# Outcomes from a virtual ward delivering oxygen at home for patients recovering from COVID-19: a real world observational study

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## ABSTRACT

### Background

There is a lack of data on the safety of providing oxygen at home to stable patients recovering from COVID-19.

### Methods

A retrospective analysis of patients discharged to a COVID-19 virtual ward (CVW) between January 2021 and March 2021 at a UK district general hospital was performed. Patients with improving clinical trajectories and oxygen requirements up to 4 L/minute were eligible. Outcomes measured were 30-day mortality and readmission rate.

### Results

From 02 January 2021 to 16 March 2021 (74 days), 147 patients discharged to the CVW were included: 71 received continuous or ambulatory oxygen, and 76 received pulse oximetry monitoring only. Five patients were readmitted within 30 days and two patients died. There were no significant differences between readmission and mortality rates between those discharged with or without oxygen.

### Conclusion

Provision of oxygen at home for selected patients recovering from COVID-19 is safe with low risk of readmission and death.

KEYWORDS: COVID-19, coronavirus, remote, discharge, virtual

## Introduction

Over the previous decade, there has been a notable increase in life expectancy.[1] As a result, providers of secondary and tertiary care have been functioning under considerable strain, with an increase in emergency department (ED) presentations and periods of hospitals working at maximum capacity.[2] This pressure on acute services has been accentuated by the COVID-19 global pandemic.

With SARS-CoV-2's considerable virulence and physical impact, it became apparent that a substantial proportion of patients would require hospital admission.[3,4] The rapid influx of COVID-19-related admissions has presented as a catalyst for considering alternative models to inpatient care.

Telemedicine may be one such alternative.[5,6] The implementation of telemedicine has led to the development of virtual wards that aim to deliver hospital-level multidisciplinary care to patients in the community. Literature has reported reduced ED presentations, hospital admissions and length of stay (LOS).[6–8] In early 2021, the NHS released a standard operating procedure (SOP) for the implementation of COVID-19 virtual ward (CVW) models in the UK.[9] The CVW is catered towards patients demonstrating improving clinical trajectories with particular respect to symptoms, function, oxygen saturation and resolved pyrexia. Criteria regarding oxygen requirement is somewhat vague with encouragement toward clinical judgement on an individual patient basis. Other sources have suggested that a broader approach to virtual care could be considered with provision of low flow supplemental oxygen for stable patients.[10]

In order to relieve the pressures on acute services during the COVID-19 'second wave', the remit of the CVW was expanded by the integrated care team at our district general hospital to include patients receiving supplemental oxygen via nasal cannulae, either continuously or on exertion. However, the safety of a virtual ward to manage patients recovering from COVID-19 requiring supplemental oxygen is currently unknown.

The aims of this study were to describe the clinical characteristics of patients discharged to the CVW, to evaluate the clinical care provided to this cohort via a virtual ward model, to report outcomes including readmission rates and mortality, and to identify any potential parameters that may act as predictors of deterioration.

## Methods

### Approval and setting

The study was a service evaluation of innovative care provision in a secondary care centre. As a result, no formal ethical approval was sought.

It was a single-centre, retrospective observational study with a single treatment arm. All components of this study were carried out at a
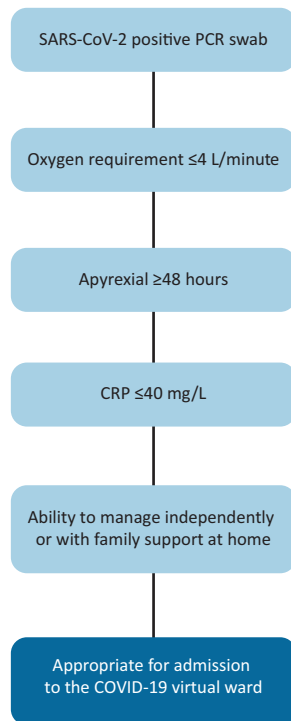
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Fig 1. Entry criteria for COVID-19 virtual ward. CRP = C-reactive protein; PCR = Polymerase chain reaction.



**Fig 2. Number of COVID-19 virtual ward admissions by week following introduction.** CVW = COVID-19 virtual ward.

district general hospital in the UK. Patients admitted to the CVW from conception on the 02 January 2021 to 16 March 2021 were included.

## Covid-19 virtual ward

Criteria for entry to CVW are shown in Fig 1. Patients not meeting these criteria could be admitted following review by a chest physician, if deemed appropriate. Patients could be discharged with dexamethasone, antibiotics or therapeutic anticoagulation if felt to be appropriate by the discharging clinician.

All patients were contacted by a specialist nurse at a minimum frequency of once weekly and patients requiring supplemental oxygen received at least one home visit. Home visits were scheduled for patients with increasing oxygen requirements, a change in clinical symptoms, a need to decide on stopping oxygen therapy or the inability to wean oxygen. A telephone advice line managed by an experienced oxygen specialist nurse was available for patients between 9am and 5pm, 7 days per week. Outside of these hours, patients were advised to attend the ED. A senior respiratory physician was available to give advice for complex patients. Once discharged to the CVW, if it was not possible to wean patients off supplemental oxygen, a referral was made to the local home oxygen service.

## Outcomes

The primary outcome was 30-day mortality. Secondary outcomes were 30-day readmission rate and 30-day venous thromboembolism (VTE) rate.

Data were collected retrospectively from patient electronic records. Follow-up was for 30 days or until discharge from CVW if not discharged within 30 days.
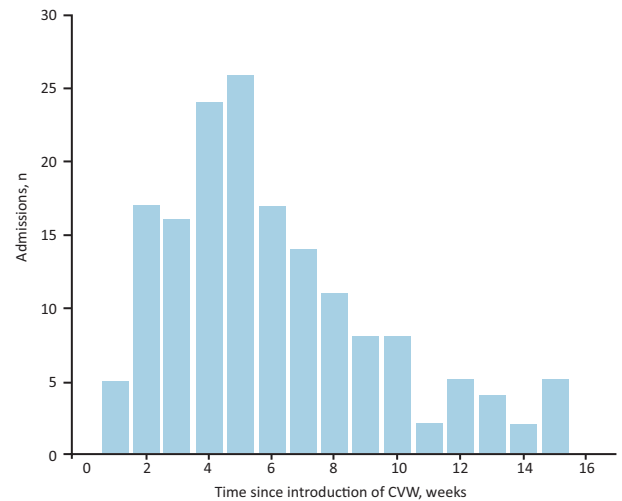
## Statistical methods

Continuous data are expressed as mean and standard deviation or median and interquartile range. Categorical data were expressed as frequency and percentage. For the C-reactive protein (CRP) data, if a value of <5 mg/L was reported by the laboratory, an absolute value of 4 mg/L was used for analysis instead.

Kolmogorov–Smirnov and Levene's tests were performed to check for assumptions of normality and homogeneity of variance for continuous data. For comparison of variables between three or more groups, if these conditions were met, a one-way ANOVA was performed with post hoc Bonferroni corrections for pairwise comparisons. If these conditions were not met, or for ordinal data, a Kruskal–Wallis test was used.

For categorical data, we performed a chi-squared test or a Fisher's exact test (when more than 80% of cells had expected frequency of less than five). Kaplan–Meier plots and log rank tests were used for survival and readmission outcomes. Data were analysed on SPSS platform version 25 (SPSS, Chicago, USA). A significance level of $p < 0.05$ was used for all analyses.

## Results

From 02 January 2021 to 16 March 2021 (74 days), 148 patients were discharged to the CVW (Fig 2). One patient did not meet the criteria for discharge into the CVW and chose to be discharged from hospital against medical advice; however, they were followed up under the CVW to allow provision of home oxygen. This patient was excluded from the analysis. Of the remaining 147 patients, 44 were discharged with an oxygen concentrator, 25 were discharged with ambulatory oxygen, 76 with no oxygen, and two were discharged for oxygen weaning at a community hospital (30%, 17%, 52% and 1%, respectively). Out of these 147 patients, 49 met the NHS England criteria for CVW discharge.[9] Median time from referral to the CVW team to discharge from hospital was 1 day (interquartile range (IQR) 0–2). Demographics and outcomes for included patients are shown in Table 1.

### Table 1. Demographics and outcomes for patients admitted to COVID-19 virtual ward

| | Overall, n=147 | No oxygen, n=76 | Ambulatory oxygen, n=25 | Oxygen concentrator, n=44 | p value (difference between groups) |
|---|---|---|---|---|---|
| Age, years, mean±SD | 58±15 | 56±14 | 60±15 | 59±16 | 0.33 |
| Men:women, n | 83:64 | 48:28 | 14:11 | 21:23 | 0.26 |
| EWS on discharge, score, median (IQR) | 2 (1–3) | 1 (1–2) | 2 (1–3) | 3 (2–4) | <0.001[a] |
| CRP on discharge, mg/L, median (IQR) | 12 (7–24) | 10 (6–27) | 19 (9–23) | 12 (7–19) | 0.38 |
| Length of inpatient stay, days, median (IQR) | 7 (4–10) | 6 (4–8.75) | 4.5 (3.25–7.75) | 8 (5–13) | 0.002[a] |
| Length of virtual ward stay, days, median (IQR) | 17 (12–27) | 15.5 (11–22) | 21 (12–28) | 21 (13–31) | 0.03[a] |
| Comorbidities, %: | | | | | |
| COPD | 10 | 5 | 4 | 18 | 0.049[a] |
| asthma | 14 | 14 | 12 | 14 | 0.95 |
| IHD | 6 | 7 | 0 | 9 | 0.38 |
| hypertension | 36 | 36 | 32 | 41 | 0.73 |
| diabetes | 24 | 24 | 16 | 32 | 0.33 |
| cancer | 8 | 9 | 16 | 2 | 0.12 |
| Dexamethasone on discharge, % | 7 | 0 | 4 | 20 | <0.001[a] |
| New anticoagulation on discharge (for COVID-19 or new PE), % | 9 | 8 | 4 | 14 | 0.36 |
| Antibiotics on discharge, % | 27 | 33 | 32 | 16 | 0.16 |
| 30-day mortality, % | 1 | 0 | 4 | 2 | 0.27 |
| 30-day readmission, % | 3 | 1 | 4 | 7 | 0.27 |
| VTE in 30 days post-discharge, % | 1 | 1 | 0 | 2 | 1.00 |

Two patients discharged with oxygen to a community hospital are included in the overall but not in the subgroup figures. [a]Statistically significant p<0.05. COPD = chronic obstructive pulmonary disease; CRP = C-reactive protein; EWS = Early Warning Score; IHD = ischaemic heart disease; PE = pulmonary embolism; VTE = venous thromboembolism.

### Primary outcome

There was no significant difference in 30-day mortality or 30-day readmission rate between individuals requiring and not requiring oxygen on discharge (p=0.14 and p=0.08, respectively). Both deaths occurred in the group not meeting the NHS England criteria for CVW discharge, but this difference was not statistically significant (p=0.52).

Two patients died within 30 days of discharge to the CVW, both in the community. One of these patients was managed by the CVW in a nursing home for 12 days but showed no sign of improvement. Due to underlying frailty and comorbidities, a decision was made to stop active treatment and the patient died 24 hours later. The second patient had advanced comorbidities and died in the community despite recovering from COVID-19, while receiving care from the local 'Hospital at Home' team. Due to the underlying diagnoses, death was not unexpected.

### Secondary outcomes

In total, five patients were readmitted (Table 1). The reasons for readmission were desaturation or increasing oxygen demand

in three patients, confusion and fall for one patient, and breathlessness and cough treated as bacterial lower respiratory tract infection for one patient. Length of readmission ranged from 2 to 18 days. One of these readmissions was initiated by the CVW team while the remaining four patients called for an ambulance outside of working hours.

LOS in the CVW ranged from 3 to 55 days (Fig 3). One patient remained under follow-up at the time of analysis (10 May 2021). CVW LOS was significantly longer in patients discharged with an oxygen concentrator compared with those discharged with no oxygen (p=0.03) and was longer for those not meeting the NHS England criteria for CVW discharge than those meeting the criteria (p<0.001).

Hospital LOS prior to discharge ranged from 0 to 60 days and was significantly longer for patients discharged with an oxygen concentrator than those discharged with ambulatory oxygen or no oxygen (p=0.02 and p=0.002, respectively; Fig 3). In addition, hospital LOS prior to discharge was longer for those not meeting the NHS England criteria for CVW discharge than those meeting the criteria (p=0.03). Early Warning Score (EWS) was significantly higher on discharge for patients discharged with an oxygen
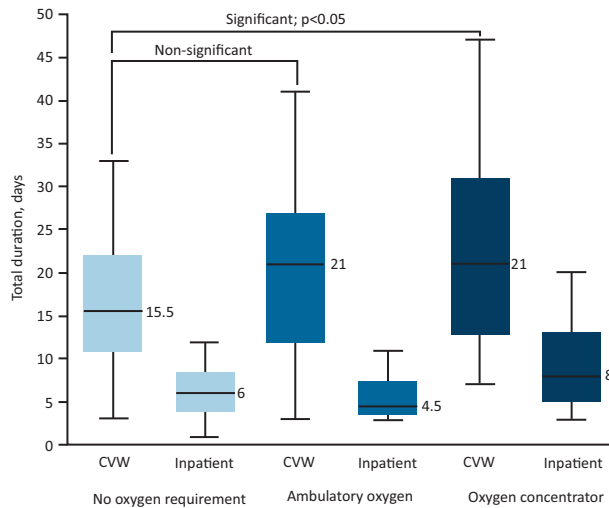
**Fig 3. Length of inpatient and COVID-19 virtual ward stay by oxygen group.** Median ± interquartile range. CVW = COVID-19 virtual ward.

concentrator than those discharged without oxygen (p<0.001) with no other significant pairwise comparisons.

Regarding community follow-up, a median of 3 reviews per patient were performed (Fig 4). The median number of total reviews for the groups requiring no supplementary oxygen, ambulatory oxygen or an oxygen concentrator were 2.5 (IQR 2–4), 3.5 (IQR 2–4.75) and 4 (IQR 2-5), respectively, (p<0.05). Significant pairwise comparisons were observed between the no supplementary oxygen and oxygen concentrator groups (p<0.05). The median number of home visits for the groups requiring no supplementary oxygen, ambulatory oxygen or an oxygen concentrator were 1 (IQR 0–1), 1 (IQR 1–2) and 2 (IQR 0–2), respectively, (p<0.05), with significant pairwise comparisons between no supplementary oxygen vs oxygen concentrator groups and ambulatory oxygen vs oxygen concentrator groups (p<0.05). The median number of telephone reviews for the groups requiring no supplementary oxygen, ambulatory oxygen or an oxygen concentrator were 2 (IQR 1–3), 2 (IQR 1–3) and 1 (IQR 0–2), respectively, (p<0.05).

Significant pairwise comparisons were observed between the no supplementary oxygen and oxygen concentrator groups (p<0.05).

Thirteen patients were prescribed anticoagulation on discharge for either venous thromboembolism (VTE) prophylaxis or newly diagnosed pulmonary embolism (PE). When prescribed VTE prophylaxis, 7 to 10 days of apixaban was prescribed, except for one pregnant patient who was given low-molecular weight heparin (LMWH) instead. Two patients developed deep vein thromboses (DVT), but no patients developed a PE within 30 days of discharge to the CVW. One DVT occurred in a patient with metastatic cancer on therapeutic LMWH with a known history of PE that had occurred 2 months prior. The second DVT occurred in a patient discharged into the community with an oxygen concentrator but without anticoagulation. The VTE incidence in those discharged on continuous oxygen without anticoagulation was 2.5%.

## Discussion

This study reports observed outcomes of patients with COVID-19 discharged to a virtual ward amid a pandemic. Despite including patients who were earlier in their recovery than suggested by NHS England guidance, results indicate that the CVW may be a safe and appropriate setting, including patients requiring supplemental oxygen via nasal cannulae. Readmission rates were low, particularly in comparison with a 13% readmission rate for patients with COVID-19 cared for at our hospital in the first 'wave' from 01 March 2020 to 30 June 2020. The CVW patient group exhibited low 30-day mortality with no preventable deaths according to existing standard care models.

The concept of a CVW is not particularly novel and has been incorporated in many settings, particularly in the UK, during the COVID-19 pandemic. However, to date, most CVWs have focused on admission avoidance through monitoring of patients via provision of pulse oximeters at home.[11,12] NHS England guidance suggests relative caution for discharge to the CVW including criteria such as observed oxygen saturations <92% as well as dyspnoea, unless it is representative of the patient's baseline. However, based on our experience of caring for these patients in the hospital, once the clinical trajectory is improving and patients are requiring only low-flow oxygen, many patients require almost no medical or nursing support while waiting for oxygen saturations to improve.
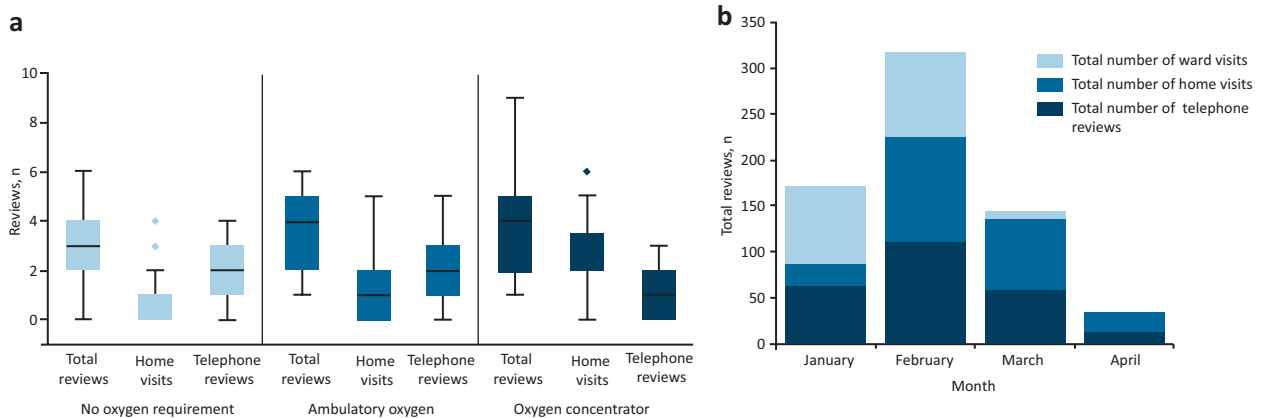


**Fig 4. Clinician reviews for patients on virtual ward. a) Average number of contacts per patient by group while on COVID-19 virtual ward.** Median ± interquartile range and full range, diamonds are outliers. **b) Total number of contacts per month for patients discharged to COVID-19 virtual ward between 02 January 2021 to 16 March 2021 including ward visits prior to discharge.**

Other authors have commented on the slow improvement in oxygen saturations for patients with COVID-19 who otherwise appear well. Daher *et al* noted a prolonged requirement of supplemental oxygen therapy for COVID-19 inpatients in comparison with those admitted with severe influenza.[13] This led to hospitalisations for COVID-19 exhibiting a greater LOS, with the median duration for supplementary oxygen and hospitalisation reported as 8 and 12 days, respectively. Furthermore, Ray *et al* reported a greater prevalence of prolonged oxygen requirement with notable difficulty in oxygen weaning among patients aged 60 years and above who are not requiring intensive care facilities compared with younger patients.[14] However, despite the interim requirement for oxygen support, patients may otherwise demonstrate stable parameters and thus not require other facilities or support from secondary and tertiary settings of care.

Despite being advocated by other groups, to the best of our knowledge, this is the first study to report the results of a CVW providing low-flow supplemental oxygen in order to facilitate early discharge in the UK.[10] This has the potential to significantly reduce the burden on acute hospital settings. One small study has retrospectively assessed the impact of early discharge with supplemental oxygen for individuals diagnosed with COVID-19.[15] In their analysis based in the Netherlands, 33 patients were discharged to a CVW, 20 of whom received supplemental oxygen at home. Patients were monitored via a smartphone or tablet application. Three (9%) patients were readmitted, which is similar to the observed readmission rate of our study. They reported no deaths, however, the follow-up period of their study is unclear.

The NHS England guidance for CVWs suggests that patients are loaned an oximeter, educated to perform serial saturation readings, and are contacted daily as they would be in a hospital ward round setting. The frequency of contact with a healthcare professional in our study was less than advised by NHS England, at a minimum of once weekly as opposed to once daily. This was changed for two reasons: firstly, the volume of patients being discharged to the CVW coupled with staff shortages due to illness and isolation made it unfeasible to provide once daily contact; and secondly, the patients in our study did not find daily contact useful or necessary. Frequency of contact was, therefore, based on clinical judgement and patient needs, with all patients on oxygen receiving at least one home visit.

This study provides a potential model for virtual hospital care that could be provided in future 'waves' of COVID-19. It is also conceivable that this model may be applicable to the management strategy of other respiratory illnesses (for example influenza), other viral pneumonias or chronic obstructive pulmonary disease. We have shown that this model can be rapidly implemented in the event of a sudden increase in pressure on acute hospital beds, allowing early discharge and better use of already stretched resources. During the period covered by this study, SARS-CoV-2 vaccination rates were increasing rapidly in the UK. We do not have data on vaccination status for patients discharged to the CVW, but it is likely that most patients were unvaccinated. It is unclear whether outcomes would be similar in future waves when vaccination rates are higher, but the CVW is likely to remain a useful model.

Implementation of a CVW requires allocation of additional resources including nurse specialists, senior respiratory doctors, equipment for delivery, and monitoring of oxygen therapy and administrative support. The unique circumstances of the COVID-19 pandemic allowed us to do this alongside inpatient clinical work through redeployment of staff from other areas of the hospital and cancellation of routine outpatient work. However, a strong argument could be made that a reduction in inpatient bed days would justify the expense of a virtual ward as part of standard care.

## Limitations

This study had several acknowledged limitations. Firstly, without a control group it is not possible to calculate saved bed days and, therefore, estimate the cost saving of the CVW. Furthermore, the absence of a contemporaneous control group means that we cannot compare mortality rates with standard inpatient hospital care. Secondly, despite a reasonable discharge to admission ratio, it is acknowledged that the total sample size is small and, as a result, readmission rates and mortality may be over- or underestimated. Finally, a minimum of once weekly review was selected in part due to staff numbers and more frequent review may have allowed more rapid oxygen weaning. However, given the low mortality and readmission rate in our population, we are doubtful that more frequent review would have led to improved outcomes for patients. Nevertheless, given the necessity for innovative delivery of care in a pandemic, we feel that this study adds useful information to aid the future management of patients with COVID-19.

## Conclusion

To the best of our knowledge, this is the first UK study to assess the safety of a CVW for patients recovering from COVID-19 who have been discharged with supplemental oxygen therapy. Extending the criteria provided by NHS England for discharge to a CVW exhibited promising outcomes regarding very low 30-day mortality and 30-day readmission rate. This study provides evidence towards a framework to be used for a virtual ward setting in the event of future waves of COVID-19, which could also potentially be extended to facilitate early discharge for patients suffering from other respiratory illnesses. ■

## Summary

### What is known?

COVID-19 virtual wards have been widely used across the UK during the recent pandemic. However, current NHS England guidelines do not currently advise discharge to virtual wards for patients with ongoing oxygen requirements.

### What is the question?

Can COVID-19 virtual wards be used to safely discharge patients for oxygen weaning at home?

### What was found?

There were no significant differences in readmission and mortality rates between patients discharged to the COVID-19 virtual ward with and without oxygen.

### What is the implication of practice now?

This study suggests that COVID-19 virtual wards can be used to safely discharge patients recovering from COVID-19 with an ongoing oxygen requirement.

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