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# Home Oxygen and Monitoring for COVID-19 Patients: A Multidisciplinary Team Approach

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## Home Oxygen and Monitoring for COVID-19 Patients: A Multidisciplinary Team Approach


### Cover Page Footnote

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# Home Oxygen and Monitoring for COVID-19 Patients: A Multidisciplinary Team Approach

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**Abstract**

*Introduction*: **During the initial COVID-19 pandemic peak, Stamford Hospital implemented a home oxygen program (HOP) to create a comprehensive, multi-disciplinary outpatient initiative without sacrificing a safe discharge. Primary care physicians monitored program participants, whose only indication for remaining admitted was an oxygen requirement. We retrospectively examined participant co-morbidities and outcomes, including death and readmission rates to evaluate HOP safety.**

*Methods*: **A retrospective analysis of program participants discharged between April 2020-Janurary 2021 was performed. Variables included demographics, oxygen requirement, days enrolled in the HOP, and major comorbidities such as cardiovascular disease (CVD), diabetes (DM), hypertension (HTN), obesity, chronic kidney disease, malignancies and underlying chronic obstructive pulmonary disease (COPD).**

*Results*: **Among the 138 HOP participants, ages ranged from 23 to 96 (Mean 65.5), with 47.1% female and 52.9% male. The most represented ethnicity included White (48.6%), Hispanic (29.7%), and Black (15.2%). Patients' average time in the HOP was 19 days, requiring an average of 1.7 L/min of home oxygen. Thirteen patients (9.4%) were readmitted to the hospital with 2.9% secondary to worsening COVID-19 hypoxia, but no deaths occurred at home. A significant relationship was found between age and highest home oxygen need. Patients with COPD, HTN, and DM had significantly higher oxygen requirements (P-value <0.05).**

*Conclusion*: **Increasing age, underlying COPD, HTN, and DM were associated with higher oxygen requirements in participants. Given limited availability of hospital beds, and no occurrences of death at home, Stamford Hospital HOP safely helped provide care for sicker patients and enhanced resource allocation.**

*Keywords:* COVID-19, Pulse oximetry, Telemedicine, Home telemonitoring, Home oxygen program

## 1. Introduction

In March 2020, like many hospitals in the New York (NY) metropolitan epicenter of the developing COVID-19 pandemic, Stamford Hospital (SH) faced dramatic surges in the number of admitted patients. By April 14th, SH reached its peak inpatient census, and the creation of additional, temporary intensive care units (ICUs) expanded our critical care capacity from 20 to 61 beds. As sick, though improving, patients were being shifted from the ICU to general medical teams, we needed to transfer general medical floor patients to other sites of care. SH's older, decommissioned hospital building was opened and designated as an Alternate Care Site (ACS) to provide space for those patients who were unable to be discharged home but no longer required acute care services. Literature that emerged early in the pandemic suggested that more mildly ill patients often decompensated quickly later in their course of their illness, so continued hospitalization for monitoring seemed warranted.[1,2]

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However, due to the influx of critically ill patients and limited space,[3] patients healthy enough to be discharged home, but still requiring monitoring and supplemental oxygen therapy, presented a COVID-19 patient population the hospital was not equipped to manage efficiently. SH, along with many other sites,[4-9] initially lacked the infrastructure to support this need.

To best support our patients requiring home monitoring and supplemental oxygen, a Home Oxygen Program (HOP) was developed. To free up inpatient beds for the predicted further surges in patients requiring hospitalization, our discharge policies were augmented to accommodate this need. This practice was guided by previous epidemics as well as HOP utilization for patients with chronic diseases during non-emergency states.[10-14] It is also important to note that under pandemic emergency policies, Centers for Medicare & Medicaid Services (CMS) and commercial insurance companies suspended the usual requirements and documentation for home oxygen, requiring only a diagnosis of COVID-19, paving the way for this important initiative.[15,16] SH's HOP was a comprehensive, multi-disciplinary outpatient initiative to help shorten the length of stay (LOS) in the hospital for COVID-19 patients without sacrificing a safe discharge. This program was designed to alleviate additional strain on an already overburdened and overwhelmed health care system by using a team of a registered nurses (RN) and case managers (CM), with supervision from primary care physicians (PCP), to carefully monitor and follow-up with these patients. Here we report on the outcomes of this program to evaluate its safety and effectiveness.

## 2. Methods

One-hundred thirty-eight patients were enrolled in the HOP at SH from April 2020 to January 2021. Patients were eligible for the short-term oxygen therapy monitoring program if their only indication for remaining hospitalized was an oxygen requirement, guided by CMS's public health emergency pandemic guidelines for home oxygen therapy post-acute COVID-19 infection.[15] Criteria included inpatients with an oxygen requirement of less than 6 L/min for more than 48 h; or an Emergency Department (ED) stay with an oxygen requirement of less than 2 L/min. Adequate home resources, cognitive abilities, and ongoing follow-up by a PCP were additional requirements. Current smokers and patients with severe or decompensated co-morbidities were excluded from program entry. Portable pulse oximeters along with oxygen tanks were delivered to the patients on discharge. RNs and CMs closely followed the patients by daily phone calls with PCP supervision and instructed the patients on an oxygen taper based on their symptoms and pulse oximeter reads. If any worsening of patients' symptoms or significant hypoxia occurred, they were referred back to the hospital ED. Some patients did not require oxygen after discharge, but they were still monitored given tenuous respiratory status. Patients were followed closely until they met all criteria to discharge from the program: improvement in COVID-19 symptoms, afebrile for more than 24 h, able to do activities of daily living (ADLs) without significant dyspnea, oxygen saturation of greater than 94% at rest on repeated measurements, and oxygen saturation greater than 90% during ADLs.

After the study protocol was approved by the SH's Institutional Review Board, this retrospective chart review was conducted to evaluate the program's safety and efficacy by measuring the number of deaths at home and COVID-19 hypoxia related readmissions. Additional demographic information extracted from patient medical records included race and ethnicity (as recorded by the hospital registrar), body mass index (BMI), and patients' comorbidities such as cardiovascular disease (CVD), diabetes mellitus (DM), hypertension (HTN), obesity, chronic kidney disease (CKD), history of malignancies, and underlying chronic obstructive pulmonary disease (COPD). Patients' readmission to the hospital along with admission diagnosis were documented as well. Secondary outcomes included investigating the relationship between comorbidities and disease severity based on days followed in the program or level of oxygen requirement.

### 2.1. Statistical analysis

SPSS version 28.0 was used for all statistical analyses. Demographic analysis for each discrete variable included count and percent within each category. Continuous data were reported as mean and standard deviation (SD), with sample size, median, minimum and maximum values also reported. To be included for the "days on home oxygen" variable, participants were required to have used the oxygen provided at home. All zero values were excluded for all analyses related to home oxygen use.

Pearson product moment correlation coefficients (r) were used to analyze the association between patient age, BMI, and the variables "days followed in oxygen program", and "highest home oxygen needs". Results include sample size, correlation coefficients and p-values. In addition, group t-tests were calculated for continuous variables including days followed in the oxygen program and "highest home oxygen needs". Grouping variables included gender and race and ethnicity (excluding Asian and other categories due to the small sample size), and other comorbidities and medical condition variables including patient readmission rates.

For race and ethnicity categories (Black, Hispanic, White) an analysis of variance (ANOVA) was performed. A supplemental analysis was additionally conducted to compare demographics and outcomes for participants who were and were not readmitted via group t-tests. A p-value of 0.05 was used for all data analyses to determine statistical significance. There were no corrections applied to the data for multiple comparisons, and no missing value imputation methods were used.

## 3. Results

Demographic characteristics for discrete and continuous variables can be found in Table 1 and Table 2. There were 138 patients included in the analysis with approximately equal numbers of male and female patients, with White patients (48.6%) outnumbering those who were Hispanic (29.7%) or Black (15.2%). HOP participants had a mean age of 65 years with the minimum age of 23 and maximum age of 96. The average BMI was 30.75 (SD = 7.96).

The average time in days of follow up while in HOP was 19.14 days (SD = 13.51, with 2 days as the minimum and 80 days on the maximum). Correlation analysis showed a significant relationship between age and highest home oxygen needs (r = 0.190, p-value 0.026) with data analyzed for 138 patients (Table 3). Group t-tests did not find significant differences between demographic variables, pre-existing comorbidities and the number of days followed in the program (Table 4).

*Table 1. Demographics and comorbidities (Discrete variables).*

| Variable | Category | Count (%) |
|---|---|---|
| Gender | Female | 65 (47.1) |
| | Male | 73 (52.9) |
| Race | Asian | 6 (5.29) |
| | Black | 21 (15.2) |
| | Hispanic | 41 (29.7) |
| | White | 67 (48.6) |
| | Unknown | 3 (2.2) |
| CKD | | 11 (8.0) |
| CVD | | 23 (16.7) |
| DM | | 51 (37.0) |
| HTN | | 76 (37.0) |
| History of Cancer | | 18 (13.0) |
| COPD | | 9 (6.5) |

*Table 2. Participant Demographics and Summary Statistics for Continuous Variables*

| Variable | n | Median | Mean (SD) |
|---|---|---|---|
| Age | 138 | 69 | 65.6 (16.04) |
| BMI | 131 | 29.4 | 30.7 (7.96) |
| Days on home Oxygen[a] | 97 | 16 | 19.86 (16.10) |
| Days followed in HOP | 138 | 15 | 19.14 (13.51) |
| Lowest Pulse Oximeter Level | 137 | 0.9 | 0.90 (0.05) |
| Highest home oxygen needs | 138 | 2.0 | 1.71 (1.33) |

[a] Excludes patients with 0 days as non-home 02 users.

*Table 3. Pearson Correlations: Interval by Interval Variables.*

| Variable | Statistic | Days followed in HOP program | Highest home 02 needs |
|---|---|---|---|
| Patient age | Correlation 'r' | −0.027 | **0.190** |
| | p-value | 0.752 | **0.026** |
| | N | 138 | **138** |
| BMI | Correlation 'r' | 0.022 | −0.012 |
| | p-value | 0.805 | 0.893 |
| | N | 131 | 131 |

Results for the "highest home oxygen needs" variable did show significant differences for patients with COPD, HTN, and DM, who required significantly more oxygen than patients without such comorbidities (p = 0.009, p = 0.012, p = 0.019, respectively) (Table 5). No differences were found for demographic variables including gender and race and ethnicity. The all-cause readmission rate within 30 days[b] was 9.4% (weakness n = 2, Bell's Palsy n = 1, urinary tract infection n = 2, vestibular neuritis n = 1, hypoxia n = 7). The total hypoxia associated readmission rate was 5.1%, with hypoxia related to COVID-19 diagnosed in 2.9% (n = 4)

*Table 4. Days followed in HOP (Group t-tests except for Race which is ANOVA).*

| Variable | Category | Mean (SD) | p-value |
|---|---|---|---|
| Gender | Female | 18.7 (12.9) | 0.351 |
| | Male | 19.6 (14.1) | |
| CKD | No | 19.2 (13.9) | 0.897 |
| | Yes | 18.6 (9.0) | |
| CAD/CHF | No | 19.0 (12.3) | 0.844 |
| | Yes | 19.7 (18.7) | |
| Diabetes | No | 18.4 (13.5) | 0.372 |
| | Yes | 20.5 (13.5) | |
| Hypertension | No | 19.5 (13.9) | 0.791 |
| | Yes | 18.9 (13.3) | |
| History of Cancer | No | 19.6 (13.8) | 0.318 |
| | Yes | 16.2 (11.2) | |
| COPD | No | 18.6 (12.9) | 0.053 |
| | Yes | 27.6 (19.5) | |
| Re-admission | No | 19.9 (13.7) | 0.058 |
| | Yes | 12.4 (8.9) | |
| Race[a] | Black | 16.3 (9.9) | 0.556 |
| | Hispanic | 20.3 (11.8) | |
| | White | 19.5 (15.8) | |

[a] Excludes Asian and Other categories (n = 4 combined).

*Table 5. Highest Home Oxygen Needs (Group t-tests except for Race which is ANOVA).*

| Variable | Category | Mean (SD) | p-value |
|---|---|---|---|
| Gender | Female | 1.7 (1.4) | 0.759 |
| | Male | 1.7 (1.3) | |
| CKD | No | 1.7 (1.3) | 0.612 |
| | Yes | 1.9 (1.1) | |
| CVD | No | 1.7 (1.3) | 0.786 |
| | Yes | 1.8 (1.4) | |
| Diabetes | No | 1.5 (1.2) | **0.019** |
| | Yes | 2.1 (1.4) | |
| Hypertension | No | 1.4 (1.3) | **0.012** |
| | Yes | 2.0 (1.3) | |
| History of Cancer | No | 1.7 (1.4) | 0.977 |
| | Yes | 1.7 (1.1) | |
| COPD | No | 1.7 (1.4) | **0.009** |
| | Yes | 2.2 (0.4) | |
| Readmission | No | 1.7 (1.3) | 0.543 |
| | Yes | 1.5 (1.7) | |
| Race[a] | Black | 1.8 (1.2) | 0.358 |
| | Hispanic | 1.5 (1.5) | |
| | White | 1.9 (1.2) | |

[a] Excludes Asian and Other categories (n = 4 combined).

participants. The other three hypoxia-related readmissions were due to CHF exacerbation or bacterial and aspiration pneumonia. Differences were not found for participant demographic variables, comorbidities (Supplemental Table 1) or home oxygen use (Supplemental Table 2).

## 4. Discussion

SH's HOP was implemented in April of 2020 during the first regional COVID-19 surge, and as of January 2021, a total of 138 patients had been followed by the program. Our results support the safety of this novel approach given there were no deaths at home and the 30-day all-cause mortality rate was 1.45% (d.n.s). The total readmission rate in our study was 9.4%, with a 30-day readmission rate of 7.2%, almost half of the 2018 national average 30-day hospital readmission rate.[17] Furthermore, as the average duration of time patients were in the HOP was 19 days, the data suggests that as the number of hospital patient days program participants were able to convalesce at home due to newly implemented pandemic emergency policies.

Four of the 13 total readmissions in our study were in the setting of worsening COVID-19 related hypoxia. Among those, one never used the oxygen at home, and one was discharged from program after 9 days due to non-adherence and readmitted on day 11. Two patients (1.4%) who were monitored and adherent with oxygen use, subsequently deteriorated at home and were readmitted to the hospital secondary to COVID-19-induced hypoxia. This further reinforces the efficacy of a post-discharge HOP with a less than a 2% readmission rate for those patient's adherent to the HOP. Similarly, Banerjee et al. reported an all-cause mortality rate of 1.5% and a 30-day readmission rate of 8.5% in 621 COVID-19 HOP participants.[18]

Significant differences in COVID-19 outcomes have been shown among racial and ethnic groups, with increased disease severity and worse outcomes in Black and Hispanic patients.[19] Our study included substantial numbers of Black and Hispanic as well as White patients, but we did not find differences between these groups in days followed in HOP, highest oxygen needs, or readmissions.

The mainstay of COVID-19 respiratory failure treatment is oxygen administration and invasive or non-invasive ventilation. Despite improvement in systemic symptoms, many patients remain hypoxic while receiving less than 6 L/min of oxygen, which is cited to be a barrier to hospital discharge.[4,14,20,21] In an attempt to shorten hospital stay, new types of management paradigms needed to be designed. Home telemonitoring of oxygen levels was proposed by several studies around the world using different modalities and outpatient monitoring techniques.[4,6,12,22,23]

A study of a HOP implemented in April 2020 at a large urban hospital system reported mixed findings. Although patient satisfaction with the program was positive 54 out of 305 (18.0%) patients were readmitted to acute care, six of whom expired due to complications from COVID-19.[7] Another HOP was initiated in 2020 by the nursing department within a Veterans Health Administration system.[6] The program relied on novel triage and follow-up protocols utilizing telehealth methodology, but participants reported major barriers when accessing or navigating the technology at home. This barrier is similarly reported among many telehealth based program participants of lower socioeconomic status and those of older ages.[24-26]

COVID-19 is likely to be more severe in patients with comorbidities such as older age, cancer, cerebrovascular disease, CKD, chronic lung disease including COPD, chronic liver diseases, DM, coronary artery disease or heart failure, obesity, smoking, pregnancy, tuberculosis, and mental health disorders.[2,27] Most studies documenting increased disease severity with these conditions analyzed the inpatient data.[1,28-31] Our study, taking place in the outpatient setting similarly found that older age, underlying COPD, HTN, and DM were associated with higher oxygen requirements. These results suggest that close monitoring of oxygen saturation should be prioritized for at risk patients. Further outpatient studies are needed to better evaluate these findings.

### *4.1. Limitations*

Our study was an observational study with potential biases in patient selection for the HOP as well as limitations in the retrospective nature of the study design. Recall bias in symptoms and relying on subjective, patient reported data is an additional limitation of this report. Data to conduct a comparison in outcomes between participants and non-participants was not available, similarly to other literature on HOP evaluations with similar results.[18] Therefore, the generalizability of results may be limited to other institutions or patient populations.

## 5. Conclusion

This study demonstrates that providing hypoxia monitoring and supplemental oxygen post-hospitalization for COVID-19 patients utilizing a comprehensive outpatient monitoring program is safe and improves resource allocation. Hospital systems can utilize this strategy during the continuing COVID-19 pandemic (and perhaps in future respiratory epidemics and pandemics) to preserve hospital beds and reallocate resources in a safe and effective manner.

## Disclaimers

Preliminary results of this research was internally presented on May 18th, 2022, at Stamford Hospital's Annual Research Day.

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### Conflict of interest

The authors do not have any conflicts of interest in relation to this work.

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## Appendix A.

*Supplemental Table 1. Readmission Rates by with Demographic variables, group t-tests.*

| Variable | Category | No Readmission | | [b]Readmission | | p-value |
|---|---|---|---|---|---|---|
| | | Count | % | Count | % | |
| Gender | Female | 61 | 48.8 | 4 | 30.8 | 0.215 |
| | Male | 64 | 51.2 | 9 | 69.2 | |
| CKD | No | 116 | 92.8 | 11 | 84.6 | 0.300 |
| | Yes | 9 | 7.2 | 2 | 15.4 | |
| CAD/CHF | No | 105 | 84.0 | 10 | 76.9 | 0.515 |
| | Yes | 20 | 16.0 | 3 | 23.1 | |
| Diabetes | No | 80 | 64.0 | 7 | 53.8 | 0.470 |
| | Yes | 45 | 36.0 | 6 | 46.2 | |
| Hypertension | No | 57 | 45.6 | 5 | 38.5 | 0.622 |
| | Yes | 68 | 54.4 | 8 | 61.5 | |
| History of Cancer | No | 109 | 87.2 | 11 | 84.6 | 0.792 |
| | Yes | 16 | 12.8 | 2 | 15.4 | |
| COPD/Asthma/OSA | No | 117 | 93.6 | 12 | 92.3 | 0.857 |
| | Yes | 8 | 6.4 | 1 | 7.7 | |
| Race[a] | Black | 19 | 16.2 | 2 | 16.7 | 0.713 |
| | Hispanic | 36 | 30.8 | 5 | 41.7 | |
| | White | 62 | 53.0 | 5 | 41.7 | |
| Followed by resident | No | 105 | 84.0 | 11 | 84.6 | 0.954 |
| | Yes | 20 | 16.0 | 2 | 15.4 | |

[a] ANOVA. Excludes Asian and Other categories (n = 4 combined).
[b] All readmissions were assessed at 30 days post-hospital discharge, except for one additional readmission captured at 33 days, included due to clinical relevance.

*Supplemental Table 2. Readmission Rates with continuous variables. Group t-tests.*

| Variable | No Readmission | | | [b]Readmission | | | p-value |
|---|---|---|---|---|---|---|---|
| | n | Mean | SD | n | Mean | SD | |
| Age | 125 | 65.4 | 15.9 | 13 | 67.1 | 17.1 | 0.721 |
| BMI | 118 | 30.2 | 6.5 | 13 | 36.2 | 15.6 | 0.193 |
| Days on home oxygen[a] | 89 | 20.7 | 16.4 | 8 | 10.5 | 7.3 | 0.086 |
| Days followed in HOP | 125 | 19.9 | 13.7 | 13 | 12.4 | 8.9 | 0.058 |
| Lowest Pulse Oximeter Level | 124 | 0.9 | 0.1 | 13 | 0.9 | 0.1 | 0.333 |
| Highest home oxygen needs | 125 | 1.7 | 1.3 | 13 | 1.5 | 1.7 | 0.543 |

[a] Excludes patients with 0 days as non-home oxygen users.
[b] All readmissions were assessed at 30 days post-hospital discharge, except for one additional readmission captured at 33 days, included due to clinical relevance.

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