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COVID-19 and Risk of Oxygen-Dependent Chronic Respiratory Failure: A National Cohort Study

To the Editor:

Coronavirus disease (COVID-19) can impair gas exchange (1), but the risk of post-infectious oxygen-dependent chronic respiratory failure is unknown.

We performed a population-based, nationwide study of cumulative incidence, risk factors and clinical course of long-term oxygen therapy (LTOT) after COVID-19, using data from the SCIFI-PEARL (Swedish Covid-19 Investigation for Future Insights – a Population Epidemiology Approach using Register Linkage) study (2). We included all people in Sweden aged ⩾16 years with a laboratory-confirmed severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection from January 1, 2020, until August 31, 2021, with no LTOT before the COVID-19 diagnosis. Data on LTOT start any time after COVID-19 until September 30, 2021, were obtained from the Swedish National Registry of Respiratory Failure (Swedevox) (3). In Sweden, home oxygen is prescribed strictly according to the American Thoracic Society (ATS)/European Respiratory Society (ERS) criteria at specific respiratory units, using stationary and portable oxygen concentrators (3).

Risk factors for starting LTOT after COVID-19 were assessed using multivariable logistic regression. Severity of COVID-19 was categorized as mild (no hospitalization), severe (hospitalized without need of ICU), or critical (ICU care), age as 16–49, 50–59, 60–69, and ⩾70 years, and education as primary (compulsory school of 9 years), secondary (2–3 years beyond compulsory school), and tertiary education (university studies). COVID-19 comorbidity risk groups according to the National Board of Health and Welfare (4) included chronic heart, lung, and renal disease, type 2 diabetes with complications, obesity, and hypertension. Chronic lung diseases included chronic obstructive pulmonary disease (COPD; 85%), interstitial lung disease, cystic fibrosis, or chronic respiratory failure from other causes (4). Cumulative incidence of LTOT starts was compared among four periods: January–July 2020 (first wave); August–December 2020 (original SARS-CoV-2 variant of concern [VOC] with standardized COVID-19 treatments including corticosteroids and ventilation strategies [5]); January–March 2021 (alpha variant dominance); and April–September 2021 (delta variant and established mass vaccination in Sweden). In two merged periods—January–December 2020 and January–September 2021, including new VOCs and mass vaccination—differences in cumulative incidence and factors associated with LTOT were analyzed using chi-square tests, interaction analysis by period, and multivariable logistic regression.

In patients starting LTOT after COVID-19, frequencies of death, LTOT discontinuation due to improvement, and ongoing LTOT up to September 30, 2021, were calculated.

During the entire observation period of 21 months, 271 of 992,968 individuals with COVID-19 started LTOT. The overall cumulative incidence was 27 (95% confidence interval [CI], 24–31) per 100,000, decreasing over time from 81 (January–July 2020) to 28 (August–December 2020), 25 (January–March 2021), and 13 (April–September 2021). The difference between 2020 and 2021 was statistically significant: 38 (32–44) versus 20 (16–23) per 100,000, $P < 0.0001$, as was effect modification by first or second period on the associations of hospitalized COVID-19 infection and chronic respiratory disease, respectively, with LTOT start (data not shown).

Median time from COVID-19 confirmation to LTOT start was 46 (interquartile range [IQR], 30–83) days. Overall and in both time periods, the strongest independent risk factors for LTOT were severe or critical COVID-19, older age, and preexisting chronic respiratory disease (Table 1 and Figure 1). Lower educational level and female sex were associated with higher LTOT risk for the entire observation period, with similar point estimates in both periods (Table 1). In an

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Table 1. Risk Factors for Long-Term Oxygen Therapy after COVID-19

Explanatory Variables	Jan 2020–Sep 2021 (*N* = *992,698*) OR (95% CI)	Jan–Dec 2020 (*N* = *424,472*) OR (95% CI)	Jan–Sep 2021 (*N* = *568,496*) OR (95% CI)
Severity of COVID-19			
Mild	Ref	Ref	Ref
Severe	35.6 (21.7 to 58.5)	21.9 (11.9 to 40.6)	67.6 (30.0 to 152.3)
Critical	161.3 (96.1 to 270.5)	112.3 (59.1 to 213.4)	259.3 (110.6 to 607.8)
Sex			
Male	Ref	Ref	Ref
Female	1.37 (1.06 to 1.76)	1.34 (0.97 to 1.86)	1.40 (0.95 to 2.08)
Age groups			
16-49	Ref	Ref	Ref
50-59	1.99 (1.03 to 3.84)	3.18 (1.17 to 8.62)	1.26 (0.51 to 3.12)
60-69	5.14 (2.88 to 9.18)	7.88 (3.15 to 19.7)	3.40 (1.58 to 7.31)
>=70	5.75 (3.24 to 10.2)	9.45 (3.83 to 23.4)	3.42 (1.59 to 7.33)
Education			
Primary	1.37 (0.94 to 2.00)	1.31 (0.81 to 2.14)	1.47 (0.82 to 2.65)
Secondary	1.53 (1.07 to 2.18)	1.55 (0.98 to 2.45)	1.51 (0.86 to 2.64)
Tertiary	Ref	Ref	Ref
Chronic heart disease	1.35 (0.98 to 1.86)	1.43 (0.96 to 2.14)	1.24 (0.73 to 2.08)
Chronic lung disease	8.16 (6.16 to 10.8)	6.82 (4.75 to 9.81)	10.7 (6.88 to 16.7)
Chronic renal disease	0.71 (0.34 to 1.49)	0.66 (0.26 to 1.66)	0.84 (0.25 to 2.77)
Type 2 diabetes with complications	0.95 (0.54 to 1.66)	0.90 (0.45 to 1.79)	1.06 (0.41 to 2.78)
Obesity	1.36 (0.87 to 2.13)	1.67 (0.96 to 2.92)	0.96 (0.45 to 2.07)
Hypertension	0.83 (0.62 to 1.11)	0.91 (0.63 to 1.33)	0.74 (0.47 to 1.17)

Definition of abbreviations: CI = confidence interval; COVID-19 = coronavirus disease; LTOT = long-term oxygen therapy; OR = odds ratio; Ref = reference.

Logistic regression analysis of associations with incident LTOT in an unselected national sample of all patients with laboratory-confirmed COVID-19 in the Swedish population aged 16 yr and above, identified January 1, 2020, until August 31, 2021. Severity of COVID-19: Mild = not hospitalized; and severe = hospitalized but not ICU; critical = hospitalized with ICU. Primary education = compulsory school; secondary education = 2–3 yr beyond compulsory school; and tertiary education = university studies.

analysis restricted to hospitalized patients, risk factors for LTOT after COVID-19 (odds ratio; 95% CI) in both merged periods were chronic respiratory disease (5.84; 4.01–8.52 and 8.11; 5.11–12.9) and higher age (60–69 years: 6.12; 2.36–15.9 and 1.71; 1.32–5.60; ⩾70 years: 5.00; 1.95–12.8 and 2.10; 1.02–4.33). During a median follow-up of 150 (IQR, 89–230) days, 181 (67%) remained on LTOT, 42 (15%) died, and 48 (18%) patients discontinued LTOT. In the latter, 67% had no previous respiratory disease, median (IQR) time on LTOT was 89 (50–158) days, and 54% discontinued LTOT within 3 months.

This is the first population-based nationwide study, to our knowledge, evaluating incidence and risk factors for LTOT in patients with laboratory-confirmed COVID-19. In summary, the proportion developing oxygen-dependent chronic respiratory failure after COVID-19 is considerably lower than reported from selected populations (6, 7). The decrease of LTOT incidence during the study period suggests protective effect from improved treatment and vaccination (5).

Chronic respiratory disease is an expected risk factor for LTOT after COVID-19, as it increases risk for chronic hypoxic respiratory failure (3) and increases mortality in COVID-19 (8). The overall number of LTOT starts in Sweden did not increase among 2019 (n = 1,084), 2020 (n = 1,037), and 2021 until last September (n = 830). However, 65 of 160 people (41%) starting LTOT after COVID-19 in 2020 had underlying chronic respiratory disease. We speculate that a substantial proportion of patients with chronic respiratory disease would have been started on LTOT anyway but received LTOT earlier owing to COVID-19. The association of higher age with risk of LTOT after COVID-19 is consistent with the progressive decline of lung function (9). The association of lower education with LTOT is consistent with the association of lower socioeconomic status with worse COVID-19 outcomes (10). The finding that LTOT was slightly more common in women confirms our previous study in which 62% of patients receiving LTOT generally are women (3). The finding that 18% of LTOT patients were able to quit oxygen treatment supports previously reported improvement of lung function in patients followed until 12 months after a COVID-19 infection (1).

Study strengths are the inclusion of all laboratory-confirmed COVID-19 cases in the entire adult population of Sweden, high data validity, and coverage of Swedevox exceeding 90% of patients starting LTOT nationwide (3). A potential limitation is that our study period could not include the most recent VOC, omicron. However, it covers both the initial phase and the establishment of treatment strategies, mass vaccination, and several new VOCs. In addition, follow-up after omicron would be too limited to date.

We conclude that the risk of developing oxygen-dependent chronic respiratory failure after COVID-19 is generally low. The strongest risk factors are severe or critical COVID-19, higher age, and preexisting chronic respiratory disease. During our follow-up, a substantial proportion were able to quit LTOT. Future research should focus on longer-term follow-up of post–COVID-19 oxygen-dependent chronic respiratory failure. ■

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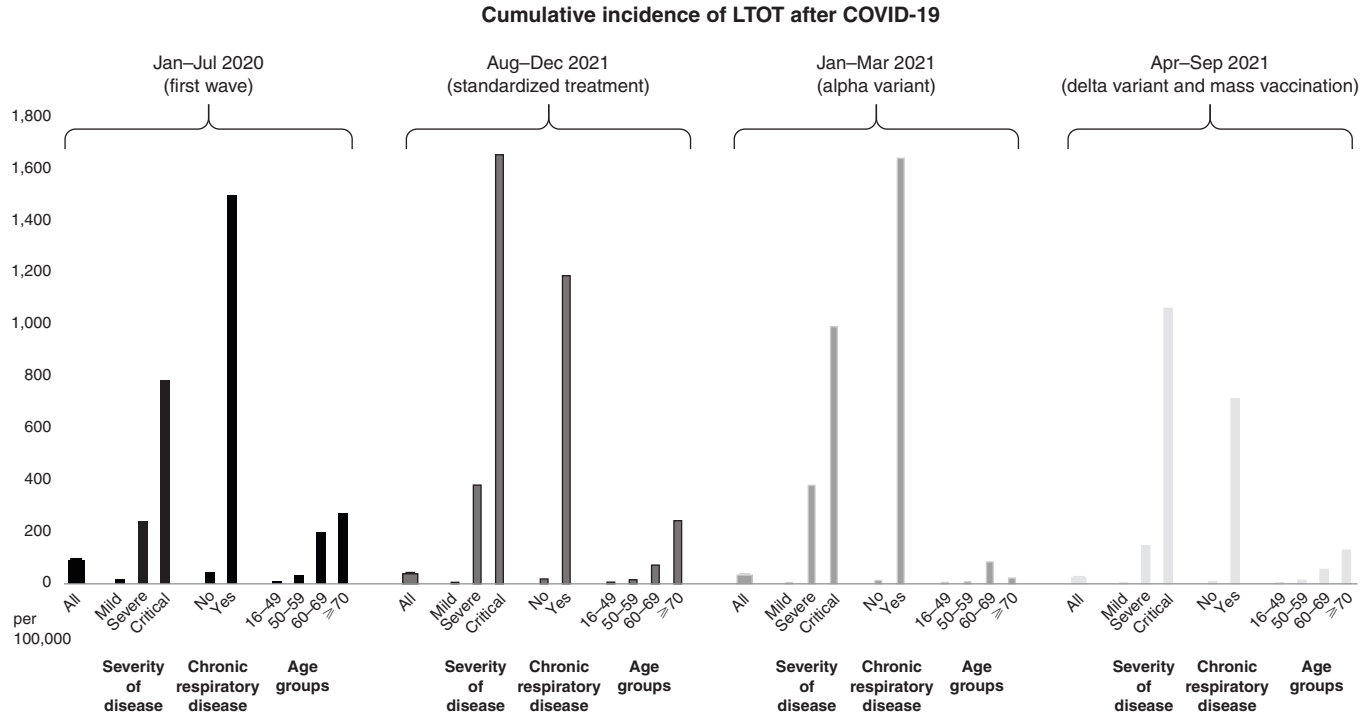

Figure 1. Incidence of long-term oxygen therapy (LTOT) after coronavirus disease (COVID-19). Cumulative incidence of LTOT starts presented as number per 100,000 patients distributed by severity of COVID-19, in an unselected national sample of all patients with laboratory-confirmed COVID-19 in the Swedish population aged 16 years and above, identified January 1, 2020, until August 31, 2021. The bar clusters refer to the periods of January–December 2020, covering the phase of the original variant of COVID-19, and January–September 2021, including new severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) variants of concern and mass vaccination. Chronic respiratory disease (yes/no) and age groups.

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Long-Term Trends in Home Respiratory Medical Equipment among U.S. Medicare Patients, 2013–2019

To the Editor:

Long-term respiratory equipment for home use, such as oxygen and positive airway pressure devices, is a vital part of treating chronic respiratory disease. This equipment, termed "durable medical equipment" (DME) in the United States, is covered by the U.S. Medicare national health insurance plan. To provide this equipment while managing costs, Medicare implemented the Competitive Bidding Program (CBP) in 2011 and scaled up the program nationwide in 2013 and 2016 (1). The CBP replaces the previous DME fee schedule with a process that awards contracts to DME suppliers with the best prices. Since the start of the CBP, the total number of DME suppliers nationwide has decreased across all equipment categories (2). Respiratory professional societies and patient groups are particularly concerned that the CBP has led to a reduction in the number of respiratory DME suppliers and, as a result, patient access to respiratory DME and its associated clinical benefits (3). Currently, few data exist about how respiratory DME specifically has changed since the CBP began.

This letter has an online data supplement, which is accessible at https://github.com/kevin-i-duan/AJRCCM-CMS-DME-Project.git.

Methods

We analyzed all publicly available nationwide Medicare DME data from 2013 to 2019 (4). DME data were not publicly available before 2013. We identified respiratory DME products by Healthcare Common Procedure Coding System codes (*see* Table E1 in the online supplement). We analyzed all respiratory DME included in the CBP (excluding accessories such as masks, tubing, and filters). Our primary outcome was the number of DME suppliers contracted by the Centers for Medicare and Medicaid Services (CMS) per product. Secondary outcomes were claims per DME supplier and percentage of Medicare beneficiaries using each DME product. We described trends and percentage changes in outcomes for each DME product between 2013 and 2019. This study did not meet the definition of human subjects research set by the University of Washington institutional review board and did not require review. Analysis was conducted using Stata version 14 (StataCorp).

Results

The three highest volume respiratory DME products were stationary oxygen concentrators, continuous positive airway pressure (CPAP) devices, and gaseous portable oxygen. Between 2013 and 2019, the number of DME suppliers decreased from 7,488 to 4,656 for stationary oxygen concentrators (−38%), from 7,197 to 4,947 for CPAP devices (−31%), and from 7,107 to 4,321 for gaseous portable oxygen (−39%) (Figure 1). Claims per supplier increased from 1,146 to 1,370 for stationary oxygen concentrators (+19%), from 408 to 911 for CPAP devices (+123%), and from 521 to 637 for gaseous portable oxygen (+22%). The percentage of Medicare beneficiaries using respiratory DME decreased for stationary oxygen concentrators (−28% change from 3.2% to 2.3%) and gaseous portable oxygen (−27% change from 1.5% to 1.1%) but increased for CPAP devices (+43% from 1.4% to 2.0%).

The DME items with the largest magnitude of outcome changes between 2013 and 2019 were portable oxygen concentrators and stationary liquid oxygen. The percentage of beneficiaries using respiratory DME increased the most for portable oxygen concentrators (+115%) and decreased the most for stationary liquid oxygen (−89%) between 2013 and 2019. Similarly, the number of DME suppliers decreased the least for portable oxygen concentrators (−18%) and decreased the most for stationary liquid oxygen (−73%). Outcome trends for other respiratory DME products are reported in the online supplement (*see* Table E2).

Discussion

Our study identified two overarching patterns for respiratory DME. First, decreases in suppliers across all items and increases in claims per supplier for the majority of items suggest greater market concentration of respiratory DME suppliers for Medicare beneficiaries. Increasing market concentration could be due to the

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