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Validation of a risk stratification tool for SARS-CoV-2 Delta community transmission in the Australian Capital Territory

Alexandra Marmor, Tze Vun Voo, Meru Sheel, Timothy Sloan-Gardner, Nevada Pingault

Abstract

During the SARS-CoV-2 Delta (B.1.617.2) variant outbreak, from August to October 2021 in the Australian Capital Territory (ACT), the number of new cases ‘in the community for part of their infectious period’ was publicly reported daily. We describe the stratification tool used during the outbreak to determine presumptive risk of community transmission from cases, and present the results of a contemporaneous validation of each case’s risk against their onward transmission detected by routine surveillance.

After case interview, epidemiologists identified the most likely source of infection for each new case and used the stratification tool to classify the case as either no, low, or high risk of community transmission. Each case notified between 12 August and 14 September 2021 was matched to its recipient case(s) to determine how well the tool predicted transmission risk. Household transmissions were excluded.

Of the 530 notified cases stratified, 159 (29.3%) were cases who transmitted to a recipient case. Of the 59 cases who were the source of community transmission, 66% (38/59) were undertaking high-risk activities not associated with permitted essential work at the time. Only six source cases stratified as low risk or no risk transmitted SARS-CoV-2 to those outside their own household.

The tool was essential in the rapid determination of community transmission risk in the ACT, and validation of the tool against detected onward transmission provided evidence for the effectiveness of public health restrictions. In the early stages of outbreaks of diseases for which transmissibility has not yet been established, the validation of such a stratification tool relies on high quality case investigation data, but may help to understand transmission dynamics and to inform interventions.

Keywords: COVID-19; SARS-CoV-2 Delta; Australian Capital Territory; transmission; risk stratification; epidemiology

Introduction

During the SARS-CoV-2 Delta (B.1.617.2) variant wave, from August to October 2021 in the Australian Capital Territory (ACT), Australia, the number of new cases was reported daily. A metric that was eagerly followed by the media—and was perceived as reflecting the community’s compliance with strict outbreak restrictions—was the proportion of these cases that were ‘in the community for part of their

infectious period’.¹ Although the ACT began implementing a coronavirus disease 2019 (COVID-19) vaccination program for residents aged ≥ 12 years in February 2021, at the start of the Delta wave only 50.2% and 26.5% of eligible residents had received one or two doses, respectively.² Therefore, stringent public health and social measures were implemented when the first locally-acquired case of the Delta

variant was identified on 12 August 2021³ until vaccination goals were met.⁴ These included restricting people in the ACT to their homes, except for five essential reasons (essential work; essential shopping; caregiving; seeking healthcare; and outdoor exercise), and requiring people aged 12 years and over to wear a mask when not at home.

We describe here the stratification system we used to indicate the presumptive risk of community transmission from a SARS-CoV-2 case, based on interview data and supplemented by genomic evidence. We present the results of a rapid analysis that validated each case's presumptive risk against their community transmission detected by our routine surveillance methods used at the time. We also describe the extent to which COVID-19 cases in high and low risk categories transmitted to others outside of their own homes, and describe the settings and conditions under which transmission occurred.

Methods

A SARS-CoV-2 case was defined as a person with a positive reverse transcription polymerase chain reaction (RT-PCR) test for SARS-CoV-2, or SARS-CoV-2 immunoglobulin G (IgG) seroconversion or a four-fold or greater increase in SARS-CoV-2 antibodies (in the absence of vaccination), who was isolating in the ACT. We defined a 'source case' as a case who likely transmitted SARS-CoV-2 infection to another case; and a 'recipient case' as any case with an identified likely source case.

Risk stratification

During the Delta wave, interviews by ACT Health case investigators were attempted with all SARS-CoV-2 cases, usually within 24 hours of notification, and using a standardised phone interview tool. Case data were collected and managed using REDCap (Research Electronic Data Capture) tools hosted at ACT Health.⁵ After case interview, a member of the ACT Health COVID-19 epidemiology team reviewed each record to identify, where possible, the likely setting where the exposure occurred (recorded as 'likely exposure setting') and the source of their infection (recorded as 'likely source case ID', which was the same as the source's unique record identifier). Cases were also stratified according to their risk of transmission outside their own household, using the categories shown in Table 1. Cases stratified as high and low risk by 8:00 pm on the day of notification were publicly reported the following day as being new

cases who were 'in the community for part of their infectious period'.

Likely exposure setting, likely source case ID and risk stratification were updated if subsequent case interviews revealed further information about the case's movements, or if genomic data clarified likely transmission. Routine genomic sequencing of SARS-CoV-2 specimens and phylogenetic analysis during the Delta wave is described by Hall et al.⁶ Each specimen sequence was assigned to a local genomic lineage, which was used to help discern the likely source case if interview data indicated there was more than one possible source.

Validation

In late September 2021, while the outbreak was ongoing, we undertook a rapid validation of the risk stratification tool to determine whether the predicted community transmission risk was reflected in the actual transmissions from each case, as detected by our routine surveillance in place at the time. This was achieved by examining records for all SARS-CoV-2 cases notified to the ACT Health Directorate between 12 August and 14 September 2021. An algorithm was developed using the R programming language. The algorithm matched the recipient case data and source case data using the source's unique record identifier and the likely source case ID variables, and the combined dataset was then used for analysis. Household transmissions (ie where the likely exposure setting was the recipient's own household) were then removed to help us to identify the extent to which cases in high- and low-risk categories transmitted the virus to individuals outside of their own homes, as well as the settings and conditions under which transmission occurred. We calculated frequencies of source cases who transmitted in each exposure setting and the number of recipient cases for each source case, by transmission risk stratification, using Excel.

For source cases stratified as no risk, low risk or high risk (essential work-related), we then examined case interview data to characterise the exposure setting and interaction between each source-recipient dyad. Exposures to source cases who were stratified as high risk because their infectious period began before outbreak restrictions, or because their activities were not associated with essential work (high risk - others), were not included in this part of the validation analysis.

Ethics approval was not sought for this project as it was conducted under the auspices of public health legislation.⁷

Table 1: Community transmission risk stratification and type of activities undertaken during infectious period, ACT Delta wave

Risk stratum ^a	Category	Type of activities undertaken during infectious period
High risk	Essential work-related	essential work in the community interacting with people with or without a mask; essential school or childcare attendance with or without a mask; case had a reason for not wearing a mask while in the community (aged < 12 years or otherwise exempt)
	Other	any activities before 13 August 2021 (pre-lockdown); mixing socially with others inside or outside their home for extended periods with a mask, or for short periods without a mask
Low risk	—	short essential trips out of the home while masked; work out of the home with limited interaction with others while masked
No risk	—	in quarantine/isolation for the entirety of infectious period
Undetermined risk	—	case or guardian not yet interviewed, or could not be interviewed

a Both high- and low-risk cases were reported as ‘in the community for part of their infectious period’.

Results

There were 542 cases notified to ACT Health between 12 August and 14 September 2021, of which 530 had been assigned as high, low or no risk using the stratification tool by 15 September. Transmission risk was unable to be determined for 12 cases. Of the notified cases, 159 (29.3%) were source cases who were determined to have transmitted to at least one recipient case, resulting in 431 incidences of transmission (Table 2). The median number of recipient cases for each source case was two (range: 0–15 recipient cases); 15% of cases ($n = 84$) were responsible for 80% of transmissions ($n = 345$). There was no transmission detected in health care, residential aged care, or correctional facilities during the study period. In 29% of transmission events (125/431), the source case transmitted to a recipient case who was not a member of the source’s household (community transmission, Table 2).

Most source cases (100/159; 63%) did not transmit to any other cases outside of their own household (Figure 1). Two thirds of cases who were the source of community transmission (66%; 38/59 source cases) were undertaking high-risk activities not associated with essential work. This includes all the source cases who transmitted to five or more others, and was largely due to social activity. Only six source cases who were stratified as low risk or no risk transmitted to anyone outside of their own household.

There was a total of 29 instances of community transmission from source cases stratified as no risk, low risk or high risk (essential work-related). A summary of the circumstances surrounding each of these is shown in Table 3.

Table 2: Incidences of transmission where a source case could be identified, by risk of community transmission of the source case and setting of onward transmission, ACT SARS-CoV-2 Delta outbreak, 12 August – 14 September 2021

Likely exposure setting of recipient case	Transmission risk of source case					Total n
	High risk Essential work-related n	High risk Others n	Low risk n	No risk n	Undetermined risk n	
Own household	70	135	50	47	4	306
Educational facility	7	15	0	0	0	22
Other workplace	7	13	1	0	0	21
Military facility	2	0	0	0	0	2
Disability residential care	2	4	0	0	0	6
Travel	1	1	1	1	0	4
Other	2	53	3	1	1	60
No likely exposure setting identified	0	1	0	0	0	1
Unknown	0	7	1	0	1	9
Total	91	229	56	49	6	431

Figure 1: Distribution of source cases by risk of community transmission, ACT Delta outbreak, 12 August – 14 September 2021

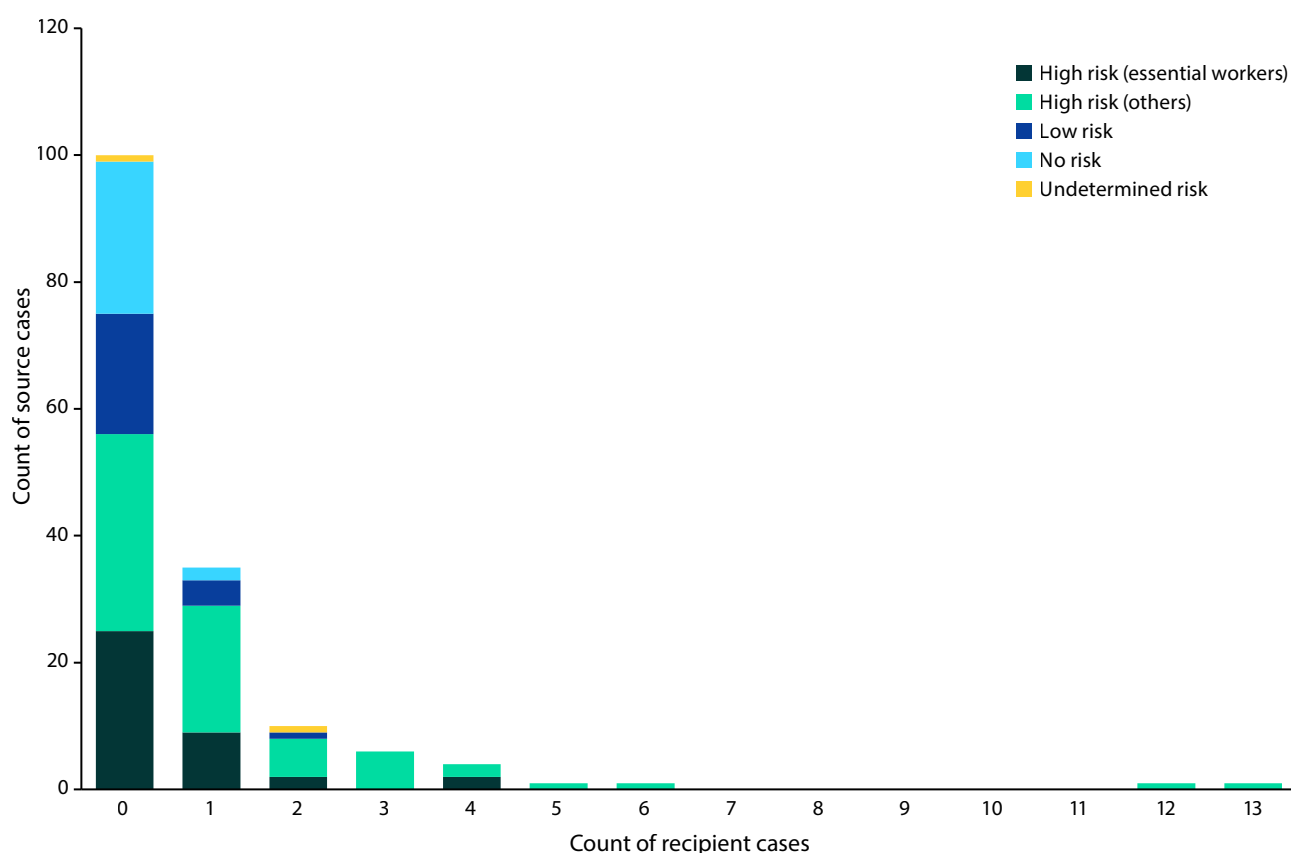


Table 3: Summary of circumstances surrounding community transmission, by risk stratum of the source case, ACT Delta outbreak, 12 August – 14 September 2021

Risk stratum		Source-recipient dyads (n)	Circumstances surrounding transmission or risk category assignment
Category	Total		
No risk	2	2	The most likely transmission event occurred before the source case's recorded infectious period. Discrepancy may be due to uncertainty regarding onset date
Low risk	6	5	At initial interview the source case did not report high risk movements that were identified during later interviews (visiting others in their homes; working). This includes one case who transmitted to a rideshare driver on the way to visiting someone else in their home
		1	Stepsiblings whose household arrangement could reasonably be classified as sharing a household
High risk (essential work-related)	21	7	Transmission between educators, children and parents associated with an early childhood education and care centre
		4	Transmission between disability care workers and clients in clients' homes
		4	Transmission between colleagues in restaurant kitchens
		2	Transmission between essential construction workers
		1	Transmission between colleagues working at a community pharmacy
		1	Transmission between driver and a passenger in a rideshare
		1	An essential care visit to the recipient's home
		1	Recipient and source were adult daughter and mother who interacted socially at the mother's workplace

Discussion and conclusion

We developed a simple COVID-19 community transmission risk stratification tool for use in the early stages of an outbreak of a variant for which transmissibility was uncertain. In the ACT, application of this tool was critical in the rapid identification and reporting of the risk for ongoing community transmission. Validation of the tool against actual onward transmission provided evidence in support of the effectiveness of the public health and social measures in place. The validation results supported the ongoing use of masks while other restrictions were gradually eased from mid-October 2021.

We found that COVID-19 cases of the Delta variant of SARS-CoV-2 stratified as low risk, when undertaking only essential shopping trips or outdoor exercise while masked, presented no risk of community transmission during the period under study. Transmission identified as being from sources stratified as high risk (essential work-related) occurred mostly between colleagues or involved people who were not required to wear masks.

These findings suggest that the public health and social measures in place during the first five weeks of the Delta outbreak were largely effective, and that most community transmission was due to social activities that contravened the public health directions. Validation of our stratification for risk of transmission was helpful in providing evidence of the effectiveness of mask wearing, and informed the staged lifting of restrictions in the ACT from October 2021. By this time, the proportion of residents aged ≥ 12 years who had received two vaccine doses exceeded 80%.² The work of Hall and others⁶ has shown that, despite the community transmission that did occur, the incidence of the SARS-CoV-2 genomic lineage responsible for transmission during the first stage of the outbreak was waning by the end of the study period, and after another four weeks was no longer detected in the ACT.

A key feature of the essential work-related settings where transmission occurred was mask usage. Masks were not worn by any of the children in early childhood education and care centres⁸ or by the disability care clients;⁹ and masks were removed for eating by colleagues who shared a lunchroom, and by restaurant workers who tasted food as they cooked. Work in disability and early childhood care also involved close contact between source and recipient cases. Although there was no transmission detected in healthcare, residential aged care, or correctional settings during the study period, some transmission incidents were detected in these settings during later stages of the Delta outbreak. Notable is the absence in the ACT of some high-transmission essential work settings such as meat processing facilities,¹⁰ which may have reduced the likelihood of community transmission.

In our study, more than two thirds of SARS-CoV-2 cases did not transmit to anyone in any setting, while 15% of cases were responsible for around 80% of transmissions. This is similar to overdispersion estimates from larger studies for the early stages of the COVID-19 pandemic in Hong Kong¹¹ and Indonesia,¹² but is lower than an estimate for Denmark during the Delta wave (10% of cases responsible for 70–87% of transmission).¹³

This study had some limitations. We were not able to control for factors related to the source or recipient cases that may have affected transmissibility, such as viral load or vaccination status. The definitions for some risk strata were open to interpretation (eg the extent of a ‘short period’), which could have led to inconsistencies in stratification. A source case could not be identified for 161 of the cases (27.2%) notified during the period. Therefore, there may be some source cases included in the validation analysis who transmitted to more recipients than could be detected by our systems. Similarly, it is likely that recipient cases were not detected or included in the analysis because they did not present for testing or they were tested in another jurisdiction. Implementation and validation of the risk stratification tool was only feasible because we had high quality data obtained through intensive case investigation by highly trained interviewers. This exhaustive case follow up was only possible during the low-incidence phase of the outbreak. Timely genomic data was very helpful in identifying likely source cases, but may not be available in all outbreaks.

We developed a tool to stratify cases according to a defined system of community transmission risk that reflected contemporaneous public health and social measures and that can be easily understood by the public. In the early stages of outbreaks of diseases for which the mode and ease of transmission has not yet been established, and where intensive case investigation is supported, the validation of such a stratification may be useful to understand transmission dynamics and inform interventions.

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