



# Assessment of COVID-19 Positive Rates Amongst COVID-19 Close Contacts Through the Health Risk Warning System

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## Abstract

From 6 Jan 22 to 17 Feb 22, a total of 729,367 close contacts classified into four distinct groups (i.e., household, social, school and nursing/ welfare home contacts) were managed by the Health Risk Warning system. High COVID-19-positive rates were demonstrated amongst household contacts, i.e., 10.9% (37,220/342,302) were detected via antigen rapid test kits and 56.5% (4,952/8,767) were detected via polymerase chain reaction testing. Household contacts represent the highest risk of being infected by virtue of the sustained close-proximity interactions in the household setting. Social, school and nursing/ welfare home contacts continue to remain at-risk groups for close monitoring. At a population level, household and symptomatic close contacts should be the groups of focus in the early phases of the pandemic, including future potential waves involving COVID-19 variants of concern.

**Keywords** COVID-19 · Close contact · Pandemic management · Digitalisation · Electronic system

## Background of the health risk warning (HRW) system

Singapore reported the first local case of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection on 23 Jan 20. Since then, a spectrum of non-pharmaceutical interventions had been instituted to reduce community spread [1]. Central to this was rigorous tracing and management of close contacts. As the pandemic evolved, there was a need to balance the disruption to people's lives arising from such public health measures aimed at limiting virus transmission against the impact on the nation's healthcare system. The HRW system represented an amalgamation of close contact notification and test-based management in pursuing a risk-balanced and sustainable approach to handling individuals with a risk of COVID-19 infection.

There were five key components constituting the HRW system which were monitored and tracked (see Fig. 1):

1. A Short Message Service (SMS) notification was sent to identified close contacts to remind them of their status as persons issued with Health Risk Warning (pHRW) for which they were to self-isolate at their place of residence until their initial ART returned negative.
2. pHRWs were required to acknowledge their status via a link provided within the SMS notification.
3. Six Antigen Rapid Test (ART) kits were made available to pHRWs through vending machines situated at accessible island-wide locations to facilitate test-based management.
4. pHRW were required to submit an "entry" ART result within 24 hours of receipt of the SMS notification.
5. pHRWs were required to test themselves daily thereafter and notify the authorities whenever they obtain a positive ART result, or of the negative "exit" ART result at the end of the isolation period.

From 11 Oct 21 to 17 Feb 22, Singapore's Ministry of Health managed more than 1 million pHRWs and successfully mitigated the extent of surges during both the Delta and Omicron waves of the COVID-19 pandemic. This paper aims to analyse and report ART- and Polymerase Chain Reaction- (PCR-) positive rates for COVID-19 amongst four distinct groups of close contacts:

1. Household contacts electronically declared by the COVID-19 positive cases themselves [2].

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**Fig. 1** Health risk warning workflow for close contacts of a COVID-19 positive case



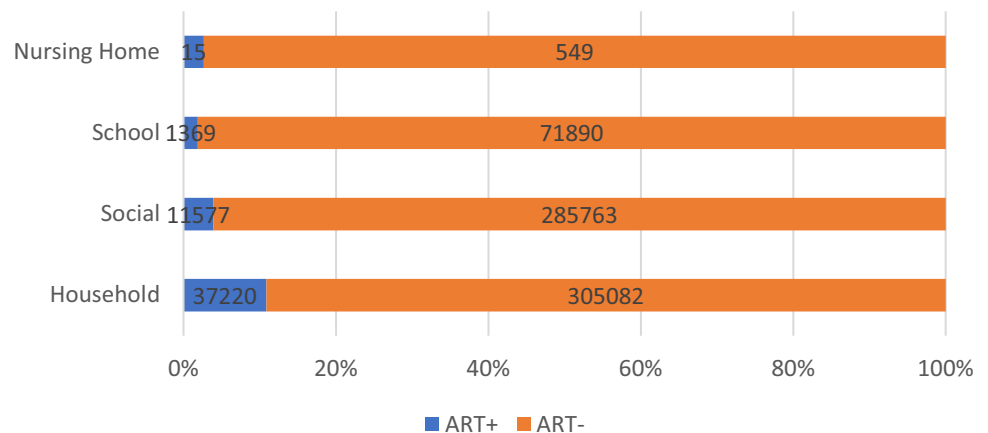
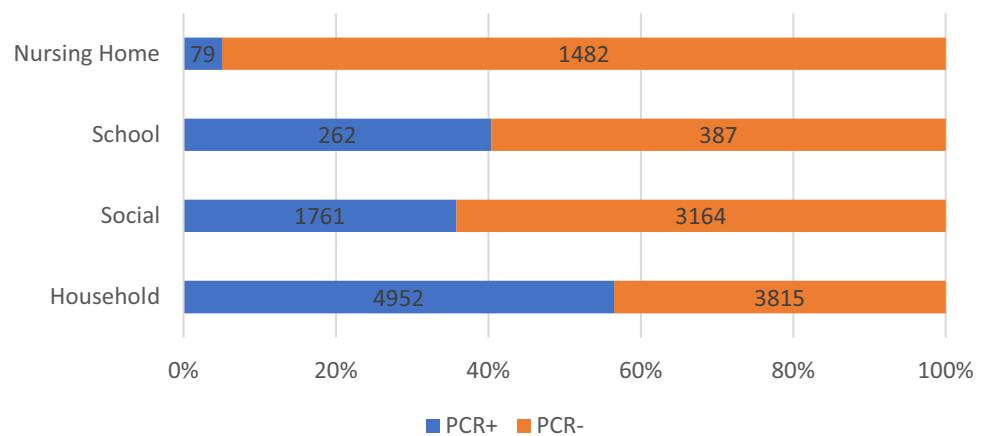
2. Social contacts identified by the TraceTogether system [3] through Bluetooth technology-enabled exchange of anonymised proximity information.
3. Close contacts identified and declared by schools.
4. Close contacts identified and declared by nursing and welfare homes.

**Table 1** Breakdown of ART-positive (ART+) and ART-negative (ART-) results by groups

	Household (%)	Social (%)	School (%)	Nursing/ Welfare Home (%)	Total (%)
<b>ART+</b>	37,220 (10.9)	11,577 (3.9)	1,369 (1.9)	15 (2.7)	<b>50,181</b> (7.0)
<b>ART-</b>	305,082 (89.1)	285,763 (96.1)	71,890 (98.1)	549 (97.3)	<b>663,284</b> (93.0)
<b>Total ART</b>	<b>342,302</b>	<b>297,340</b>	<b>73,259</b>	<b>564</b>	<b>713,465</b>

**Table 2** Breakdown of PCR-positive (PCR+) and PCR-negative (PCR-) results by groups

	Household (%)	Social (%)	School (%)	Nursing/ Welfare Home (%)	Total (%)
<b>PCR+</b>	4,952 (56.5)	1,761 (35.8)	262 (40.4)	79 (5.1)	<b>7,054</b> (44.4)
<b>PCR-</b>	3,815 (43.5)	3,164 (64.2)	387 (59.6)	1,482 (94.9)	<b>8,848</b> (55.6)
<b>Total ART</b>	<b>8,767</b>	<b>4,925</b>	<b>649</b>	<b>1,561</b>	<b>15,902</b>

**Fig. 2** Charts of ART- and PCR-positive (ART+/PCR+) and ART- and PCR-negative (ART-/PCR-) results by groups**Chart of ART-positive (ART+) and ART-negative (ART-) Results by Groups****Chart of PCR-positive (PCR+) and PCR-negative (PCR-) Results by Groups**

A mandatory PCR test was conducted if pHRWs were or became symptomatic and required medical attention from between November 2021 to January 2022. From 6 Jan 22 [4], the mandatory PCR test requirement was removed, and ART-positive results were accepted for the provision of medical care in the outpatient setting.

## COVID-19 positive rates amongst COVID-19 close contacts through the health risk warning system

From 6 Jan 22, after Protocol 2 (Primary Care) was first introduced to manage COVID-19-positive patients in an outpatient setting, to 17 Feb 22, before the HRW notification was modified to a Health Risk Notice (HRN) advisory on 18 Feb 22 [5], a total of 729,367 close contacts from the four groups described above who underwent an ART or PCR test were managed under the HRW system (see Tables 1 and 2 and Fig. 2). High COVID-19-positive rates were demonstrated amongst household contacts, i.e., 10.9% (37,220/342,302) were detected via ART kits and 56.5% (4,952/8,767) were detected via PCR testing.

ART-positive results were associated with grouping (Pearson's  $\chi^2$  test of independence;  $p < 0.05$ ). There was a significant difference in ART-positive results between all groups except between social and nursing/ welfare home contacts ( $p = 0.13$ ), and school and nursing/ welfare home contacts ( $p = 0.17$ ).

PCR-positive results were associated with grouping (Pearson's  $\chi^2$  test of independence;  $p < 0.05$ ). There was a significant difference in PCR-positive results between all groups.

## Discussion

The HRW system leveraged an increasing sense of social responsibility amongst the Singaporean population, coupled with their ability to receive and submit results electronically, to mitigate virus transmission at the population level. This was largely successful, with only <2% requiring assistance from public officers and <3% needing additional reminders.

The public were also able to collect a total of 2.5 million kits from vending machines, with 95% submitting ART results uneventfully. The successful implementation of the HRW system highlights that the public would be able to comply and accept an electronic system, and this can continue to be an effective close contact management system for future pandemics of similar characteristics.

The high COVID-19-positive rates amongst household contacts is testament to the fact that this group represents

the highest risk of being infected by virtue of the sustained close-proximity interactions in the household setting. Social, school and nursing/ welfare home contacts continue to remain at-risk groups for close monitoring. If symptoms are present and a PCR test is performed, the risk of infection has been demonstrated to be much higher, contributed in part by both the higher pre-test probability and better sensitivity of the PCR test. As such, household and symptomatic close contacts should be the populations of focus in the early phases of the pandemic, including future potential waves involving COVID-19 variants of concern.

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**Data availability** All data supporting the findings of this analysis are available within the paper.

## Declarations

**Ethical approval** Not Applicable.

**Conflict of interest** The authors have no relevant financial or non-financial interests to disclose

## References

1. Tan JB, Cook MJ, Logan P, Rozanova L, Wilder-Smith A. Singapore's Pandemic Preparedness: An Overview of the First Wave of COVID-19. *Int J Environ Res Public Health*. 2020 Dec 31;18(1):252.
2. Ministry of Health, Singapore. (2021). News Highlights – “Updating our Healthcare Protocols for a More COVID-19 Resilient Nation” dated 14 Sep 2021. Available from <https://www.moh.gov.sg/news-highlights/details/updates-our-healthcare-protocols-for-a-more-covid-19-resilient-nation>. [Last accessed on 3 Oct 2022].
3. TraceTogether Programme. (2021). “How does TraceTogether work?” Available from <https://support.tracetogogether.gov.sg/hc/en-sg/articles/360043543473-How-does-TraceTogether-work>. [Last accessed on 3 Oct 2022].
4. Ministry of Health, Singapore. (2022). Circular – “Update on the Management of COVID-19 with Protocol 2 (Primary Care)” dated 6 Jan 2022. Available from <https://www.cfps.org.sg/assets/1-Circular-for-GPs/10-UpdateontheManagementofCovid19withProtocol2PrimaryCare-C-04-2022-1.pdf>. [Last accessed on 3 Oct 2022].
5. Ministry of Health, Singapore. (2022). News Highlights – “Resetting our Measures to Live with the Omicron Variant” dated 16 Feb 2022. Available from <https://www.moh.gov.sg/news-highlights/details/resetting-our-measures-to-live-with-the-omicron-variant-16Feb2022>. [Last accessed on 3 Oct 2022].

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