Remote patient monitoring for managing acute COVID-19, and mortality and hospital use in Sydney, New South Wales, 2021–22: a retrospective observational cohort study

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The known: The COVID-19 pandemic increased the burden on health care systems. The effect of community remote patient monitoring for managing acute COVID-19 on hospital use and patient outcomes has not been examined in Australia.

The new: Remote monitoring of people with COVID-19, based on a smartphone application, clinical portal, and phone calls from clinicians, was associated with increased numbers of hospitalisations, but also with shorter mean length of stay and lower risk of death within 28 days of clinical onset.

The implications: Community remote monitoring of people with acute COVID-19 is feasible and safe, and could also be used for managing other medical conditions.

Abstract

Objectives: To evaluate the influence of remote patient monitoring (RPM) for managing people with acute coronavirus disease 2019 (COVID-19) on 28-day mortality and hospital use in Australia.

Study design: Retrospective observational cohort study; analysis of deterministically linked NSW Notifiable Conditions Information Management System and hospital, emergency department, and non-admitted patient data.

Setting, participants: South Eastern Sydney Local Health District catchment area residents aged 15 years or older for whom positive severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) test results (polymerase chain reaction or rapid antigen testing) during 26 November 2021 – 30 June 2022 were recorded.

Main outcome measures: Primary outcome: All-cause mortality within 28 days of positive SARS-CoV-2 test result. Secondary outcomes: Hospital length of stay, and numbers of emergency department presentations, hospital admissions, and intensive care unit admissions within 14 days of positive test results. All analyses were undertaken for the unadjusted data (original cohort analysis) and after propensity score matching and inverse probability treatment weighting.

Results: Of 276 236 people aged 15 years or older with positive SARS-CoV-2 test results and complete demographic information, 4399 (1.6%) participated in RPM. Twenty-eight-day mortality was lower for the RPM group than the usual care group (propensity score-matched: adjusted odds ratio [aOR], 0.19; 95% confidence interval [CI], 0.08–0.43; inverse probability treatment-weighted: aOR, 0.21; 95% CI, 0.10–0.46). The 14-day likelihood of intensive care unit admission and emergency department presentation was similar for both groups; the likelihood of hospital admission was higher for the RPM group (propensity score-matched: aOR, 1.42; 95% CI, 1.12–1.78; inverse probability treatment-weighted: aOR, 1.51; 95% CI, 1.28–1.78), but the mean hospital length of stay was shorter (adjusted mean difference, original cohort: –2.01 [95% CI, –2.81 to –1.21] days; propensity score-matched: –3.54 [95% CI, –6.39 to –0.69] days; inverse probability treatment-weighted: –3.26 [95% CI, –6.01 to –0.50] days).

Conclusion: RPM was associated with greater 14-day likelihood of hospital admission, but also with shorter mean length of stay and lower 28-day mortality, which may indicate that clinical deterioration was detected and treated earlier than with usual care. The benefit of RPM for managing other acute health conditions in the community, particularly infectious diseases, should be examined.

The coronavirus disease 2019 (COVID-19) pandemic, caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), reached Australia somewhat later than other countries.[1] Clinical phenotypes ranged from asymptomatic and mild disease to fatal pneumonitis.[2] In New South Wales, the waves of SARS-CoV-2 variants can be characterised as pre-Delta (1 January 2020 – 15 June 2021), predominantly Delta (16 June 2021 – 14 December 2021), and predominantly Omicron (since 15 December 2021).[1]

In-person consultations are the mainstay of health care in Australia. In some countries, the COVID-19 pandemic led to the rapid implementation of new models of remote care, including telehealth monitoring.[3,4] Telehealth services were introduced to manage COVID-19 more safely in the community, reduce the numbers of emergency department presentations and hospital admissions, and minimise the associated infection transmission risk to health care workers and other people. Remote patient monitoring (RPM) was used during the first three COVID-19 waves in Australia.[5]

In NSW, the South Eastern Sydney Local Health District (SESLHD) employed a care model for managing SARS-CoV-2-positive people isolating at home. A preliminary study found that clinicians reviewing people in phone consultations, without monitoring vital signs, was effective and safe during the pre-Delta period.[6] At about the same time, an RPM trial for people discharged home after hospital admissions with cardiac conditions, based on a smartphone application (TeleClinical Care app) and clinician portal, was associated with clinical benefits.[7] The TeleClinical Care service allowed people to submit pulse, blood pressure, weight, and symptom-related data to a centralised clinical monitoring team. The TeleClinical Care team and the SESLHD infectious diseases team collaborated to adapt the TeleClinical Care system for remote monitoring of

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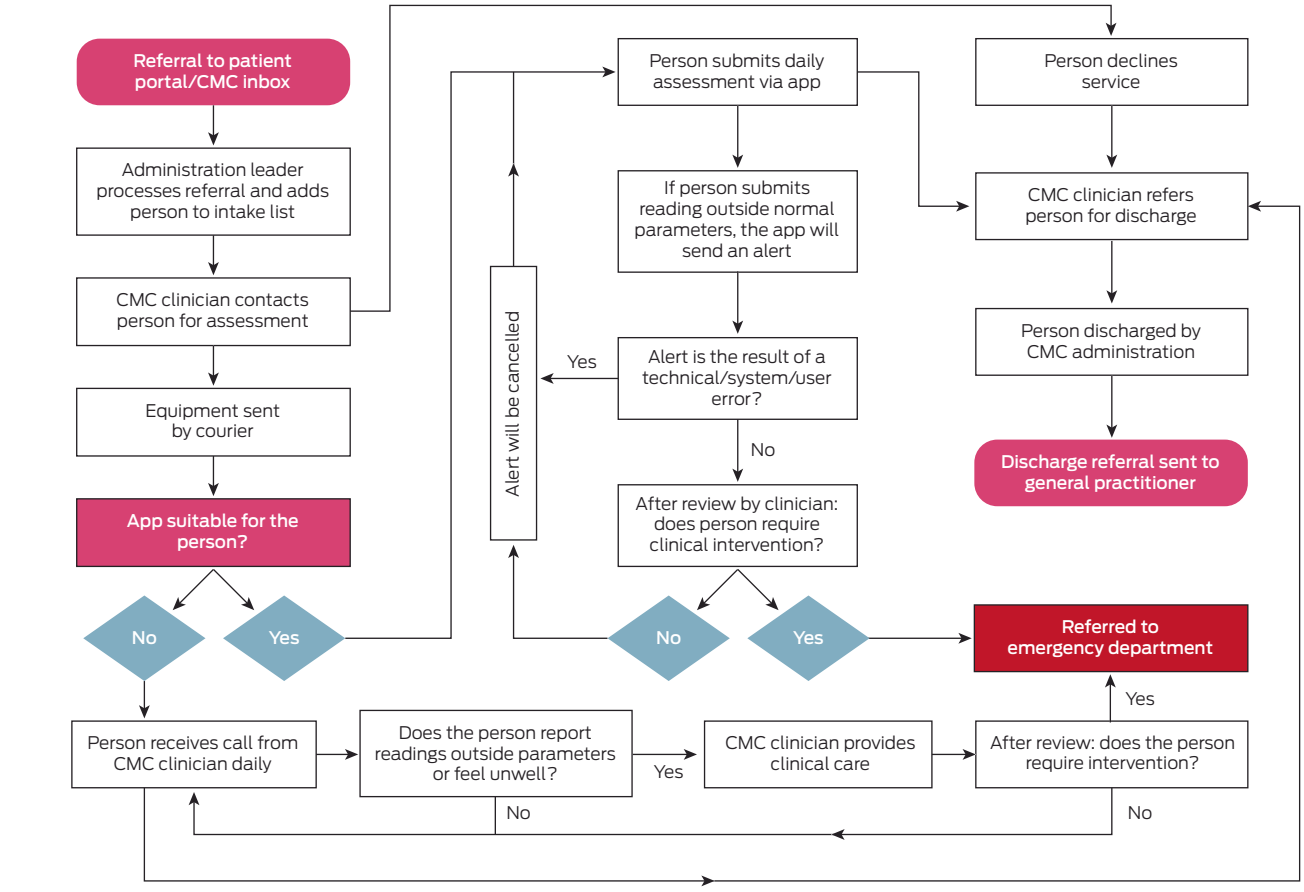
1 The South Eastern Sydney Local Health District COVID-19 remote patient monitoring (RPM) service algorithm



CMC = community management centre; COVID-19 = coronavirus disease 2019.

people with COVID-19 (the TCC-COVID system) (Supporting Information, parts 1 and 2).

High patient and staff satisfaction with telehealth services has been reported, and no differences in morbidity or mortality among people with chronic diseases.[8,9] Virtual health care services for managing people with acute COVID-19 in high income countries have been described,[10,11] but no reported studies have examined mortality and safety outcomes or described services in Australia. We therefore evaluated the influence of RPM for managing people with acute COVID-19 on 28-day mortality and hospital use in the SESLHD during the Omicron wave (26 November 2021 – 30 June 2022), by which point remote care for people with COVID-19 in NSW had moved to an opt-in model.

Methods

We undertook a retrospective observational cohort study of all people residing in the SESLHD catchment area (468 km^2, 970 000 residents) diagnosed with COVID-19 during 26 November 2021 – 30 June 2022. The SESLHD Public Health Unit extracted COVID-19 case data from the NSW Notifiable Conditions Information Management System. RPM data was extracted from the TCC-COVID database; hospital, emergency department, and non-admitted patient data were extracted from local administrative data sources. Deterministic data linkage used combinations of personal identifiers, including first name, last name, sex, date of birth, postcode, and local medical record numbers, to facilitate complete matching across data sources.

In the SESLHD, two tertiary hospitals (Prince of Wales, St George) and one major metropolitan hospital (Sutherland) provided most COVID-19 care during the study period. We included all people aged fifteen years or older living in the SESLHD for whom positive SARS-CoV-2 test results (polymerase chain reaction or rapid antigen testing) during 26 November 2021 – 30 June 2022 were recorded in the NSW Notifiable Conditions Information Management System. People were categorised as receiving RPM if they were monitored with the TCC-COVID app or by clinician phone calls, and blood oxygen saturation (using a pulse oximeter) and symptom data were collected in their homes.

Remote patient monitoring

SARS-CoV-2-positive people were referred to the community management centre after completing an online survey sent by the New South Wales Ministry of Health. People who reported health concerns and opted into care were allocated to SESLHD on the Patient Flow Portal and were assessed by the clinical team to determine their risk of clinical deterioration or hospitalisation (Box 1). Following the initial assessment, people were triaged as being at low, moderate, high, or very high risk of clinical deterioration or hospitalisation (Supporting Information, part 3). People at low risk were given information about self-management at home and about whom to contact in the event of deterioration, and were discharged from the community management centre. People at moderate risk remained in the care of the team and

2 Characteristics of South Eastern Sydney Local Health District residents with COVID-19, by treatment group: unadjusted and after propensity score matching or inverse probability treatment weighting

			Weighted cohorts			
	Original cohort		Propensity score-matched		Inverse probability treatment-weighted	
Characteristic	Standard care	Remote monitoring	Standard care	Remote monitoring	Standard care	Remote monitoring
All people	271 837	4399	4385	4385	4419	4399
Age group (years)						
15–24	46 980 (17.3%)	320 (7.3%)	321 (7.3%)	320 (7.3%)	320 (7.2%)	320 (7.3%)
25–34	70 615 (26.0%)	636 (14.5%)	628 (14.3%)	636 (14.5%)	635 (14.4%)	636 (14.5%)
35–44	55 925 (20.6%)	591 (13.4%)	594 (13.5%)	590 (13.5%)	589 (13.3%)	591 (13.4%)
45–54	41 674 (15.3%)	562 (12.8%)	560 (12.8%)	561 (12.8%)	560 (12.7%)	562 (12.8%)
55–64	28 283 (10.4%)	597 (13.6%)	592 (13.5%)	593 (13.5%)	597 (13.5%)	597 (13.6%)
65–74	16 302 (6.0%)	777 (17.7%)	768 (17.5%)	773 (17.6%)	785 (17.8%)	777 (17.7%)
75 or older	12 058 (4.4%)	916 (20.8%)	922 (21.0%)	912 (20.8%)	933 (21.1%)	916 (20.8%)
Sex						
Male	129 070 (47.5%)	1843 (41.9%)	1843 (42.0%)	1836 (41.9%)	1844 (41.7%)	1843 (41.9%)
Female	142 767 (52.5%)	2556 (58.1%)	2542 (58.0%)	2549 (58.1%)	2575 (58.3%)	2556 (58.1%)
Index of Relative Socio-Economic Advantage and Disadvantage[12]						
Quintiles 1 to 3	42 830 (15.8%)	676 (15.4%)	674 (15.4%)	676 (15.4%)	678 (15.4%)	676 (15.4%)
Quintile 4	94 231 (34.7%)	2009 (45.7%)	1997 (45.5%)	2000 (45.6%)	2018 (45.7%)	2009 (45.7%)
Quintile 5	134 776 (49.6%)	1714 (39.0%)	1714 (39.1%)	1709 (39.0%)	1722 (39.0%)	1714 (39.0%)
Indigenous status						
Non-Indigenous	268 885 (98.9%)	4254 (96.7%)	4238 (96.6%)	4241 (96.7%)	4272 (96.7%)	4254 (96.7%)
Indigenous	2952 (1.1%)	145 (3.3%)	147 (3.4%)	144 (3.3%)	147 (3.3%)	145 (3.3%)
Medical conditions						
None recorded	266 854 (98.2%)	3983 (90.5%)	3989 (91.0%)	3983 (90.8%)	4004 (90.6%)	3983 (90.5%)
Diabetes	1565 (0.6%)	148 (3.4%)	131 (3.0%)	141 (3.2%)	160 (3.6%)	148 (3.4%)
Asthma	1450 (0.5%)	114 (2.6%)	113 (2.6%)	108 (2.5%)	120 (2.7%)	114 (2.6%)
Heart disease	1143 (0.4%)	82 (1.9%)	79 (1.8%)	78 (1.8%)	85 (1.9%)	82 (1.9%)
Hypertension	898 (0.3%)	73 (1.7%)	60 (1.4%)	71 (1.6%)	73 (1.7%)	73 (1.7%)
Obesity	494 (0.2%)	74 (1.7%)	67 (1.5%)	67 (1.5%)	81 (1.8%)	74 (1.7%)
Chronic obstructive pulmonary disease	464 (0.2%)	45 (1.0%)	40 (0.9%)	42 (1.0%)	47 (1.1%)	45 (1.0%)
Chronic kidney disease stage 3 or higher	449 (0.2%)	71 (1.6%)	55 (1.3%)	62 (1.4%)	76 (1.7%)	71 (1.6%)
Liver disease	237 (0.1%)	11 (0.3%)	9 (0.2%)	11 (0.3%)	12 (0.3%)	11 (0.3%)
Immunosuppressed	160 (0.1%)	42 (1.0%)	15 (0.3%)	33 (0.8%)	48 (1.1%)	42 (1.0%)
Interstitial lung disease	32 (< 0.1%)	2 (< 0.1%)	1 (< 0.1%)	2 (< 0.1%)	2 (< 0.1%)	2 (< 0.1%)
Bronchiectasis	51 (< 0.1%)	7 (0.2%)	7 (0.2%)	6 (0.1%)	7 (0.2%)	7 (0.2%)
Local risk of hospitalisation group						
Low risk	210 219 (77.3%)	2128 (48.4%)	2115 (48.2%)	2128 (48.5%)	2125 (48.1%)	2128 (48.4%)
Medium risk	48 051 (17.7%)	1264 (28.7%)	1263 (28.8%)	1263 (28.8%)	1264 (28.6%)	1264 (28.7%)

Continues

2 Continued

Characteristic	Original cohort		Weighted cohorts: Propensity score-matched		Weighted cohorts: Inverse probability treatment-weighted	
	Standard care	Remote monitoring	Standard care	Remote monitoring	Standard care	Remote monitoring
High risk	10 208 (3.8%)	690 (15.7%)	690 (15.7%)	685 (15.6%)	700 (15.8%)	690 (15.7%)
Very high risk	3359 (1.2%)	317 (7.2%)	317 (7.2%)	309 (7.0%)	330 (7.5%)	317 (7.2%)

COVID-19 = coronavirus disease 2019. * The standardised mean differences for each category by treatment group are included in the Supporting Information, table 1. ◆

were offered enrolment for RPM via the TCC-COVID app; people who could not or declined to use the app were remotely monitored via phone calls from the clinical team. People at high risk were referred to and managed by the COVID-19 telehealth assessment clinic (CTAC) service of their local hospital and were remotely monitored via the TCC-COVID app (if they consented) and phone calls from the CTAC.

For all eligible people enrolled for RPM, a courier delivered a pulse oximeter to measure their pulse rate and blood oxygen saturation (SpO_2); people submitted pulse rate and SpO_2 readings twice daily via the app or phone calls. A daily symptom assessment comprised seven outcome measures. The SESLHD RPM services operated during 08:00–20:00, seven days a week. People were advised to call a provided telephone number if they felt unwell or experienced technical problems. They were actively monitored until the clinical team informed them that they met the criteria for ending isolation, required admission to hospital, or they declined to be monitored further.

Data collection

The SESLHD TeleClinical Care trial of remote monitoring of people with cardiovascular disease used a web-based system that comprised a clinician dashboard with data analysis features for monitoring and triaging incoming patient data, a server, and an app;[7] it was designed in consultation with the NSW Ministry of Health to meet privacy and security guidelines. A version of this system was used in our study; further data were collected in electronic case report forms using the REDCap electronic data capture tool.[12] Information about treatment during the trial was also recorded in patient electronic medical records.

The personal characteristics included in analyses were age, sex (male, female), Indigenous status, residential postcode-based socio-economic status (Index of Relative Socio-economic Advantage and Disadvantage, IRSAD[13]), and other medical conditions (diabetes, hypertension, asthma, chronic obstructive pulmonary disease, interstitial lung disease, bronchiectasis, liver disease, heart disease, obesity, chronic kidney disease stage 3 or higher, immunosuppression status).

The risk of hospitalisation algorithm was developed by the NSW Ministry of Health to support enrolment for the Integrated Care for People with Chronic Conditions program, and was implemented in the patient flow portal.[14] It estimates the individual likelihood of an unplanned hospitalisation within twelve months, based on socio-demographic characteristics, health service use during the preceding four years, and an extensive list of chronic physical and mental conditions; it was used in an earlier phase of community care triage for people with COVID-19 in NSW (Supporting Information, part 4).

Outcomes

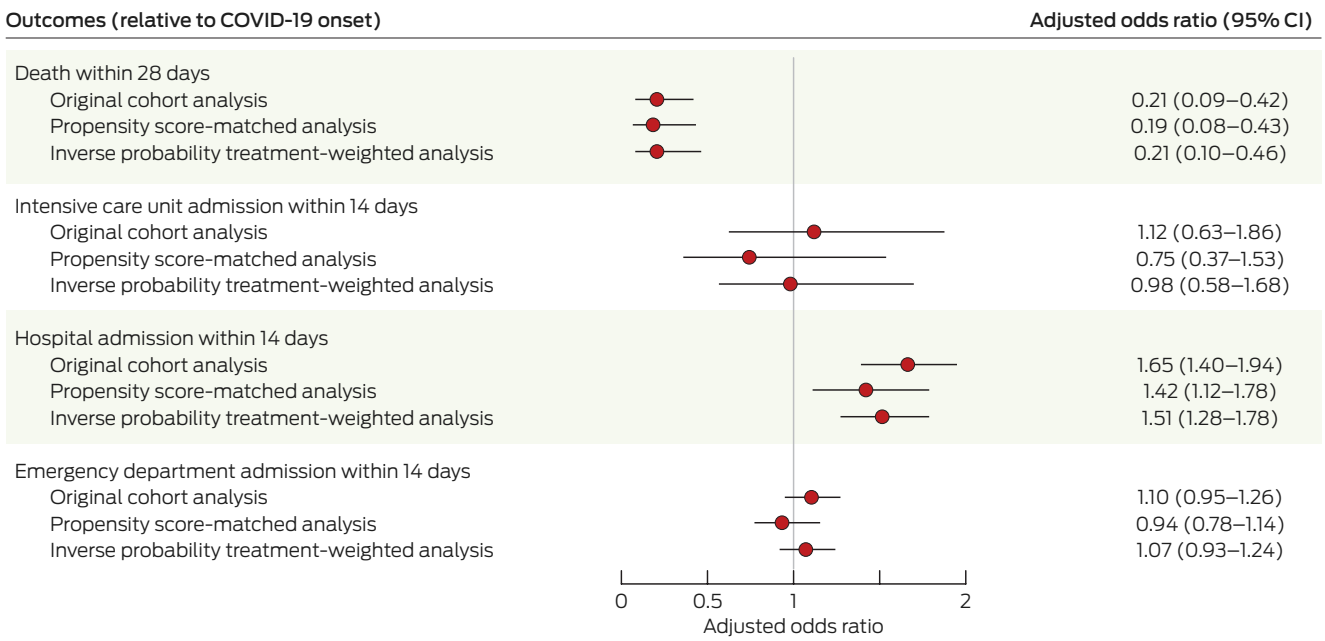
The primary outcome was all-cause mortality within 28 days of positive SARS-CoV-2 test results in the RPM and usual care groups. Secondary outcomes were hospital length of stay, and numbers of emergency department presentations, hospital admissions, and intensive care unit admissions within 14 days of positive test results.

Statistical analysis

To minimise the bias caused by potential confounders associated with assignment to models of care, we used two propensity score-based adjustment methods: propensity score matching and inverse probability of treatment weighting. Propensity scores were estimated in a multivariate logistic regression model that included socio-demographic factors (age, sex, Indigenous status, IRSAD quintile) and health profile (local risk of hospitalisation group, selected medical conditions) as covariates. People were matched using nearest-neighbour matching without replacement (1:1, calliper width of 0.05). A standardised mean difference between the two groups for baseline covariates of 0.1 was deemed to indicate adequate balance. Inverse probability of treatment weighting was used to supplement propensity score matching for estimating the average treatment effect for the treated (ATT). The stable propensity score (PS) inverse weights for ATT were applied to the usual care group as PS/(1–PS).

Associations between treatment groups and outcomes was quantified in multivariate logistic regression analyses adjusted for all covariates; we report adjusted odds ratios (aOR) with 95% confidence interval (CIs). For SESLHD hospital admissions (overnight or longer) within fourteen days of a positive SARS-CoV-2 test result, length of stay was calculated as the number of days between admission and discharge date, excluding leave days; we report both median values with interquartile ranges (IQRs) and mean values with standard deviations. We evaluated the association of RPM with SESLHD hospital length of stay for people with COVID-19 (overnight or longer hospital stays) within fourteen days of a positive SARS-CoV-2 test result in multivariate negative binomial regression analyses adjusted for all covariates; we report adjusted odds ratios (aORs) with 95% CIs. We undertook time-to-event analyses for the primary outcome (28-day mortality); mortality in the two groups was compared using Kaplan–Meier analysis and the log-rank test. Associations between covariates and 28-day survival were evaluated using multivariate Cox proportional hazards regression analysis; we report adjusted hazard ratios (aHRs) with 95% CIs. All analyses were conducted in R 4.3.0 (R Foundation for Statistical Computing).

3 Comparison of clinical outcomes for people with COVID-19 who received remote patient monitoring and those who received usual care: multivariate negative binomial regression analyses*



CI = confidence interval; COVID-19 = coronavirus disease 2019. * Adjusted for age group, sex, Indigenous status, socio-economic status (Index of Relative Socio-economic Advantage and Disadvantage quintile), selected medical conditions (diabetes, hypertension, asthma, chronic obstructive pulmonary disease, interstitial lung disease, bronchiectasis, liver disease, heart disease, obesity, chronic kidney disease stage 3 or higher, immunosuppressed), and local risk of hospitalisation group. The numbers of people for each outcome by treatment group are included in the Supporting Information, table 2. ◆

Ethics approval

The study design and access to clinical data was approved by the South Eastern Sydney Local Health District human research ethics committee (2022/ETH02067).

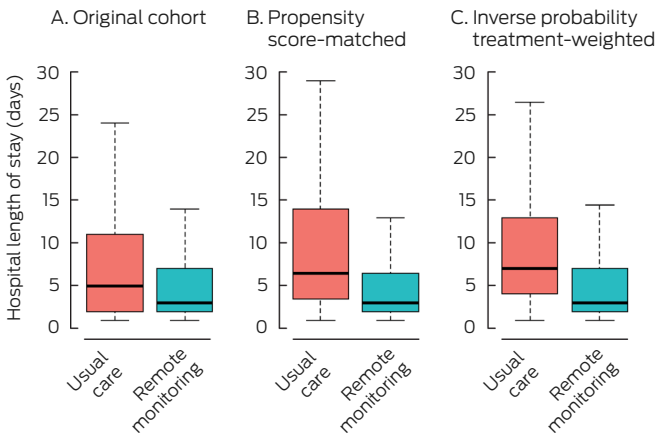
Results

During 26 November 2021 – 30 June 2022, positive SARS-CoV-2 test results were recorded for 326 898 people residing in the SESLHD catchment area. After excluding 48 480 people under 15 years of age, 40 because age and 178 because sex information was not available, and 1964 people for whom IRSAD could not be determined, we included data for 276 236 people in our analysis. A total of 4399 people (1.6%) participated in RPM, including 3161 who used the TCC-COVID app (71.9%).

The proportions of people in the RPM group with certain medical conditions were larger than in the usual care group: diabetes (3.4% *v* 0.6%), obesity (1.7% *v* 0.2%), heart disease (1.9% *v* 0.4%), and chronic kidney disease (1.6% *v* 0.2%). The proportions of female participants (58.1% *v* 52.5%), people with high or very high risk of hospitalisation scores (22.9% *v* 5.0%), people aged 75 years or older (20.8% *v* 4.4%), and Indigenous people (3.3% *v* 1.1%) were also larger in the RPM than the usual care group. The proportion of people living in the top highest socio-economic status quintile was smaller in the RPM group (39.0% *v* 49.6%) (Box 2). After propensity score matching or inverse probability treatment weighting, the standardised mean differences for all baseline characteristics were less than 0.1 (Supporting Information, table 1), indicating good covariate balance between the two treatment groups.

Twenty-eight-day mortality was lower for the RPM group than the usual care group (propensity score-matched: aOR, 0.19; 95% CI; 0.08–0.43; inverse probability treatment-weighted: aOR, 0.21; 95% CI, 0.10–0.46). The likelihood of intensive care unit admissions and emergency department presentations within fourteen days of a positive SARS-CoV-2 test result was similar for both groups. The likelihood of hospital admission was higher for the RPM group than the usual care group (propensity score-matched: aOR, 1.42; 95% CI, 1.12–1.78; inverse probability treatment-weighted: aOR, 1.51; 95% CI, 1.28–1.78) (Box 3).

4 Median hospital length of stay for people with COVID-19 who received remote patient monitoring and those who received usual care*



COVID-19 = coronavirus disease 2019. * Excludes two people in the standard care group who were still in hospital at the time of data extraction. The boxplots depict the median values, interquartile ranges, and overall ranges for hospital length of stay. The data for these graphs are included in the Supporting Information, table 3. ◆

In the original cohort analysis, the median length of stay was three days (interquartile range [IQR], 2–7 days) in the RPM group and five days (IQR, 2–11 days) in the usual care group (Box 4). The adjusted mean difference in length of stay was –2.01 (95% CI, –2.81 to –1.21) days (propensity score-matched: –3.54 [95% CI, –6.39 to –0.69] days; inverse probability treatment-weighted: –3.26 [95% CI, –6.01 to –0.50] days) (Box 5).

After propensity score matching or inverse probability treatment weighting, unadjusted Kaplan–Meier survival analysis indicated that 28-day survival was higher for people remotely monitored than for those who received usual care (log-rank test: $P < 0.001$) (Box 6). In multivariate Cox model analyses, 28-day risk of death was lower (propensity score-matched: HR, 0.19; 95% CI, 0.09–0.44; inverse probability treatment-weighted: aHR, 0.20; 95% CI; 0.09–0.42) (Box 7).

The 28-day risk of death was higher for Indigenous than non-Indigenous people in the original cohort (aHR, 4.27; 95% CI, 2.01–9.05) and inverse probability treatment-weighted analyses (aHR, 3.40; 95% CI, 1.21–9.56). The risk was higher for people aged 75 years or older than for people under 75 years in all analyses (original cohort: aHR, 81.1; 95% CI, 61.4–107; propensity score-matched: aHR, 13.5; 95% CI, 6.26–29.2; inverse probability treatment-weighted: aHR, 12.9; 95% CI, 7.86–21.3); it was higher for men than women only in the original cohort analysis (aHR, 1.28; 95% CI, 1.04–1.58). Having two or more of the listed medical conditions was associated with higher 28-day mortality risk in all analyses (Box 7).

Discussion

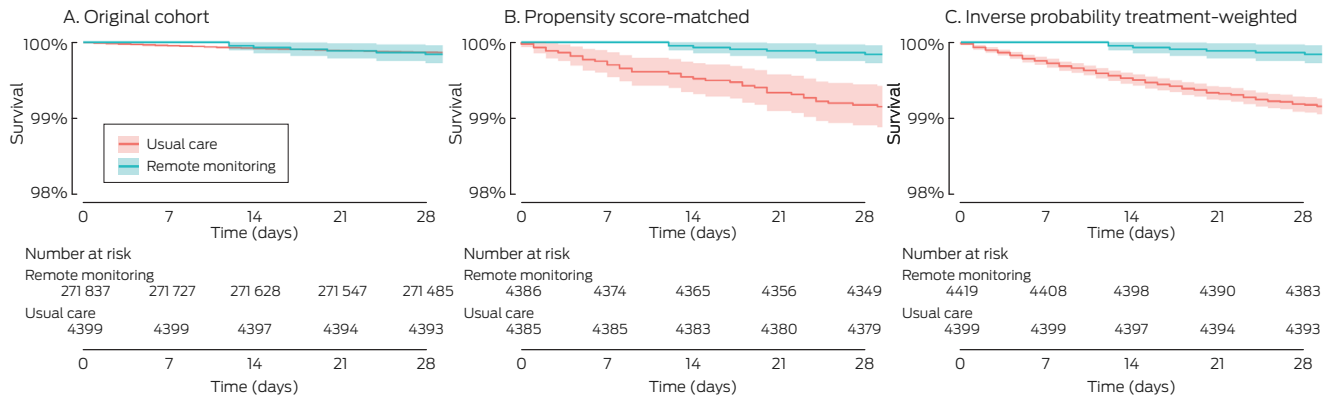
In our retrospective cohort study in the SESLHD during November 2021 – June 2022, the likelihood of death (any cause) within 28 days of positive SARS-CoV-2 test results was lower for people receiving RPM than for those receiving usual acute care for COVID-19 (original cohort: aOR, 0.21; 95% CI, 0.09–0.42; propensity score-matched: aOR, 0.19; 95% CI; 0.08–0.43), despite selection for the RPM group being based on greater risk of clinical deterioration. The likelihood of hospital admissions was higher for the RPM group (original cohort: aOR, 1.65; 95% CI, 1.40–1.94; propensity score-matched: aOR, 1.42; 95% CI, 1.12–1.78), but the mean difference in length of stay was two days

5 Mean hospital length of stay for people with COVID-19 who received remote patient monitoring and those who received usual care*

Study cohort	Standard care	Remote monitoring	Mean difference (95% CI)	
			Unadjusted	Adjusted†
Original cohort				
Number of people	2043	190		
Hospital length of stay (days), mean (SD)	8.9 (11.8)	6.2 (11.6)	–2.71 (–4.44 to –0.97)	–2.01 (–2.81 to –1.21)
Propensity score-matched cohort				
Number of people	136	187		
Hospital length of stay (days), mean (SD)	10.7 (11.7)	6.0 (11.5)	–4.68 (–7.25 to –2.10)	–3.54 (–6.39 to –0.69)
Inverse probability of treatment-weighted cohort				
Number of people	143	190		
Hospital length of stay (days), mean (SD)	10.6 (11.5)	6.2 (11.6)	–4.41 (–6.18 to –2.60)	–3.26 (–6.01 to –0.50)

CI = confidence interval; COVID-19 = coronavirus disease 2019; SD = standard deviation. * Excludes two people in the standard care group who were still in hospital at the time of data extraction. † Adjusted for Adjusted for age group, sex, Indigenous status, socio-economic status (Index of Relative Socio-economic Advantage and Disadvantage quintile), selected medical conditions (diabetes, hypertension, asthma, chronic obstructive pulmonary disease, interstitial lung disease, bronchiectasis, liver disease, heart disease, obesity, chronic kidney disease stage 3 or higher, immunosuppressed) and local risk of hospitalisation group. ◆

6 Survival of people with COVID-19 from date of positive SARS-CoV-2 test result, by treatment group: unadjusted Kaplan–Meier analyses



COVID-19 = coronavirus disease 2019; SARS-CoV-2 = severe acute respiratory syndrome coronavirus 2. ◆

7 Risk of death for people with COVID-19 within 28 days of positive SARS-CoV-2 test result, by treatment group: multivariate Cox proportional hazards regression analyses*

Characteristic	Adjusted hazard ratio (95% confidence interval)		
	Original cohort	Propensity score-matched	Inverse probability treatment-weighted
Remotely monitored	0.27 (0.13–0.57)	0.19 (0.09–0.44)	0.20 (0.09–0.42)
Aged 75 years or older	81.1 (61.4–107)	13.5 (6.26–29.2)	12.9 (7.86–21.3)
Sex (male)	1.28 (1.04–1.58)	1.29 (0.71–2.35)	1.35 (0.98–1.86)
Indigenous people	4.27 (2.01–9.05)	4.14 (0.96–17.9)	3.40 (1.21–9.56)
Other medical conditions (*v* none)			
One	2.21 (1.55–3.14)	2.80 (1.22–6.41)	1.26 (0.84–1.90)
Two or more	5.59 (4.23–7.39)	3.62 (1.57–8.36)	3.04 (1.95–4.72)

COVID-19 = coronavirus disease 2019; SARS-CoV-2 = severe acute respiratory syndrome coronavirus 2. * Adjusted for all other variables in this table. ◆

shorter for the RPM group. The odds of emergency department presentation and intensive care unit admission were similar for the two groups.

Factors associated in our study with greater likelihood of hospital use or death within 28 days of positive SARS-CoV-2 test results, such as more advanced age and having other medical conditions, have also been reported by other studies.[15-17] After adjusting analyses for variables such as number of other medical conditions and socio-economic status, we found that 28-day mortality risk was higher for Indigenous people than other Australians. Other studies have also found that outcomes for people with COVID-19 are poorer for those from ethnic minorities and First Nations peoples.[18,19] Possible explanations include problems with access to certain services and differences in health care for particular ethnic groups because of cultural or linguistic barriers.[20,21]

We found that RPM was associated with greater likelihood of hospital admission. This is not unexpected, as the model of care was designed to identify early signs of clinical deterioration by monitoring physical parameters and symptoms that could prompt referral to the clinical team and a recommendation to visit an emergency department. The likelihood of emergency department presentation was similar for the two groups, but likelihood of hospital admission was greater for the RPM group, which suggests they were more unwell or admitted specifically for inpatient assessment or treatment. The mean hospital length of stay was two days shorter with RPM than with usual care.

Clinical factors that influence the risk of death for patients with COVID-19 include body temperature and oxygen saturation during the first emergency department presentation.[22,23] RPM may have led to earlier recognition and treatment of people with deteriorating conditions, resulting in more frequent hospital admissions, but also to shorter length of stay and reduced mortality. Our findings are consistent with other reports of shorter length of stay with RPM[24-26] and lower mortality.[25] Two other studies, however, reported fewer hospitalisations of remotely monitored people with COVID-19,[25,26] but the first of these studies included only people at high risk of severe disease,[25] and the second included all people with COVID-19.[26] In our study, we compared outcomes for people at high risk of severe disease who were remotely monitored with those for all people with COVID-19 who were not remotely monitored.

Limitations

Limitations inherent to our retrospective observational study design include the possibility of incomplete or inaccurate clinical documentation in the patient flow portal. Further, deterministic linkage is convenient and achieves lower linkage error rates than probabilistic linkage, but the likelihood of excluding matches between datasets because of data entry error is greater. Secondly, our datasets were limited to information about people using hospitals in a single local health district, not other health care facilities. Other potentially important factors were therefore not included in our analysis, such as disease severity, frailty, and intrinsic personal characteristics, including health-seeking behaviours, cultural and language barriers to health care access, and health and technology literacy. Propensity score-based adjustment cannot eliminate residual confounding by unmeasured variables, which could influence the estimated treatment effect. However, the outcomes of our unadjusted and propensity score-adjusted analyses were similar. Propensity score matching and inverse probability treatment weighting were used to estimate average treatment effects on the treated, a measure of interest for program evaluation. However, it also limits our findings to people who meet the inclusion criteria for remote monitoring rather than all people with COVID-19.

We did not assess COVID-19 vaccination status or the use of active antiviral agents, each of which could reduce the incidence of hospitalisation and death. Notifications data may not have captured all COVID-19 cases because testing capacity was restricted during some parts of the study period, which could have increased the proportion of people at high risk of serious disease in our study. As the reasons for emergency department presentations and hospital admissions were unknown, we could not determine whether RPM reduced avoidable emergency department presentations. Finally, the study was restricted to people with COVID-19 who lived in the SESLHD catchment area or received care in SESLHD hospitals during the SARS-CoV-2 Omicron epidemic wave. However, our findings regarding the safety and benefits of RPM can probably be generalised to people with other diseases.

Conclusion

We report evidence for the safety and benefits of at-home monitoring for managing people with acute COVID-19. While RPM was associated with greater likelihood of admission to hospitals than usual care, the mean length of stay was shorter

and 28-day mortality was lower; broader use of the intervention could reduce the hospital bed demands associated with COVID-19. Our findings support the monitoring of people isolating at home with COVID-19 or, possibly, other conditions, including chronic heart or lung disease.[4,24-26] Programs need to be specific for particular diseases and conditions, and focused on people at greatest risk of severe disease so that resources are directed to those who will benefit most. Targeted RPM should be considered for improving care and outcomes, and strategies for optimising the monitoring process for those with the greatest needs should be investigated.

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Competing interests: Since the conduct of this published work, the technology used for remote monitoring has been commercialised by Connected Health Technologies Pty. Ltd. (trading as Apostele); Sze-Yuan Ooi and Nigel Lovell are founding directors of this company.

Data sharing: The study data can be accessed by contacting the corresponding author. ■

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Supporting Information

Additional Supporting Information is included with the online version of this article.