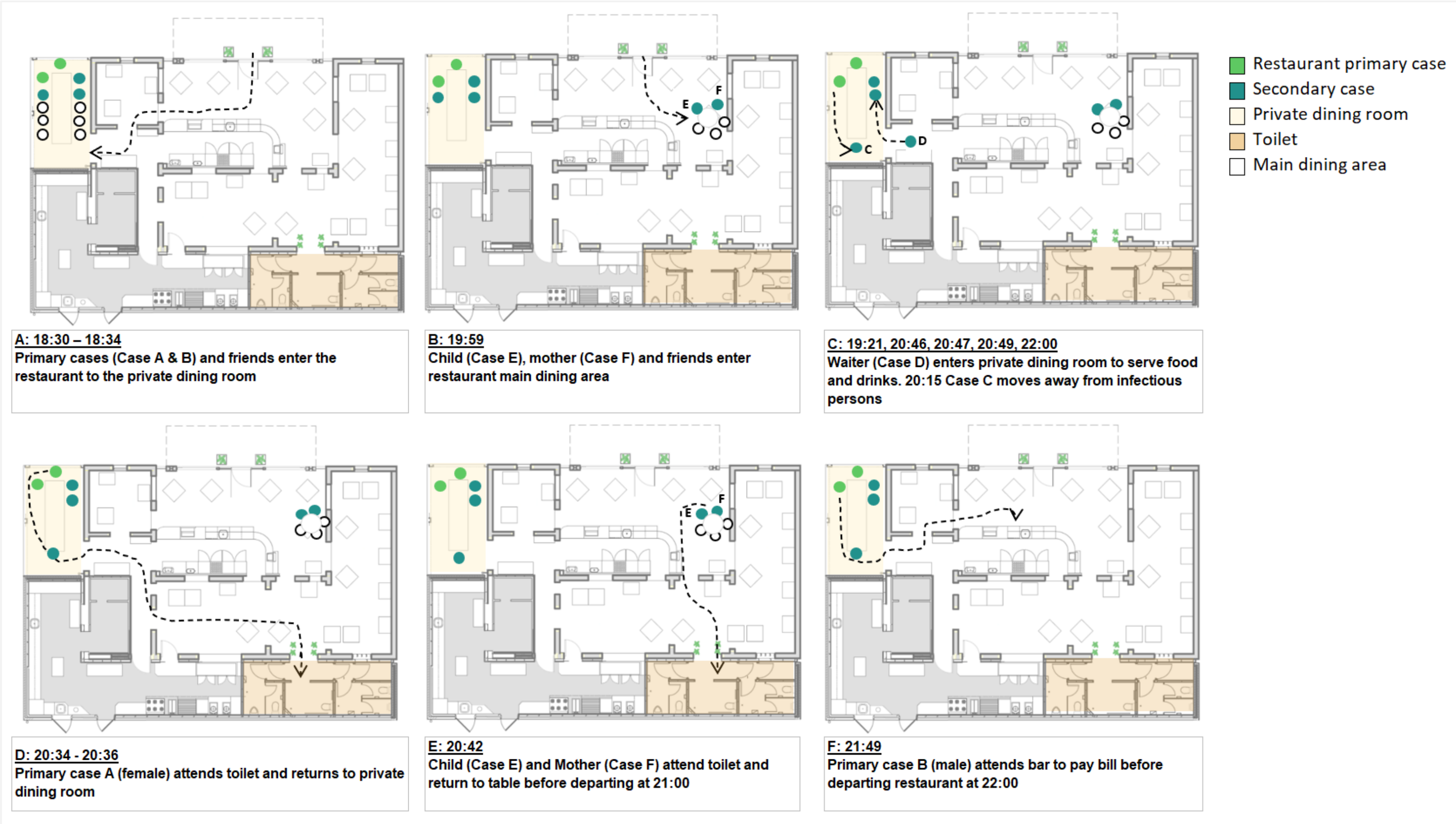
Case E, a female aged 0–5 years, and her mother, Case F, dined between 19:59–21:27 in the restaurant's main dining area (Figure 3, panel B). CCTV footage captured them seated at their table or walking within one metre of their allocated table (Case E). At 20:40, both the child (Case E) and mother (Case F) attended the bathroom six minutes after the female index case attended (Figure 3, panel E). It is not known if they used the same cubicle. However, case E and F had no further interaction with the two primary cases.

Nine close contacts met the face-to-face exposure definition, and three became secondary cases. The remaining close contacts (n=119) had no face-to-face exposure; however, two became cases. The attack rate for face-to-face exposure was 33.3% and 2.5% for those not exposed. The relative risk of becoming a COVID-19 case was 13.22 times higher (95% CI: 3.10–56.36; p = 0.004) among close contacts with face-to-face exposure (Table 3).

Table 3. Attack rates and relative risk of COVID-19 by exposure status, Restaurant X, South Australia, July 2021

Face-to-Face exposure			No Face-to-Face exposure			RR	*p*-value	95% CI
Cases	Non-cases	AR	Cases	Non-cases	AR			
3	6	33.3%	3	116	2.5%	13.22	0.004	3.10–56.36

Figure 3. Map and timepoints of interest, Restaurant X, South Australia, July 2021



Discussion

This study describes the first significant community transmission event of the SARS-CoV-2 Delta variant (B.1.617.2) in South Australia. Consistent with super-spreading events globally (19), the closed environment of the restaurant likely played a critical role in the transmission of SARS-CoV-2 (26). However, for unknown reasons, the attack rate in the private dining room is at the lower end of previously reported attack rates (range: 19.2–86.9%) of COVID-19 in indoor settings (18, 27-29).

While resource-intensive, a review of CCTV footage from the restaurant established exposure time and distance for all cases. Three secondary cases spent >one hour face-to-face with the two infectious persons, confirming that transmission likely occurred via infected respiratory droplets or aerosols, because of close and prolonged contact. The three secondary cases had minimal and no direct contact with the infected persons. For the mother and child, the most likely exposure occurred in the bathroom, where they were possibly exposed to infected bioaerosols following the departure of the infectious female. The female waiter did enter the private dining room several times; however, their exposure time was minimal and not face-to-face. Aerosol transmission of COVID-19 has previously been reported in a diverse range of indoor settings (19). Air samples contaminated with SARS-CoV-2 RNA in hospitals have been upto five meters from infectious patients, with particularly high viral loads detected in toilets (30); an faecal shedding of SARS-CoV-2 and faecal aerosol transmission via pipes in high-rise apartment buildings have also been documented (31). While biologically plausible, no other studies have demonstrated airborne transmission of COVID-19 within public toilets (32).

Although not a perfect measure, Ct values indicate cases were effectively isolated early in their infectious period. QR check-in possibly contributed to this, reducing the time between exposure, contact tracing and quarantine. At this event, the time delay between quarantining those who checked in and those who did not was only one day. In more significant outbreaks, the difference could be several days and be critical in swiftly quarantining large numbers of potentially infectious people, reducing exposure sites and preventing secondary transmission. While emerging evidence indicates digital contact tracing can positively impact the epidemiology of an outbreak (28), high levels of adoption are needed to ensure it is a valuable public health measure (33). Although a check-in system was in place for more than six months, within SA, compliance was low, with only 67% of people at the restaurant checking in. For future pandemics, the value and uptake of QR check-in should be evaluated, and alternative contact tracing methods considered. Regardless of the digital contact tracing method, effectiveness will need to be weighed carefully against the need to protect the privacy of individuals.

Transmission of SARS-CoV-2 by children in institutional care has been reported globally (34-37). However, consistent with earlier studies (34, 38), this investigation observed that a child attended childcare for one day while symptomatic and in their COVID-19 infectious period with no onward transmission. Factors contributing to this phenomenon could include lower viral loads seen in children (39) or interaction between SARS-CoV-2 and a second respiratory virus in the host, which is unknown in this study and not currently well understood (40). Furthermore, there have been reports of under-detection of COVID-19 infection in children tested by PCR (41, 42). It remains unclear whether Case F and Case H acquired their infection at the restaurant or during isolation with their infected family member. If transmission occurred at the restaurant, the incubation period for case F and Case H was six and ten days, respectively. If household transmission occurred, the incubation period for Case F and Case H was three and five days, respectively. Incubation periods related to household exposure for these cases are more consistent with the previously reported average Delta variant incubation period (6); however, without daily SARS-CoV-2 PCR testing, the true onset for these cases remains unknown. It is also possible that cases G and H were exposed during their time with the male primary case two days before the event.

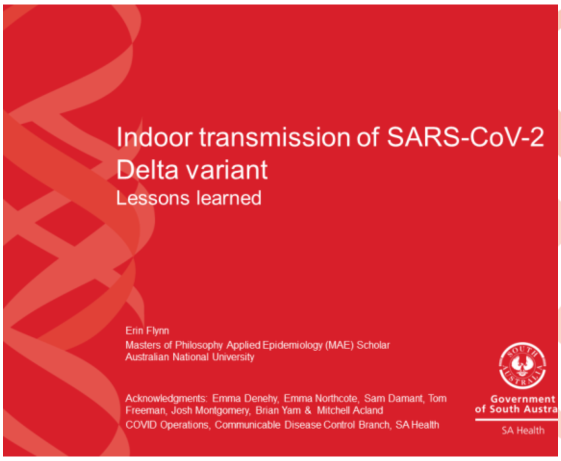
This outbreak occurred before sufficient COVID-19 vaccination coverage and the widespread adoption of face masks in South Australia. While it cannot be confirmed, both immunisation and mask-wearing may have played an essential role in reducing the number of cases from this event. Modelling (43, 44), observational studies, and a large-scale randomised controlled trial (45) indicate that masks worn in the community reduce COVID-19 transmission. Importantly, masks have been found to prevent illness in healthy persons and asymptomatic transmission (44). In addition, two doses of Comirnaty (Pfizer) or Vaxzevria (AstraZeneca) provide significant protection against Delta variant infections (46), hospitalisation (47) and death (48). In the absence of these two vital public health measures, rapid quarantine of close contacts and hotel quarantine of cases likely played a fundamental role in stopping onwards transmission in this outbreak.

Like most outbreak investigations, this study is subject to several limitations. Firstly, CCTV footage does not cover the entire period the two infectious persons were in the restaurant, making conclusions regarding the exposure of Case D at the end of the evening a challenge. Nor does it capture which toilet cubicle was used by the outbreak cases. Out of respect, no follow-up calls were made to confirm the toilet cubical used by the cases, making it difficult to validate the transmission theory. Secondly, close contacts did not undergo daily SARS-CoV-2 PCR testing making it challenging to interpret Ct values and viral loads. Finally, no ventilation studies were conducted, making it difficult to say whether ventilation may have played a role in the low attack rate.

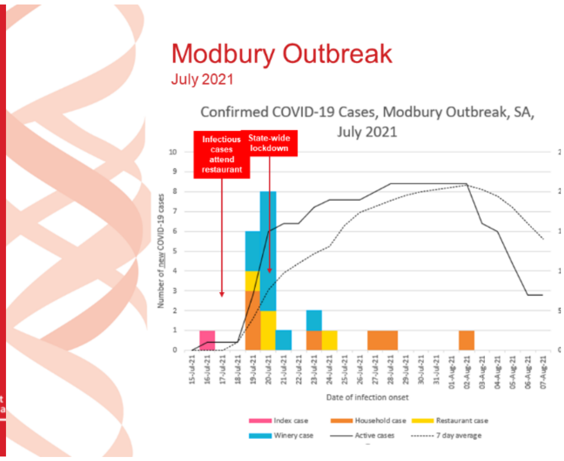
Conclusions

This study analysed an outbreak of COVID-19 in South Australia in 2021. It found evidence of airborne transmission of COVID-19, highlighting the the potential importance of mask use and adequate ventilation in reducing the burden of COVID-19 in a population. It also demonstrates the impact of rapid contact tracing and quarantine in suppressing a COVID-19 outbreak, and suggests that short of a statewide lockdown QR check-in data is likely a very efficient way to identify close contacts and direct them to quarantine. While QR check-in has become redundant in most Australian states for COVID-19, the emergence of a new VOC or pandemic disease may require the rapid deployment and effective use of QR check-in data by public health units. Lastly, this study demonstrated that although analysing CCTV footage can be a labour intensive method, the footage is a powerful source of information when determining the transmission dynamics of a novel respiratory virus.

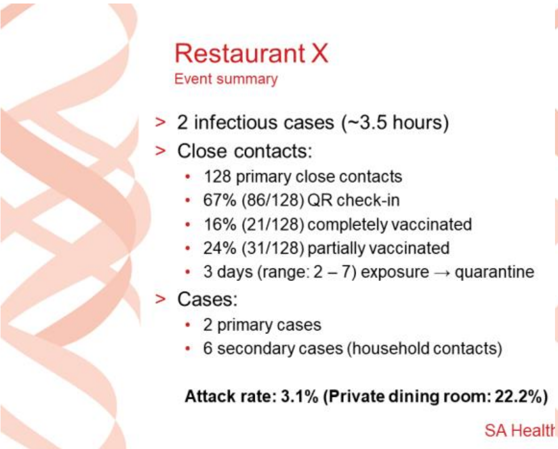
Appendix I: SA Branch 2021 State Population Health Conference presentation



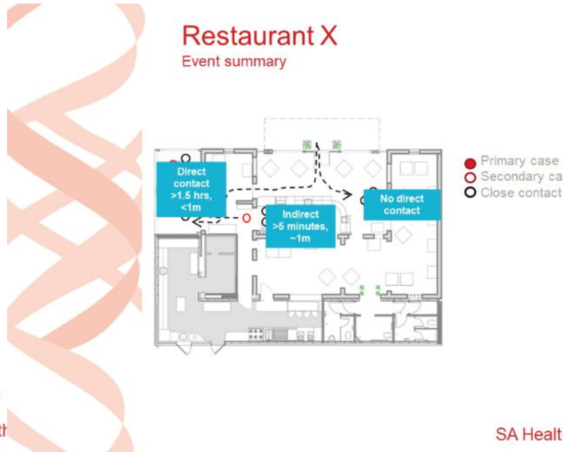
1



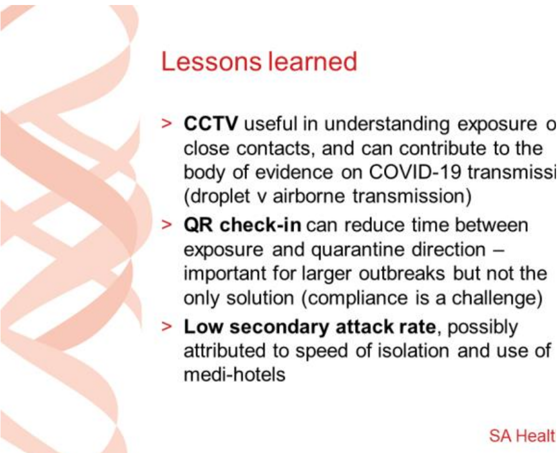
2



3



4



5

Appendix II: COVID-19 Timeline

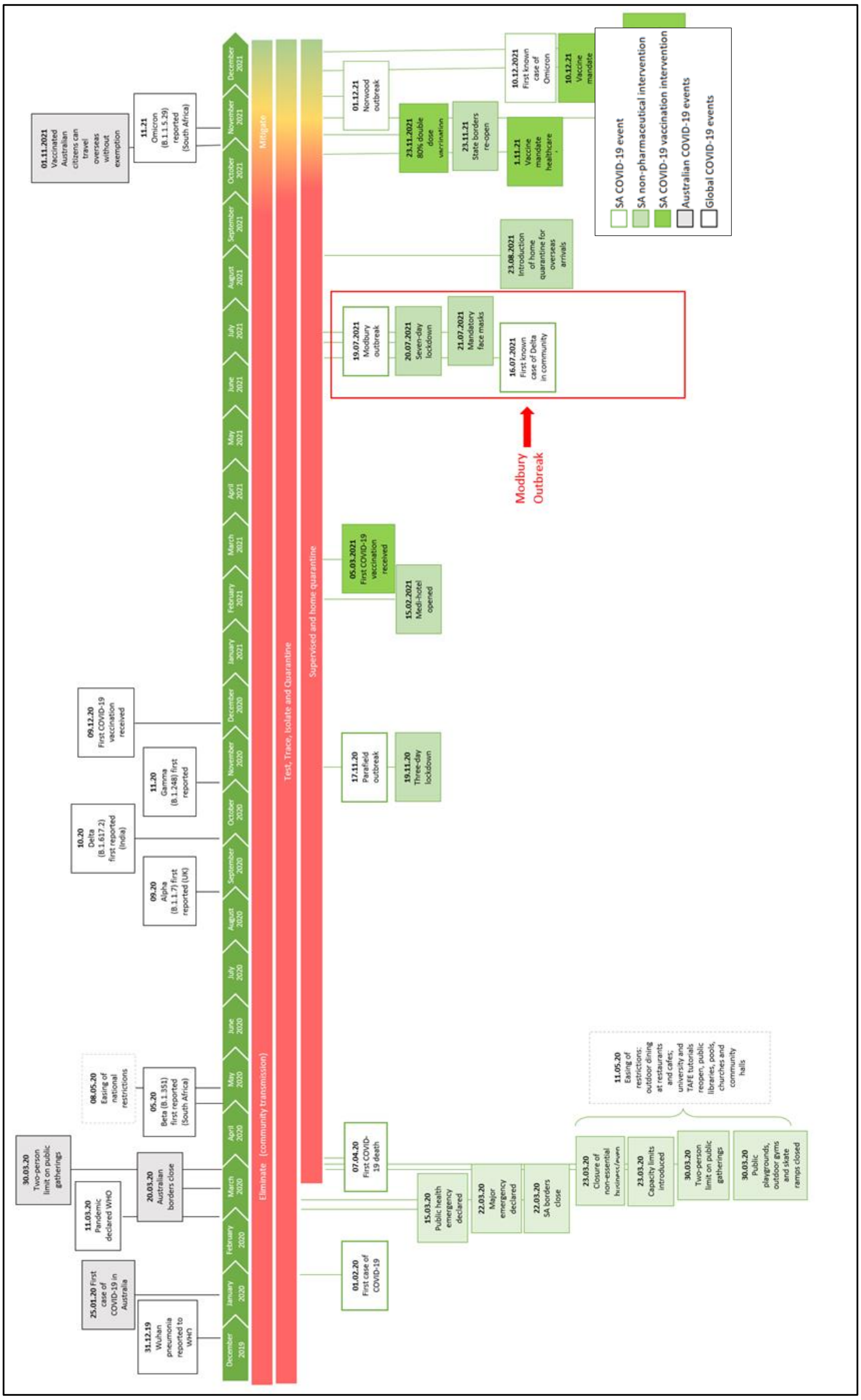


Figure 4. South Australian (SA) COVID-19 Timeline, December 2019 – December 2021

Appendix III: Summary of the Modbury COVID-19 outbreak

On 19 July 2021, the SA Health CDCB received a medical notification for a male aged >80 years old who tested positive for SARS-CoV-2 by PCR. The case and his daughter were returned travellers from Argentina, completed mandatory 14-day quarantine in Special Health Accommodation in Sydney from 23 June (Figure 5). Due to an unrelated medical condition, the male was transferred to the Royal Prince Alfred Hospital for care on 27 June 2021, until 8 July 2021. After testing negative on 6 July, the man and his daughter, aged 55–64 years, travelled by air on 8 July from Sydney to Adelaide, returning to their shared private residence. At 22.00 hours on 18 July, the >80 year old male presented to Modbury Hospital with respiratory symptoms and, on 19 July, tested positive for SARS-CoV-2 by PCR. His daughter and son-in-law (male aged 65–74 years) also tested positive by PCR on the same day. SA Pathology, via AusTrakka (the national integrated genomics platform), identified a genomic match with the index case and a COVID-19 case in NSW, and a SNP difference to 21 other NSW cases – genomic evidence that the outbreak index case acquired their infection in NSW.

Figure 5. Timeline COVID-19 index case and contacts, Modbury, July 2021

<table>
<tr><th></th><th>>80 y/o, Male</th><th>55–64y/o, Female</th><th>65–74y/o, Male</th></tr>
<tr><td>23-Jun</td><td colspan="2">Flight: Argentina → Sydney</td><td rowspan="6">Adelaide, SA</td></tr>
<tr><td>24-Jun</td><td rowspan="3">Hotel quarantine (Sydney, NSW)</td><td rowspan="4">Hotel quarantine (Sydney, NSW)</td></tr>
<tr><td>25-Jun</td></tr>
<tr><td>26-Jun</td></tr>
<tr><td>27-Jun to 7-Jul</td><td>Royal Prince Alfred Hospital (Sydney, NSW)</td></tr>
<tr><td>8-Jul</td><td colspan="2">Flight: Sydney → Adelaide</td></tr>
<tr><td>9-Jul</td><td colspan="3" rowspan="7">Living together at a private residence (not required to be in quarantine) (Adelaide, SA)</td></tr>
<tr><td>10-Jul</td></tr>
<tr><td>11-Jul</td></tr>
<tr><td>12-Jul</td></tr>
<tr><td>13-Jul</td></tr>
<tr><td>14-Jul</td></tr>
<tr><td>15-Jul</td></tr>
<tr><td>16-Jul</td><td>Symptom onset</td><td></td><td>Symptom onset</td></tr>
<tr><td>17-Jul</td><td></td><td></td><td></td></tr>
<tr><td>18-Jul</td><td>22.00: Modbury Hospital (Adelaide, SA)</td><td></td><td></td></tr>
<tr><td>19-Jul</td><td colspan="3">Test positive for SARS-CoV-2 by PCR</td></tr>
<tr><td>20-Jul</td><td>Isolation in hospital</td><td colspan="2">Isolation in medihotel</td></tr>
<tr><td>21-Jul</td><td colspan="3">18.00: State-wide lockdown</td></tr>
</table>

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