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Home telemonitoring makes early hospital discharge of COVID-19 patients possible

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To the editor:

With great interest we read the article by Annis et al. 2020 in which they report a quick and effective implementation of a remote patient monitoring program as an effective approach for managing coronavirus disease 2019 (COVID-19) symptoms at home.[1]

Recently we have rapidly implemented another type of COVID-19 home telemonitoring which we would like to share with the readers of the *Journal of the American Medical Informatics Association*. We developed home telemonitoring after hospital discharge in COVID-19 patients to potentially reduce hospital stay whilst preserving good care. Furthermore, we report our experience with pulse oximetry, as was also suggested by Annis et al.[1]

Up to 15% of patients with COVID-19 require hospitalization and oxygen support due to respiratory dysfunction. The need for oxygen therapy increases length of hospitalization, since patients stay admitted until oxygen is tapered down. An increased duration of hospital stay increases use of facemasks and protective clothing, prolonged COVID-19 exposure for health care providers, and less available beds for other patients. During the COVID-19 pandemic, home telemonitoring emerged as a new and powerful modality.[1–3] We are the first to report on home telemonitoring in COVID-19 patients for early hospital discharge. We retrospectively report on our pilot of home telemonitoring for COVID-19 patients in the Netherlands. Main outcomes were reducing length of hospitalization, safety, and patient satisfaction.

Patients hospitalized for COVID-19 with clinical improving trend and oxygen therapy tapered down to a maximum of 3 L/min, were approached for discharge with home telemonitoring with or without oxygen therapy at home. Home telemonitoring consisted of daily control of oxygen saturation measured by pulse oximeter, temperature, and COVID-19 respiratory symptoms scored on a 0–10 numerical rating scale via an application (Luscii, Amsterdam, the Netherlands) on smartphone or tablet. Minimal system requirements for downloading the application was Android 7.0 or Apple iOS12. In the application, personalized thresholds with orange for moderate or red for severe deteriorations were set. Besides, patients could give comments. Warnings for deterioration or comments were sent directly to the dashboard available via a web browser. The dashboard updated several times a minute and was controlled by the home telemonitoring team consisting of medical residents supervised by pulmonologists. All data entries were saved and graphically displayed as trend to the team and patient. Patients received daily automatic reminders to fill in the app. Besides, the team could send personal messages to the patient. Furthermore, the team actively contacted patients by phone to assist in titration of oxygen therapy via nasal cannula and to control clinical follow-up.

We retrospectively included all COVID-19 patients discharged with home telemonitoring from the St. Antonius Hospital in the Netherlands between April 8 and May 20, 2020. We recorded demographic data, diagnostic method, admission at intensive care unit (ICU), oxygen therapy, disease duration, and length of hospitalization. In case of oxygen therapy at home, earlier discharge was the sum of days receiving oxygen therapy at home plus one day, compa-

Table 1. Patient characteristics of our COVID-19 home telemonitoring cohort (n = 33)

Gender, n (%)	
Male	22 (67)
Age, mean years (±SD)	57 (±12)
COVID-19 diagnosis based on, n (%)	
Polymerase chain reaction	31 (94)
Computed tomography	1 (3)
Chest X-ray	1 (3)
Admission to the intensive care, n (%)	7 (21)
Length of stay on intensive care, median days (IQR)	8 (5–14)
Oxygen therapy during hospitalization, n (%)	
Nasal oxygen or non-rebreather mask	26 (79)
Non-invasive ventilation or nasal high flow oxygen therapy	5 (15)
Intubation	2 (6)
Duration of disease on admission to home telemonitoring, mean days (±SD)	19.5 (±9.6)
Length of hospitalization, mean days (±SD)	10.6 (±7.0)
Oxygen therapy when discharged, n (%)	
Yes	20 (61%)
No	13 (39%)
Total reduction in length of hospitalization, days	
In need for oxygen therapy, $n = 19$[a]	124
No need for oxygen therapy, $n = 8$[b]	10
Average reduction in length of stay, mean days (±SD), $n = 27$	5.0 (±3.8)
Length of home telemonitoring, mean days (±SD)	13.4 (±4.1)
Amount of telephone contact, mean number (±SD)	7.2 (±2.6)

Normally distributed data were presented as mean and standard deviation (±SD). Non-normally distributed data were presented as median and interquartile range (IQR). Categorical data were presented as number and percentage.

[a]One patient was excluded due to underlying pulmonary disease.

[b]In 5 patients, no reduction in length of stay was expected.

rable to the hospital's ward protocol. A maximum of 14 days was noted if patients received more than 14 days of oxygen therapy at home. If patients did not require oxygen therapy at discharge, the treating physician estimated the diminished amount of hospitalization days at time of discharge. We recorded duration of telemonitoring and number of telephone contacts. Furthermore, patients completed a satisfaction questionnaire based on Consumer Quality Index in General Practice questionnaires.[4] Study data were collected using REDCap electronic data capture tools.[5] The Medical Research Ethics Committees United of the St. Antonius Hospital approved this study (reference number W20.107/Z20.065). Normally distributed data were presented as mean and standard deviation (±SD) and non-normally distributed data as median and interquartile range (IQR). Categorical data were presented as number and percentage. SPSS version 23.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analyses.

During the first 6 weeks of home telemonitoring, we included 33 patients (67% male). Patient's characteristics are shown in Table 1. A total of 20 patients (61%) received oxygen therapy after discharge ranging from 1 to 3 L/min. Estimated total reduction in length of hospitalization was 134 days with an average of 5.0 (±3.8) days per patient. For patients with oxygen therapy the estimated reduction was 6.5 (±3.4) days, without oxygen therapy 1.3 (±0.4) days.

Reassessment at the hospital was indicated in six (18%) patients due to suspicion of pulmonary embolism (n = 3), persistent hypoxemia (n = 2), and the inability to taper oxygen (n = 1). Three of these patients were readmitted to the ward and one patient was discharged with treatment for a diagnosed pulmonary embolism. No fatalities or emergency reassessments occurred. Satisfaction questionnaire was completed in 30 (91%) patients. Ninety-seven percent of patients rated home telemonitoring as user friendly. It took 87% less than 10 minutes a day to take the measurements and fill in the app. In respectively 13% and 87% of cases it was mostly or always clear what to do when low oxygen saturation was measured. One hundred percent would recommend home telemonitoring to acquaintances.

In summary, while Annis et al[1] focused on the use of telemonitoring for potential COVID-19 patients, we are the first study to focus on home telemonitoring of severe COVID-19 after discharge from the hospital. We show that early discharge is possible in this group if home telemonitoring with use of pulse oximetry is offered. The greatest reduction in hospitalization duration is seen in patients in need of home oxygen therapy. Reduction in length of hospitalization makes more beds available for patients thereby reducing the use of protection materials, staff COVID-19 exposure, and overall healthcare costs. Furthermore, telemonitoring is safe, positively contributes to patient satisfaction, and enables them to recover in their home environment. A positive response of patients was also recorded by Annis et al.[1] In our institution, home telemonitoring is cost effective. The costs for the application and staff are approximately 4-fold lower than the estimated costs of the saved admission days. We are aware that a cost effectiveness analysis for other COVID-19 telemonitoring projects will vary according to country and type of institution and cannot be generalized. A limitation of our study is that the reduction in length of hospitalization was not studied with a control group. Although patient numbers are decreasing in the Netherlands, our results remain of relevance since the COVID-19 pandemic is globally still ongoing with a risk for a second wave.

To conclude, home telemonitoring after early discharge in COVID-19 patients is a safe, cost-effective, and patient-friendly tool, which reduces mean duration of hospitalization, especially in patients in need of home oxygen therapy.

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CONFLICT OF INTEREST STATEMENT

None to declare.

AUTHOR CONTRIBUTIONS

All authors made substantial contributions to the conception or design of the work, the analysis, and interpretation of data. LG, KM, and AV drafted the work. Critical revision was done by AV, EM, JH, and CvS. All authors approved the final version to be published. All authors agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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