A virtual ward model of care for patients with COVID-19

Olivia R Ferry, Emma C Moloney, Owen T Spratt, Gerald FM Whiting, Cameron J Bennett

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Table of Contents

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Abstract

Background: The COVID-19 pandemic has necessitated the implementation of innovative healthcare models in preparation for an influx of patients. A virtual ward model delivers clinical care remotely to patients in isolation. We report an Australian cohort of patients with COVID-19 treated in a virtual ward.

Objective: The aim of this study was to describe and evaluate the safety and efficacy of a virtual ward model of care for an Australian cohort of patients with COVID-19.

Methods: A retrospective clinical audit was undertaken of 223 patients with confirmed COVID-19 treated in a virtual ward in Brisbane, Australia, from March 25 to May 15, 2020. Statistical analyses of variables associated with length of stay and hospitalisation were undertaken.

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Conclusions: Our results suggest a virtual ward model of care to treat patients with COVID-19 is safe and efficacious. A small number of patients required escalation to hospital care. Further studies are recommended to validate this model of care.

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Keywords: COVID-19, virtual care, telemedicine

Introduction

On March 11, 2020 the World Health Organization declared a global pandemic of coronavirus disease 2019 (COVID-19), a respiratory infection caused by the novel betacoronavirus, SARS-CoV-2 [1]. A key consideration in this pandemic has been managing the rapid influx of patients with COVID-19. The subsequent strain on healthcare systems has acted as a catalyst for the increased implementation of telemedicine [2]. Telemedicine refers to the provision of healthcare via information technologies and telecommunication systems [3]. A Cochrane review concluded telemedicine can have equivalent health outcomes to face-to-face care [4]. However, the implementation of novel telemedicine approaches can be challenging with both staff and patient adaptation required. In the current pandemic, telemedicine has been utilised in triage, treatment and care coordination of patients with COVID-19 to improve healthcare access, reduce disease transmission and optimise resource allocation [5-7]. A ‘virtual ward’ delivers hospital-level care to patients in the community via telemedicine. Through the provision of timely multidisciplinary care, virtual ward models have been shown to reduce emergency department presentations and hospital admissions [8,9]. These outcomes are desirable in a pandemic, where the judicious use of finite healthcare resources is critical.

To care for patients safely and effectively through a virtual care model, understanding the clinical course of COVID-19 is important [2]. Several meta-analyses of published cohort studies have described the most common initial symptoms of fever, cough and fatigue [10-12]. Common comorbidities identified in patients with confirmed COVID-19 are hypertension (15.6%), diabetes (7.7%) and cardiovascular disease (4.7%) [11]. The most common laboratory abnormalities include a raised C-reactive protein (CRP) (68.6%), lymphopenia (57.4%) and increased lactate dehydrogenase (LDH) (51.6%) [12]. The reported clinical spectrum of COVID-19 is broad, ranging from asymptomatic infection and mild upper respiratory tract illnesses to severe pneumonia and critical

multiorgan failure [13]. Current literature suggests that approximately 80% of cases are mild [13]. However, out of 44 500 SARS-CoV-2 infections in China, 14% of patients experienced severe disease with hypoxia and 5% critical disease with respiratory failure, shock or multiorgan dysfunction [13]. Mortality rates vary by region and data collection method. Initial studies in China report mortality rates of 2.3 to 3.6%, with higher mortality associated with increasing age or comorbidities [11-13]. This emphasises the potential for most patients with COVID-19 to be treated in lower acuity settings with monitoring for deterioration.

Predictors of deterioration during acute COVID-19 illness have been proposed through early retrospective cohort studies of patients with COVID-19 pneumonia or severe disease [14-18]. Baseline characteristics such as increasing age, male sex and comorbidities confer greater risk of severe disease and mortality [14,17,19,20]. Namely, chronic lung disease, cardiovascular disease, hypertension, diabetes mellitus and immune-suppression have been proposed as risk factors [21-23]. In severe disease, a higher incidence of dyspnoea, in approximately 67%, has been reported in those requiring intensive care unit (ICU) admission [14,18]. Additionally, new onset dyspnoea may reflect the development of COVID-19 pneumonia. In COVID-19 pneumonia cohort studies, the median time to dyspnoea onset has been reported as five to eight days after initial symptom onset [15,16]. Additionally, high-grade temperatures, 39 degrees Celsius or above, have been associated with an increased likelihood of acute respiratory distress syndrome (ARDS) [17]. The time to deterioration is notable with a median of eight to twelve days from illness onset to ARDS and ten days to ICU admission reported [14-16,19]. Whilst further data is needed, this second week of acute illness likely represents a high-risk period for deterioration that may assist in clinical decision-making regarding need for hospitalisation.

The aims of this study were to: (i) describe the clinical characteristics of an Australian cohort of

patients with COVID-19, (ii) evaluate the clinical care provided to this cohort through a virtual ward model and (iii) identify any possible predictors of deterioration.

Methods

Study design

A retrospective single centre clinical audit was undertaken of patients admitted to the Metro North Virtual Ward from March 25 to May 15, 2020. This study was deemed low/negligible risk by the Royal Brisbane and Women's Hospital Human Research Ethics Committee. No formal power calculations were undertaken with inclusion of all patients meeting study criteria.

Study population

All patients admitted to the virtual ward during the specified time period were assessed for inclusion into this study. Inclusion required a laboratory confirmed diagnosis of COVID-19 by polymerase chain reaction (PCR) detection of SARS-CoV-2 RNA on nasopharyngeal swab (NPS). Patients were excluded if they had a preliminary positive or inconclusive PCR result, but subsequent confirmatory PCR testing did not detect SARS-CoV-2 RNA. Patients were admitted to the virtual ward from the community after Metro North Public Health Unit notification of a positive SARS-CoV-2 PCR test result or following hospital discharge, if a confirmed case.

Virtual care

Patients remained in out-of-hospital isolation during their virtual ward admission with nursing observations conducted via telephone consultation. Virtual ward staff were located in a secure dedicated hospital workspace with medical records maintained as per local hospital procedures and protocols. Patients were risk stratified by age, comorbidities and symptom burden to determine the frequency of telephone consultation; low-risk patients once daily and high-risk patients twice daily. Observations were structured to monitor patient symptoms and identify potential deterioration. During each consultation patients were asked to rate (on a scale of none, mild, moderate or severe) the following symptoms: shortness of breath, cough, fatigue, sputum production, nausea/vomiting,

headache, myalgia and sore throat. These symptoms were numerically scored at each review. Patients' general wellbeing, social situation and adherence to isolation were also assessed.

Clinical reviews by medical officers occurred when pre-specified escalation criteria were met. These criteria were: (i) patient reported severe symptoms related to shortness of breath, cough or fatigue, (ii) symptoms increasing in severity on one observation in patients aged over 65 years with comorbidities or over two observations in those without comorbidities or (iii) any nursing or patient concern for deterioration. If required, hospital referral for further assessment was organised. All patients were reviewed by a medical officer prior to discharge. Multidisciplinary care was provided with pharmacists ensuring patient access to medications and social workers offering psychosocial support.

In accordance with the Communicable Diseases Network Australia (CDNA) COVID-19 guidelines, patients were discharged and released from self-isolation once the following recovery criteria were met: (i) ten days since onset of symptoms and resolution of all symptoms of acute illness for the previous 72 hours and (ii) ten days since hospital discharge and resolution of all symptoms of acute illness for the previous 72 hours, if hospitalised for severe COVID-19 [24].

Data collection

Data was collected from existing medical records on patient demographics, epidemiological history, comorbidities, medications, COVID-19 symptoms, clinical reviews, pathology results, hospital assessment and treatment outcomes.

Data analysis

We expressed descriptive statistics as number (%) for categorical data and median or mean (range) for continuous variables. We performed Pearson Chi-square tests to explore associated risk factors for (i) patients requiring referral to hospital and (ii) virtual ward length of stay greater than seven days. Fisher's exact tests were utilised where event counts were less than five. Missing data was not imputed in analyses. Odds ratios and corresponding 95% confidence intervals were calculated. All tests were two-sided with an α less than 0.05 considered statistically significant. Data was not adjusted for multiple testing and as such, findings should be considered descriptive rather than to infer definitive effects. SPSS version 26.0 (IBM) was utilised for analyses.

Results

Study population

A total of 223 patients with a median age of 45 years (range, 14 to 78) of which 52.9% were female, were analysed in this study (Table 1). This included two patients under the age of 18. Almost half (44.8%) of patients had a comorbidity, with hypertension (17%) and asthma (10.8%) most common. A total of 178 cases were epidemiologically linked to overseas travel (Figure 1). The most common countries were the United Kingdom (UK) (38%) and the United States of America (USA) (17%). Sixteen patients (7.2%) had travelled on cruise ships. The most common COVID-19 symptoms at presentation were cough (73.1%), fever (52.5%) and headache (46.2%). Prior to virtual ward admission, 44.8% of patients were assessed by a medical practitioner, either in person or via telemedicine, 9.4% had a chest radiograph performed and 10% had laboratory blood tests. Initial diagnostic PCR detected SARS-CoV-2 RNA at a median cycle threshold of 23.88.

Table 1. Baseline characteristics of the study population (n=223).

	All patients	**Patients not**	**Patients referred**

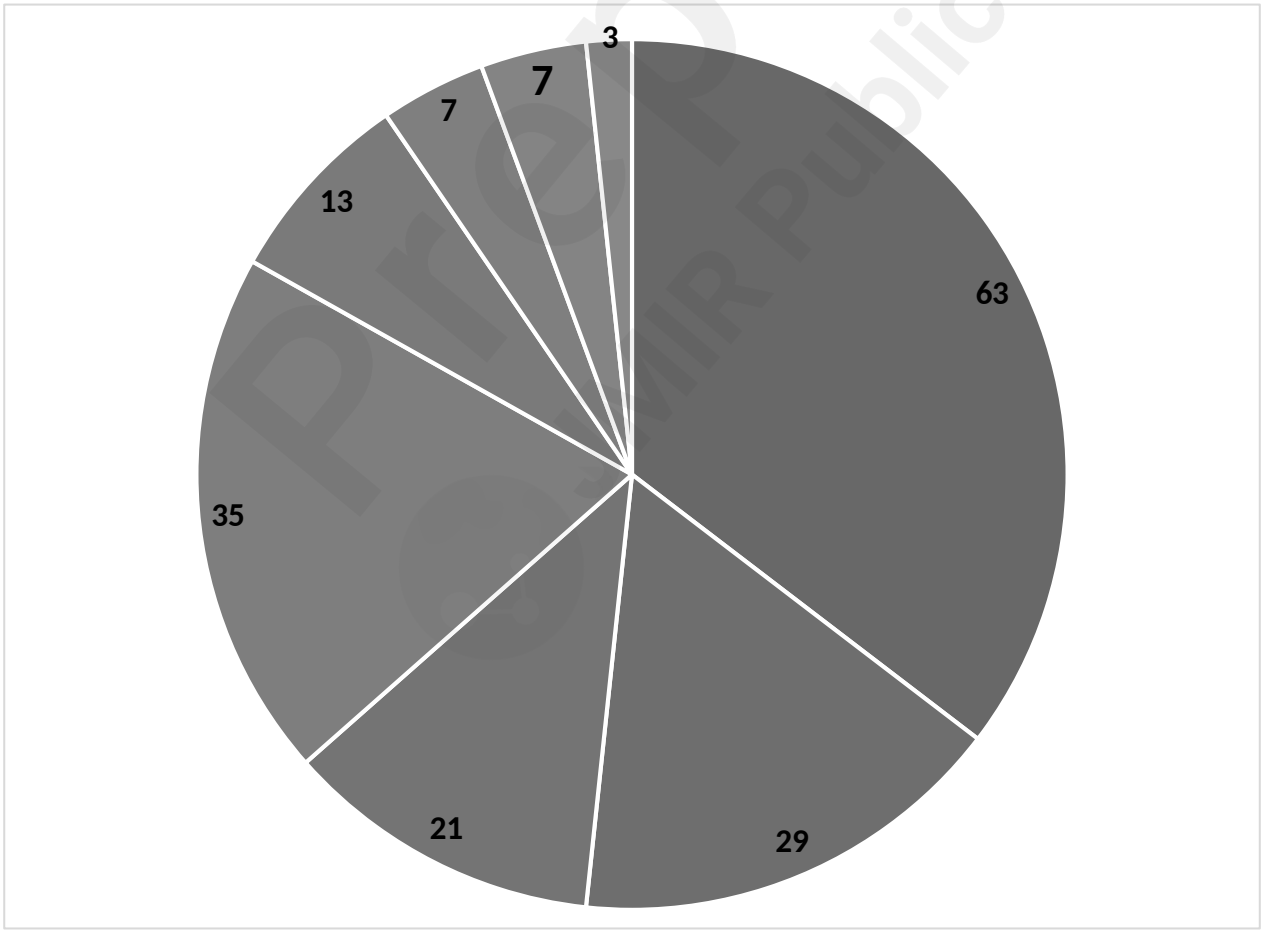
	(n=223)	**referred to hospital (n = 205)**	**to hospital (n = 18)**
Median age (range)	45.0 (14-78)	42.0 (14-78)	54.0 (23-71)
Female sex – n (%)	118 (52.9)	108 (52.7)	10 (55.6)
High risk – n (%) [a]	63 (28.3)	54 (26.3)	9 (50)
Transmission source – no. (%)			
Overseas travel	178 (79.8)	167 (81.5)	11 (61.1)
Contact with a confirmed case	47 (21.1)	43 (21)	4 (22.2)
Locally acquired	43 (19.3)	35 (17.1)	8 (44.4)
Unknown	3 (1.3)	3 (1.5)	0 (0)
Comorbidities – n (%)			
Any	100 (44.8)	87 (42.4)	13 (72.2)
Hypertension	38 (17)	31 (15.1)	7 (38.9)
Asthma	24 (10.8)	23 (11.2)	1 (5.6)
Diabetes mellitus	13 (5.8)	12 (5.9)	1 (5.6)
Immune-suppressed [b]	6 (2.7)	5 (2.4)	1 (5.6)
COPD	3 (1.3)	3 (1.5)	0 (0)
Medications – n (%)			
ACEi or ARB (n=135)	25 (11.2)	19 (9.3)	6 (33.3)
Initial symptoms at onset – n (%)			
Cough	163 (73.1)	149 (72.7)	14 (77.8)
Fevers	117 (52.5)	104 (50.7)	13 (72.2)
Headache	103 (46.2)	97 (47.3)	6 (33.3)
Sore throat	97 (43.5)	90 (43.9)	7 (38.9)
Fatigue	84 (37.7)	74 (36.1)	10 (55.6)
Rhinorrhoea	82 (36.8)	76 (37.1)	6 (33.3)
Myalgias	78 (35)	70 (34.1)	8 (44.4)
Shortness of breath	52 (23.3)	46 (22.4)	6 (33.3)
Nausea/vomiting	37 (16.6)	33 (16.1)	4 (22.2)
Diarrhoea	37 (16.6)	35 (17.1)	2 (11.1)
Anosmia	36 (16.1)	35 (17.1)	1 (5.6)
Ageusia	30 (13.5)	27 (13.2)	3 (16.7)
Sputum	24 (10.8)	18 (8.8)	6 (33.3)
Arthralgias	24 (10.8)	19 (9.3)	5 (27.8)
Chest tightness	20 (9)	17 (8.3)	3 (16.7)
Initial patient presentation			
Initial assessment by a medical practitioner – n (%)	100 (44.8)	90 (43.9)	10 (55.6)
Initially admitted to hospital prior to virtual ward admission – n (%)	32 (14.3)	29 (14.1)	3 (16.7)
Median time in days from symptom onset to initial NPS test	4 (0 – 23)	4 (0 – 23)	1 (0 – 5)

(n=177)			
Median cycle threshold of initial NPS PCR (n=135) (range)	23.88 (11 – 36)	24.00 (11 – 36)	18.04 (14.61 – 33)
Chest radiograph performed – no. (%)	21 (9.4)	20 (9.8)	1 (5.6)
Blood tests performed – n (%)	22 (9.9)	21 (10.3)	2 (11.1)

a High-risk was defined as 65 to 85 years of age with any comorbidity or 49 to 65 years of age with a comorbidity of chronic lung disease, cardiovascular disease, immunosuppression, diabetes or hypertension.

[b] Immune-suppressed was defined as patients on immunosuppressive medication or having a primary immune-deficiency. COPD, chronic obstructive pulmonary disease. ACEi angiotensin converting enzyme inhibitor. ARB, angiotensin receptor blocker. NPS, nasopharyngeal swab. PCR, polymerase chain reaction.

Figure 1. Cases epidemiologically linked to overseas or interstate travel (n= 178).



*Other includes Argentina, Cuba, Egypt, Hong Kong, Indonesia, Japan, Myanmar, Norway, Philippines, Singapore,

South Africa, Sweden, Turkey, United Arab Emirates.

Virtual ward outcomes

Of the 223 virtual ward patients, 205 patients (92%) were discharged after clinical recovery without escalation of care to hospital (Table 2). The median virtual ward admission length was 8 days (range, 1 to 44). The median time to clinical recovery was 16 days (range, 10 to 52). A total of 18 patients (8.1%) were referred for in-person hospital assessment (Table 3). Of these, one third were assessed in the emergency department and discharged back into the virtual ward after review. The remaining two thirds were admitted to an inpatient ward with two patients admitted to the ICU, requiring mechanical ventilation (Table 3). The average length of hospital stay was 3.5 days (range, 1 to 15) when ICU care was not required. There was no mortality at discharge for the 223 patients audited in this study.

There were several factors associated with virtual ward length of stay beyond seven days. These included having any comorbidity (OR 2.0, CI 1.15-3.40, *P*=.01), being classified as high risk on admission (OR 2.2, CI 1.16-4.00, *P*=.02) or being hospitalised prior to virtual ward admission (OR 2.6, CI 1.10-5.99, *P*=.03). Initial COVID-19 symptoms of cough (OR 2.2, CI 1.22-4.10, *P*=.008), fevers or night sweats (OR 2.2, CI 1.26-3.70, *P*=0.005) and diarrhoea (OR 2.3, CI 1.06-5.07, *P*=.03) were also associated with a virtual ward admission over seven days.

Table 2. Virtual ward patient outcomes (n=223).

Outcome	**Patients** (n=223)
Median length of stay in days (range)	8.0 (1 – 44)
Median time to clinical recovery in days (range) [a]	16 (10 – 52)
Discharged without complication – n (%)	205 (91.9)
Requiring hospital assessment – n (%)	18 (8.1)

Admitted to inpatient ward – n (%)	12 (5.4)
Mean length of inpatient hospitalisation in days, if ICU not required (range) [a]	3.5 (1 – 15)
Admitted to intensive care unit – n (%)	2 (0.9)
Mortality	0

[a] Time from onset of symptoms to clinical recovery criteria as per CDNA guidelines (at least 10 days since symptom onset and 72 hours asymptomatic).

Hospitalised patients

Of the 18 patients assessed in hospital during their virtual ward admission, the median age was 54 years with 56% female and 50% classified as high risk (Table 3). Referral to hospital occurred a median of 8.5 days into their COVID-19 illness. Approximately half (43.9%) had been reviewed by a medical officer prior to their virtual ward admission. The most common reason for care escalation, in 55% of cases, was worsening, ongoing or new onset dyspnoea. A further 22% were referred due to new or ongoing fevers and 17% for further clinical assessment of chest pain or chest tightness (Table 3). The remaining patients were referred due to high symptom burden, functional decline with worsening fatigue, pre-syncopal symptoms or suspected bacterial superinfection.

On presentation to hospital, four patients (22%) were febrile. Four patients (22%) were hypoxemic with an oxygen requirement on presentation or shortly thereafter. Of the 18 patients presenting to hospital, 16 had blood tests with the most common abnormalities being an elevated LDH, liver function derangement, elevated CRP or a lymphopenia. A further 15 patients were investigated with chest radiographs, of which four had features of consolidation. Clinically, bacterial pneumonia was suspected in seven hospitalised patients with eight patients treated with antibiotics. Complications identified during hospitalisation included respiratory failure in three patients (16.7%), acute kidney injury in three patients (23.1%) and liver function derangement in six patients (37.5%). Two patients required admission to the ICU for mechanical ventilation.

Several possible predictors of deterioration associated with escalation of care were identified. The presence of hypertension (OR 3.6, CI 1.28-9.87, *P*=.01), sputum production at symptom onset (OR 5.2, CI 1.74-15.49, *P*=.001), arthralgia at onset (OR 3.8, CI 1.21-11.71, *P*=.02) and PCR cycle threshold for SARS-CoV-2 RNA detection on diagnostic NPS of 20 or less (OR 5.0, CI 1.25-19.63, *P*=.02) were associated with an increased likelihood of referral to hospital from the virtual ward.

Table 3. Clinical characteristics of those requiring hospital care while on the virtual ward (n = 18).

	Hospitalised patients (n=18)
Median age – n (range)	54 (23 – 71)
Female sex – n (%)	10 (55.6)
High risk – n (%) [a]	9 (50)
Median day of illness referred to hospital – n (range)	8.50 (3 – 20)
Previous medical review at initial presentation – n (%)	10 (55.6)
Initial median PCR Cycle threshold – n (range)	18.04 (14.61 – 33)
Primary reason for referral – n (%)	
Shortness of breath	10 (55.6)
New or ongoing fevers	4 (22.2)
Chest pain or chest tightness	3 (16.7)
Hospital assessment on presentation	
Median oxygen saturation – % on room air (range) (n=13)	96 (88 – 100)
Median heart rate – beats per minute (range) (n=10)	80 (57 – 105)
Median respiratory rate – breaths per minute (range) (n=9)	19 (16 – 28)
Febrile (≥37·5 degrees Celsius) – n (%) (n=11)	4 (22.2%)
Chest auscultation findings – n (%) (n=15)	Clear: 9 (60%) Unilateral crackles: 2 (13.3%) Bilateral crackles: 4 (26.7%)
Chest radiograph performed on presentation (n= 15) – n (%)	
No acute abnormality	8 (53.3)
Unilateral consolidation	2 (13.3)
Bilateral consolidation	2 (13.3)
Blood tests performed on presentation (n = 16) – n (%)	
Elevated lactate dehydrogenase (n=15)	9 (60)
Elevated C-reactive protein (n=6)	5 (83.3)
Lymphopenia (n=16)	4 (25)
Outcome – n (%)	
Assessed in Emergency Department and discharged	6 (33.3)

Admitted to inpatient ward	12 (66.7)
Antibiotics prescribed	8 (44.4)
Oxygen requirement during admission	4 (22)
Admitted to intensive care unit	2 (11.1)
Mechanical ventilation	2 (11.1)
Mortality	0
Complications – n (%)	
Liver function derangement (n=16)	6 (37.5)
Respiratory failure	3 (16.7)
Acute kidney injury (n=13)	3 (23.1)

a High-risk was defined as 65 to 85 years of age with any comorbidity or 49 to 65 years of age with a comorbidity of chronic lung disease, cardiovascular disease, immunosuppression, diabetes or hypertension.

Discussion

This retrospective study described the characteristics and clinical course of an Australian cohort of patients with COVID-19 treated in a newly established virtual ward. To our knowledge, this is the first study to evaluate a community virtual ward model for patients with COVID-19 and the largest clinical audit of patients with COVID-19 in an Australian setting to date.

Epidemiologically, most cases were linked to overseas travel, particularly from the UK, USA or cruise ships, consistent with Australian reports [24]. Clinically, our patients presented most often with cough, fever and headache. The symptom frequencies differed from meta-analyses of hospitalised patients in China, which may reflect lower disease severity in our cohort or reporting differences. Our cohort recorded a higher incidence of sore throat (43.5% versus 11.6%) and rhinorrhoea (36.8% versus 7.3%) with a lower incidence of chest tightness (9% versus 22.9%) and sputum expectoration (10.8% versus 23.7%) [10]. Approximately half of our patients were comorbid, with hypertension (17%) and asthma (10.8%) most common, comparable to previous studies [11].

Outcomes of this study suggest that a virtual ward model is safe for patients with COVID-19. Overall, 205 patients (92%) recovered without escalation to hospital care. Eighteen patients (8.1%)

required hospital assessment with only twelve (5.4%) admitted to hospital and two (0.9%) to intensive care. This reflects a lower incidence of critical COVID-19 disease in our cohort of 0.9% compared to 5% previously reported [15]. Our mortality rate of zero is consistent with the low case fatality rate of 1.3% in Australia, at the time of writing [24]. The median virtual ward admission length was eight days with a median time to clinical recovery of 16 days (range, 10 to 52). This discrepancy likely reflects returned international travellers who acquired infection overseas. Higher risk patients with regards to comorbidity and prior COVID-19 hospitalisation spent longer on the virtual ward. These findings suggest that a virtual model of care has the potential to preserve hospital inpatient capacity and resources, reduce disease transmission risk and hospital-related patient sequelae. Although majority of our patients had mild illness, the regular monitoring and supportive care provided may have reduced hospital presentations.

The timely identification of deteriorating patients is imperative for safe virtual care. Several studies have reported high diagnostic agreement between virtual and in-person consultations [25,26]. However, clinicians have cited concerns with telephone consulting, primarily due to a lack of physical examination [27]. The COVID-19 pandemic has provided an opportunity to introduce a range of telemedicine approaches to medical staff, through necessity to deliver safe patient care during a pandemic. The remote assessment of dyspnoea, the most common reason for hospital referral in our study, has been flagged as a challenge in this pandemic [28]. A difficulty in ruling out urgency via telephone may have resulted in a lower threshold for hospital referral in our study, with one-third of patients referred subsequently discharged after in-person assessment [26]. Our virtual ward model was simple without monitoring equipment beyond household thermometers. Enhanced assessment capabilities through real-time telemonitoring may reduce diagnostic uncertainty [29].

The patients referred to hospital in our study had a higher median age of 54 years, with referral

occurring a median of 8.5 days into their illness. Pre-existing hypertension, a proposed risk factor for severe COVID-19 disease, was associated with a 3.6-fold increase in hospitalisation. Initial symptoms of sputum production and arthralgia were associated with referral to hospital, which have not previously been reported. Patients with a PCR cycle threshold for SARS-CoV-2 RNA detection on diagnostic NPS testing of 20 or less were 5-times more likely to be referred to hospital. Although a lower cycle threshold indicates a higher sample quantity of RNA, the significance of this for disease progression is unclear. Further research is needed to validate these findings.

The two patients admitted to ICU had risk factors for critical COVID-19 disease [14]. These two males, over 60 years of age with pre-existing hypertension deteriorated on day 10 of their illness to require ICU admission and ventilatory support. This is consistent with the reported median 8 to 12 days to progression to ARDS and 10 days to ICU admission in critical COVID-19 [14-16,19]. The pathogenesis of this late decline has not yet been fully elucidated but pathological hyperinflammation is likely [30].

Limitations of this study include the observational design with retrospective data collection which contributed to missing data across variables reported. There were few patients with severe COVID-19 disease in our cohort. There may have been ascertainment bias as patients with more severe COVID-19 may have been directly admitted to hospital for the duration of their illness, bypassing the virtual ward.

To our knowledge, this is the largest cohort study of Australian patients with COVID-19 to be described to date and the first to evaluate a virtual ward model of care. This study provides evidence of the safety and feasibility of a virtual ward to treat patients with COVID-19. Further research is needed to identify early predictors of deterioration in COVID-19 and validate this healthcare model.

Contributors

OF, EM and OS were responsible for data collection, data analysis and drafting of the manuscript. GW and CM contributed to data interpretation and critically revised the manuscript. All authors were involved in study design, critical revision of the manuscript and approval of the final version.

Conflict of interest

None declared.

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Supplementary Files

Figures

Cases epidemiologically linked to overseas or interstate travel (n= 178).