Long-haul COVID: Healthcare Utilization and Medical Expenditures 6 Months Post-diagnosis

Antonios Marios Koumpias
University of Michigan-Dearborn
David Schwartzman
Washington University in St. Louis
Owen Fleming (ofleming@umich.edu)
Wayne State University

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Abstract

Background

Despite evidence that long-term COVID-19 symptoms may persist for up to a year, their implications for healthcare utilization and costs 6 months post-diagnosis remain unexplored.

Methods

Our objective is to determine for how many months post-diagnosis healthcare utilization and costs of COVID-19 patients persist above pre-diagnosis levels and explore response heterogeneity across age groups. This population-based retrospective cohort study followed COVID-19 patients' healthcare utilization and costs from January 2019 through March 2021 using claims data provided by the COVID-19 Research Database. The patient population includes 328,777 individuals infected with COVID-19 during March-September 2020 and whose last recorded claim was not hospitalization with severe symptoms. We measure the monthly number and costs of total visits and by telemedicine, preventive, urgent care, emergency, immunization, cardiology, inpatient or surgical services and established patient or new patient visits.

Results

The mean (SD) total number of monthly visits and costs pre-diagnosis were .4805 (4.2035) and 130.67 (1,216.66) dollars compared with 1.1998 (8.5184) visits and 341.7576 (2,439.5581) dollars post-diagnosis. COVID-19 diagnosis associated with .7338 (95% CI, 0.7175 to 0.7500 visits; $P < .001$) more total healthcare visits and an additional $215.40 (95% CI, 210.76 to 220.00; $P<.001$) in monthly costs. Excess monthly utilization and costs for individuals under 19 years old subside after 5 months to .021 visits and $3.7, persist at substantial levels for all other groups and most pronounced among individuals 50-59 (.236 visits and $78.60) and 60-69 (.196 visits and $73.10) years old.

Conclusions

This study found that COVID-19 diagnosis was associated with increased healthcare utilization and costs 6 months post-diagnosis. These findings imply a prolonged burden to the US healthcare system from medical encounters of COVID-19 patients and increased spending.

1. Background

Does excess healthcare utilization and medical expenditures of patients infected by SARS-CoV-2 (COVID-19) persist over time and for how many months following contraction? These are important questions, as COVID-19 has affected a sizable fraction of the population whose future medical needs and their financial implications are not well-understood. COVID-19 can increase healthcare utilization and costs directly in response to COVID-19 related illness and indirectly to treat non COVID-19 related health conditions identified in the course of the COVID-19 medical encounter or decrease utilization and costs due to deferral of care.[1–8] If the post-acute sequelae of COVID-19 symptoms (long-haul COVID) are not ephemeral, the prolonged burden they place on the healthcare system could further undermine its capacity to cater to the growing healthcare needs of the population.

There is extensive evidence that COVID-19 leads to functional decline and that symptoms related to either mild or critical COVID-19 hospitalizations can persist for 60 days or longer.[9–15] A number of studies report symptom persistence for COVID-19 patients up to 12 months following infection.[16–18] A survey of 11-17 year-olds infected with COVID-19 revealed that symptoms persist at least 15 weeks following infection.[19] Al-Aly et al. report an increased likelihood of health resource usage by COVID-19 survivors 30 days post-discharge. [11] Chopra et al.[20] provide evidence of increased morbidity, physical and emotional symptoms among COVID-19 patients 60 days post-discharge and report that the majority of the surveyed population experienced some degree of financial impact from hospitalization whereas a minority of respondents had to ration necessities or used most, if not all of their savings. Chua et al. (2021) computed a mean out-of-pocket healthcare spending of individuals hospitalized for COVID-19 within 90 days of discharge of $534 among privately insured and $680 among Medicare Advantage patients, with spending exceeding $2,000 for 7.0% of the privately insured and for 10.3% of Medicare Advantage patients. [21]

The contributions of this work are threefold. First, we provide an account of the association between COVID-19 diagnosis and healthcare utilization or medical expenditures for up to six months post-diagnosis. This extends our understanding of long-haul COVID's persistence as it constitutes the longest post-diagnosis time frame examined in the literature on healthcare utilization and medical expenditures to date. Second, this study provides suggestive evidence of long haul COVID's duration across age groupings. Comparing outcome levels across 30-day time intervals centered around the COVID-19 diagnosis date, we are able to timestamp the month when healthcare utilization and medical expenditures subside for individuals under 19 years at 5 months. Lastly, grouping healthcare utilization on a monthly basis helps us potentially separate shorter-run COVID utilization more-likely associated with the initial treatment of the virus from more medium-term utilization of services after recovering from COVID-19. This is helpful in understanding which kinds of healthcare services may be most needed by those who have had COVID-19, as well as how health care capacity may be shifted by the COVID-19 pandemic.

We find that COVID-19 diagnosis is associated with .7338 more healthcare visits per month, on aggregate, and $215.40 in additional monthly healthcare expenditures during the first 6 months post-diagnosis. Inpatient care, emergency care and telemedicine services exhibit the largest increase in utilization whereas inpatient, emergency and surgical services exhibit the greatest rise in costs. Excess relative healthcare utilization and costs, defined as the relative difference of monthly outcome levels 31-

60, 61-90, 91-120, 121-150 and 151-180 days before and after the COVID-19 diagnosis date, clearly decline from month to month, but do not return to baseline levels six months post-diagnosis. Excess utilization is reduced from .508 excess monthly visits 31-60 days following diagnosis to .162 excess monthly visits 151-180 days following diagnosis. Excess relative monthly costs peak in the second post-diagnosis month at $164.20 and gradually fall to $52 by the sixth month. Finally, our results illustrate significant heterogeneity among long-haul COVID patterns for different age groups. Five months post-diagnosis, excess relative healthcare utilization and costs return to their corresponding pre-diagnosis levels among individuals 18 or younger. For all other age categories, excess relative healthcare use and costs persists in non-negligible levels until the sixth and last post-diagnosis month of the analysis.

2. Methods

2.1 Data Description

The datasets analyzed during the current study are not publicly available due to the nature of healthcare claims data but can be made available upon approval from the COVID-19 Research Database [covid19researchdatabase.org]. The dataset employed contains de-identified insurance claims data from providers or billers. The study sample includes claims of patients diagnosed with COVID-19 by September 2020. Each patient's date of COVID-19 diagnosis was obtained using the ICD-10 code included in the data. Pre-diagnosis information for this cohort of patients is tracked from January 2019. All 50 states are represented in the patient population, albeit there is a significantly higher density of claims from California and of Medicaid claims from Colorado, North Carolina, Texas and Washington.

We identified different types of outpatient and inpatient medical encounters based on current procedural terminology (CPT) codes and designated broader classifications to each service, creating 10 distinct and mutually exclusive categories using a standard method of classifying services by the Health Care Cost Institute. These categories were selected to reflect responses to COVID-19 diagnosis in the modality (telemedicine), severity (immunization, cardiology, inpatient, surgery) point of care (preventive, urgent care, emergency), and patient-physician relationship (established patient visit, new patient visit). Finally, we summed all ten categories to obtain an aggregate measure of healthcare utilization and medical expenditures for every patient in each month. In the absence of patient-level mortality information, we removed all hospitalized patients who had a visit with CPT code 99233 "Subsequent Hospital Care Evaluation and Management (E/M) Services" recorded as their last claim to ensure our results were not potentially downwards biased from sample attrition due to mortality.

For the 336,371 patients included in our sample, claims data were aggregated to the individual-month level to provide an account of monthly utilization and healthcare cost for the six months prior to and following a COVID diagnosis, excluding the actual diagnosis date's claims. To account for the presence of extreme outliers in the sample, we winsorized monthly outcomes at the 99.995% level for each CPT category. The resulting sample of 4,036,452 observations over 336,371 patients was used for the empirical analysis, but due to missing geographic data for 7,594 patients, our estimates were based on

91,128 fewer observations. Table 1 in the additional file summarizes the distribution of the outcome variables before and after COVID-19 diagnosis on aggregate and by CPT code category [see Additional file 1].

2.2 Empirical Analysis

First, we compare utilization of health care services and healthcare expenditures before and after COVID diagnosis using a linear regression model that includes a COVID-19 diagnosis month indicator, a male gender indicator, age grouped in 7 categories and aggregate demographic information at the 3-digit zip code level. We specify state and time fixed effects, defined as the COVID-19 diagnosis month of the year, to capture month-specific trends in the evolution of the pandemic, and cluster standard errors at the individual level [see equation (1) in Additional file 1].

Next, we investigate the dynamic evolution of healthcare utilization and costs from month to month relative to the diagnosis month's values using the same linear regression model. The COVID-19 diagnosis month corresponds to the 30 days immediately following a patient's COVID-19 diagnosis and therefore the post diagnosis period now spans 31-180 days following the COVID-19 diagnosis date.

Finally, we use the healthcare utilization and cost monthly estimates to compute, for each corresponding month-pair, excess utilization and excess cost. These excess utilization and cost estimates reflect the difference in healthcare utilization or cost for a given post-COVID-19 diagnosis month and the corresponding pre-diagnosis month. Our primary interest lies in the evolution of these excess values both for all patients and across age groups.

3. Results

3.1 Baseline Results

Figure 1 shows the estimated increase in the monthly number of aggregate services and the increases for ten service-specific categories over six months, inclusive of the first 30 days [see Table 2 in Additional file 1]. COVID-19 diagnosis is associated with .7338 (95% CI, 0.7175 to 0.7500 visits; $P < .001$) more healthcare visits per month, on aggregate, during a six-month period following COVID-19 diagnosis. The sharpest rise in utilization is reported for inpatient visits (.5433 more visits, 95% CI .5288 to .5579 visits; $P < .001$) followed by emergency care (.0648 more visits, 95% CI .0624 to .0671 visits; $P < .001$) and telemedicine (.0346 more visits, 95% CI .0339 to .0353 visits; $P < .001$). Non-negligible increases are reported for surgery (.0157 more visits, 95% CI .0149 to .0166 visits; $P < .001$) and cardiology services (.0173 more visits, 95% CI .0165 to .0181 visits; $P < .001$).

Figure 2 depicts the estimated post-diagnosis increase in aggregate monthly healthcare costs and separately for each of the 10 categories examined. We estimate that COVID-19 diagnosis is correlated with an additional $215.40 (95% CI, 210.76 to 220.00; $P<.001$) in total monthly medical expenditures, on average. This increase was driven primarily by financial costs associated with inpatient care ($98.55, 95%

CI $95.68 to $101.41; P<.001), emergency care ($42.12, 95% CI $40.52 to $43.72; P<.001) and surgical services ($27.83, 95% CI $26.34 to $29.31; P<.001). We find smaller but notable increases in the cost of care delivered via telemedicine ($6.73, 95% CI $6.57 to $6.90; P<.001) and for cardiology services ($3.52, 95% CI $3.30 to $3.75; P<.001). For more information, see Table 3 in the additional file [see Additional file 1].

3.2 Dynamic Effects

Figures 3 and 4 display the large decrease in the utilization of care and medical expenditures in months before or after diagnosis. The month-specific comparisons imply that the positive baseline estimate is not solely driven by excess use in the COVID-19 diagnosis month but also by utilization and costs in the post-diagnosis months. We interpret these results as evidence that utilization persisted for up to 5 months following COVID-19 diagnosis with a robust drop-off in month six to smaller but far from negligible levels.

Figure 3 specifically shows the evolution of healthcare utilization relative to the diagnosis month, adjusted by gender. It shows that 3.044 fewer services are used in month t+1 or 31-60 after diagnosis whereas 60-31 days before diagnosis (month t-2) there are 3.552 fewer visits relative to diagnosis month utilization. This amounts to approximately .508 more monthly visits in month t+1 relative to month t-2, on average. Repeating these calculations for following month-pairs comparisons, we find .284 excess relative utilization in the next month-pair [t-3, t+2], .25 excess visits in month-pair [t-4, t+3], 222 excess visits in month-pair [t-5, t+4], and .162 excess visits for the last month-pair [t-6, t+5].

Figure 4 shows the evolution of healthcare costs relative to the diagnosis month, adjusted by gender. We carry out similar month-pair comparisons which uncover excess relative costs of $164.20, 31-60 days before and after diagnosis to $115.30 in the subsequent month-pair [t-3, t+2], $97.30 in month-pair [t-4, t+3], $78.10 in month-pair [t-5, t+4], and a minimum of $52 for the last month-pair [t-6, t+5].

4. Heterogeneity Analysis

Finally, we explore the heterogeneity of healthcare use and costs in age, using the following seven age groupings: individuals 18 & under, 19-29, 30-39, 40-49, 50-59, 60-69, or 70+ years old.

Figure 5 demonstrates that healthcare utilization is greater in the vast majority of post-diagnosis months across all age groups; however, responses are largely heterogeneous [see Table 4 in Additional file 1]. The association of COVID-19 diagnosis with additional care sought does not vary substantially over time for individuals aged 18 years old or those 19 to 29 years old. Healthcare utilization by the next three cohorts of individuals (30-39, 40-49 and 50-59 years of age) decays faster in the first three months following diagnosis. Steep reductions in utilization are reported 31 to 90 days following diagnosis for 60-69 years and 70 or more year-old individuals which become more modest by the sixth post-diagnosis month. Finally, there is evidence of a lead-up in healthcare utilization 30-1 days prior to diagnosis which may reflect medical encounters immediately prior to the detection of infection as initial symptoms emerge; these observations are not used for excess utilization comparisons.

Back-of-the-envelope computations indicate that excess relative utilization persists for individuals under 19 years old for five months but subsides by the sixth month post-diagnosis. On the contrary, we find that excess relative utilization of all age groupings of individuals 19 years or older persisted at higher levels relative to pre-diagnosis months.

Figure 6 shows cost estimates for all months relative to the COVID-19 diagnosis month across age groupings. Increased spending is reported for all months following diagnosis across all adult age groups. However, individuals 18 years old or younger show a virtually flat trend of post-diagnosis utilization which returns to its pre-diagnosis levels by the sixth month. Individuals 19-29 years old exhibit a small, negative linear trend for the duration of the post-diagnosis period. Medical expenditures of individuals 30-39 and 40-49 years of age exhibit increasingly more negative linear trends. The three more senior age groupings exhibit large decreases in costs which still remain relatively higher to their pre-diagnosis levels. We find that individuals 60-69 years old experience the largest positive difference in post-diagnosis healthcare costs relative to their pre-diagnosis levels. Back-of-the-envelope calculations suggest that excess relative healthcare costs persist for individuals under 19 years old for five months and return to pre-diagnosis levels by the sixth month. However, all adult age groupings exhibit substantially larger excess relative utilization to baseline in all post-diagnosis months.

5. Discussion

Using near real-time claims data, we compare healthcare utilization and costs of COVID-19 patients before and after diagnosis. We estimate that COVID-19 diagnosis is associated with .7338 more visits and $215.40 more in healthcare costs per month over a 6-month post-diagnosis period. The largest increases in utilization are reported for inpatient, emergency care and telemedicine services. Inpatient and emergency care remain the two categories with the largest excess relative costs with surgical services being the third largest one. We illustrate significant heterogeneity of the baseline results across seven age groups. Individuals 18 years or younger engage in minor excess relative use and costs which persist for five months. Modest excess relative utilization and costs are reported for the 20-29 age group while estimates are increasing in magnitude for individuals 30-39 and 40-49 years old. The three more senior age groupings, particularly those aged 50-59 and 60-69 years old, experienced the largest excess relative utilization and costs which are gradually reduced but persist in considerable levels throughout the post-diagnosis period. In sum, we interpret these results as descriptive evidence that excess healthcare utilization and costs of adults persisted for six months following COVID-19 whereas excess use and costs subside after five months for individuals 18 years or younger, on average.

This work is subject to a number of limitations which illustrate the importance of future research on long haul COVID-19. First, since the source of our data is on the provider side, we do not have comprehensive data on all health care utilization of patients. Therefore, our estimates are a lower bound of health care utilization and costs, although there is no reason to believe that the extent of underestimation due to plan switching is different before and after COVID diagnosis. Additionally, we cannot detect whether health care utilization after diagnosis is a result of post COVID-19 symptoms or whether it is due to pre-existing health conditions unrelated to COVID-19. Moreover, we do not observe patient mortality and, thus, cannot exclude sample attrition due to this reason. To address this limitation, we exclude likely non-survivors from the study sample. This implies our estimates are even less likely to overestimate the influence of COVID-19 diagnosis on utilization and costs. The analysis does not consider utilization of pulmonology services despite the direct clinical link between COVID-19 and pulmonological symptoms because our goal is to highlight the generalized excess relative utilization and costs associated with COVID-19 diagnosis as opposed to its correlation with closely related services. Finally, we do not distinguish among COVID-19 vaccination status given that all individuals in the sample were infected by October 2021, prior to any emergency authorization of COVID-19 vaccines in the US.

Declarations

Ethics approval and consent to participate: Not applicable

Consent for publication: Not applicable

Availability of data and materials: The datasets generated and/or analyzed during the current study are not publicly available due to the nature of claims data but are available from the COVID-19 Research Database upon approval.

Competing interests: Not applicable

Funding: Not applicable

Authors' contributions: AK and DS formulated the empirical strategy which was implemented by OF. Conceptualization of the broader research strategy was performed by all three. All authors read and approved the final manuscript.

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Figures

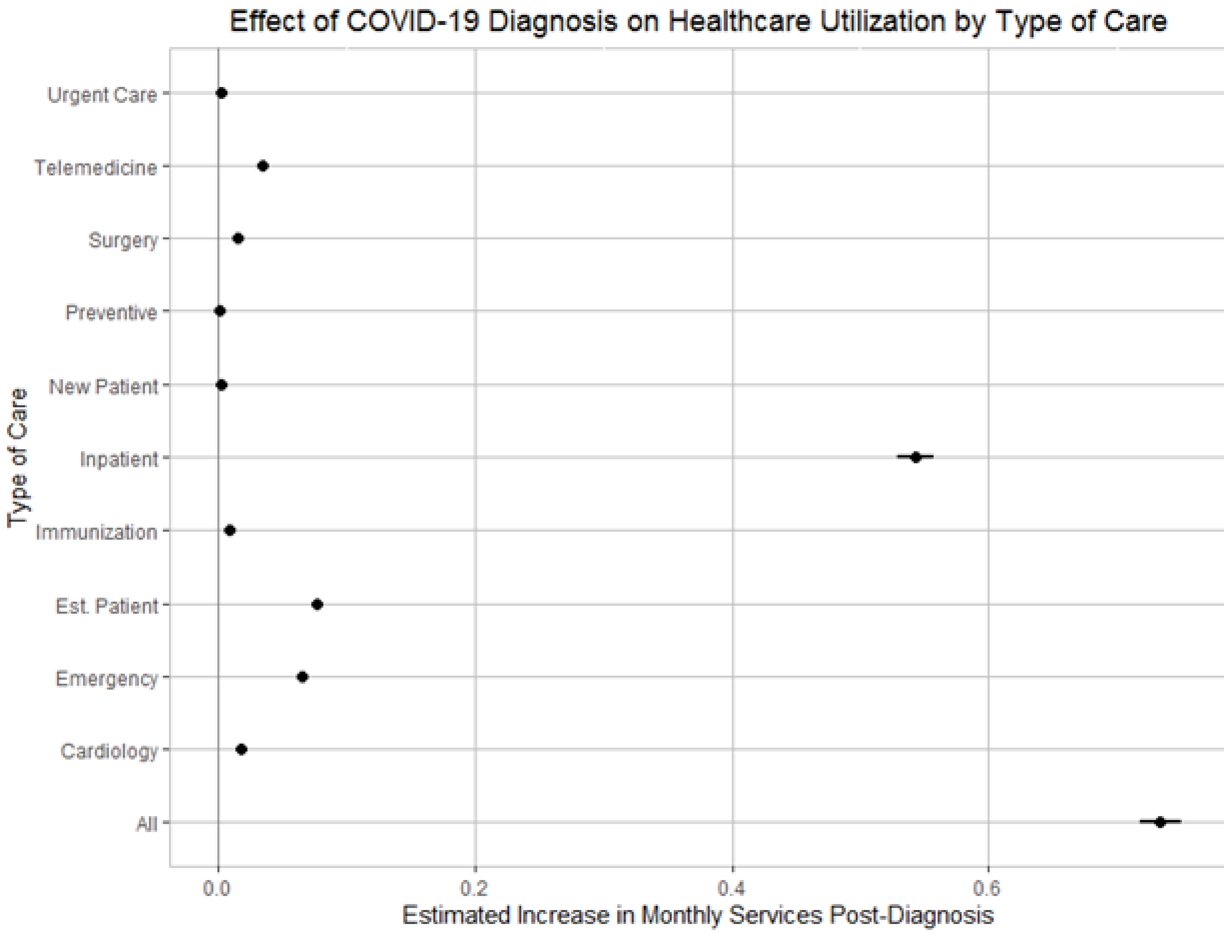

Figure 1

Effect of COVID-19 Diagnosis on Healthcare Utilization by Type of Care

Figure 1 shows the estimated increase in the monthly number of aggregate services and the increases for ten service-specific categories over six months, inclusive of the first 30 days.

Each dot on the plot represents the coefficient estimate, the lines extending from each dot represent a 95% confidence interval for each estimate.

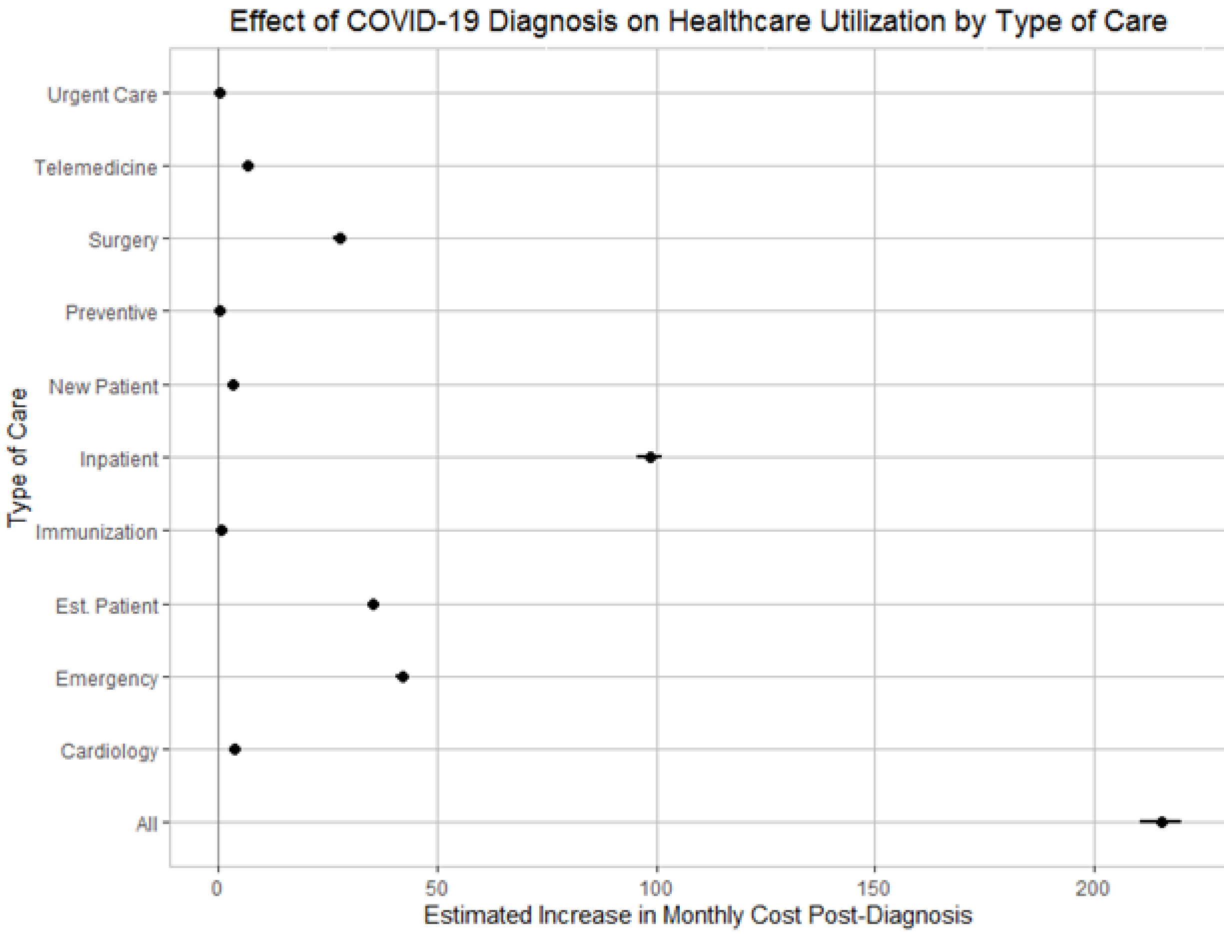

Figure 2

Effect of COVID-19 Diagnosis on Healthcare Cost by Type of Care

Figure 2 depicts the estimated post-diagnosis increase in aggregate monthly healthcare costs and separately for each of the 10 categories examined.

Each dot on the plot represents the coefficient estimate, the lines extending from each dot represent a 95% confidence interval for each estimate.

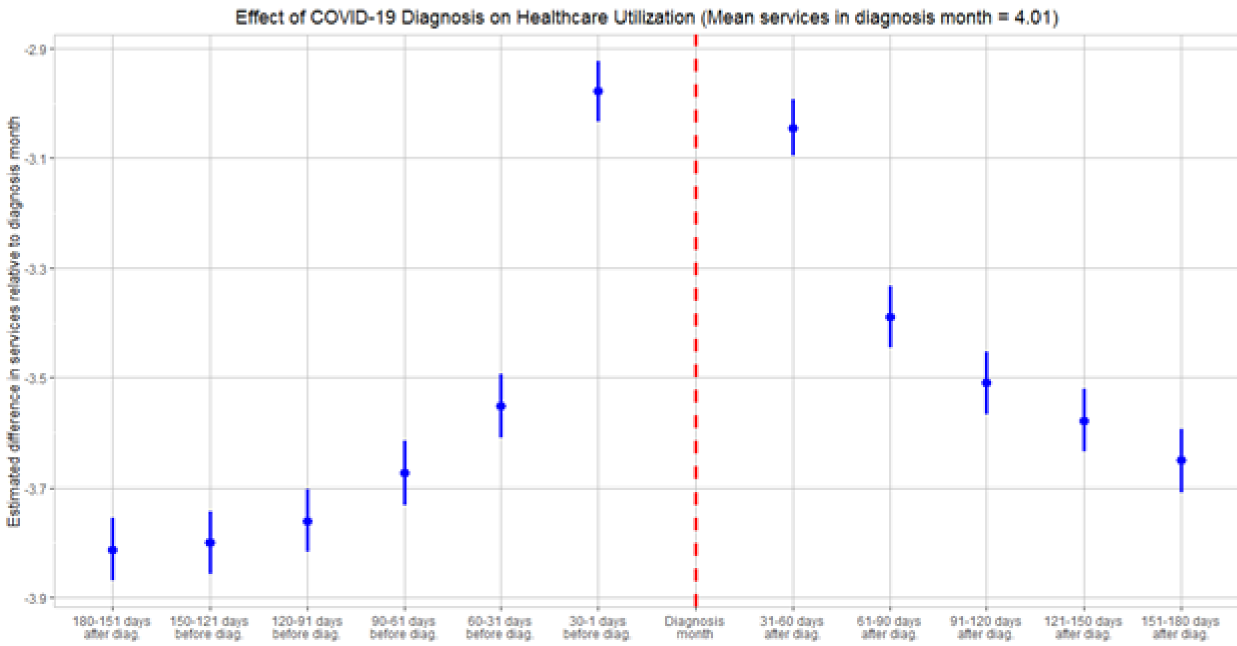

Figure 3

Evolution of Healthcare Utilization Relative to Diagnosis Month (Mean services in diagnosis month = 4.01)

Figure 3 shows the evolution of healthcare utilization relative to the diagnosis month.

Each blue dot on the grid represents the estimated average change in number of monthly services relative to the diagnosis month, in which an average of 4.01 monthly services was recorded. Each blue dot represents a coefficient estimate and the vertical lines are coefficient estimates at the 95% level.

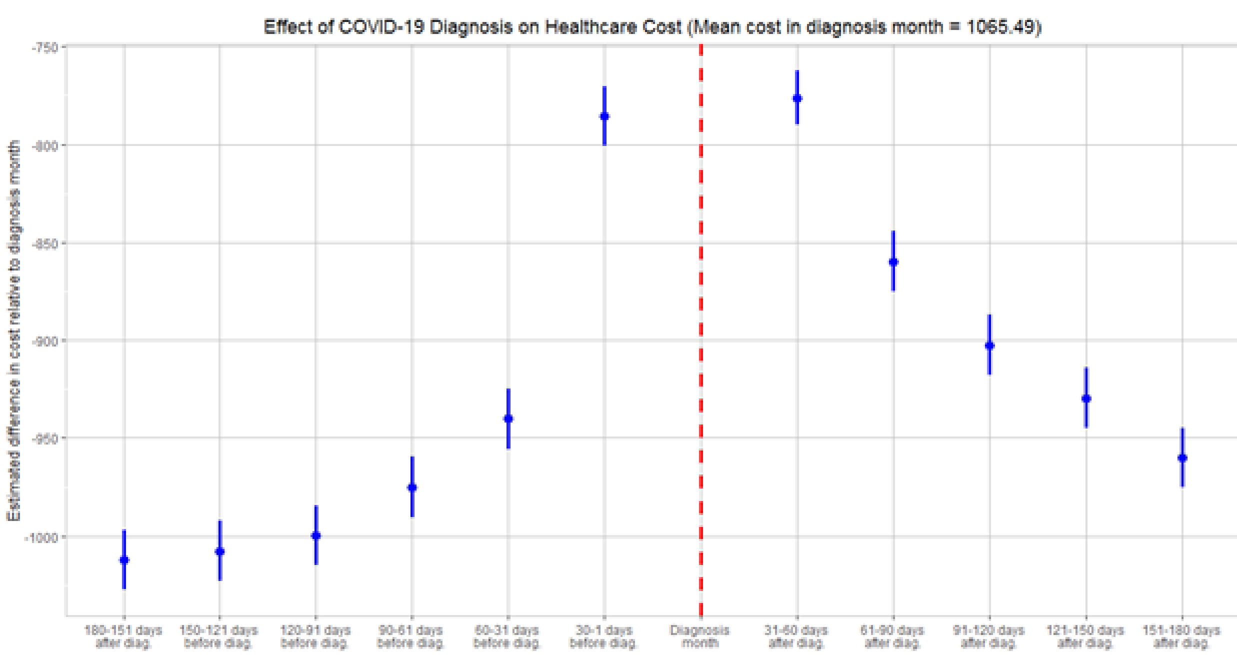

Figure 4

Evolution of Healthcare Cost Relative to Diagnosis Month: (Mean cost in diagnosis month = 1065.49)

Figure 4 shows the evolution of healthcare cost relative to the diagnosis month.

Each blue dot on the grid represents the estimated average change in the monthly cost relative to the diagnosis month, in which an average cost of 1065.49 was recorded. Each blue dot represents a coefficient estimate and the vertical lines are coefficient estimates at the 95% level.

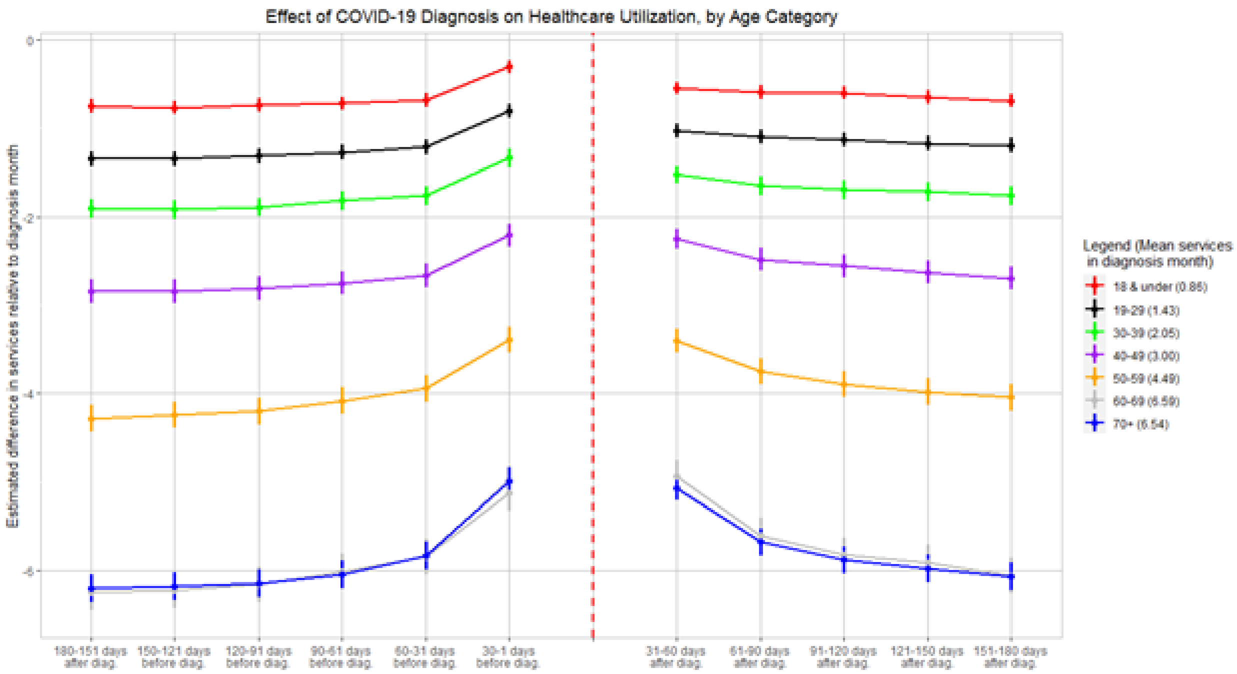

Figure 5

Evolution of Healthcare Utilization by Age

Figure 5 demonstrates the heterogeneity of healthcare utilization across the following seven age groupings: individuals 18 & under, 19-29, 30-39, 40-49, 50-59, 60-69, or 70+ years old.

The red line depicts the age group 18 & under, which registered an average of 0.85 services in the diagnosis month.

The black line depicts the age group 19-29, which registered an average of 1.43 services in the diagnosis month.

The green line depicts the age group 30-39, which registered an average of 2.05 services in the diagnosis month.

The purple line depicts the age group 40-49, which registered an average of 3.00 services in the diagnosis month.

The orange line depicts the age group 50-59, which registered an average of 4.49 services in the diagnosis month.

The grey line depicts the age group 60-69, which registered an average of 6.59 services in the diagnosis month.

The blue line depicts the age group 70+, which registered an average of 6.54 services in the diagnosis month.

Dots are the coefficient estimates and vertical bars represent confidence intervals at the 95% level.

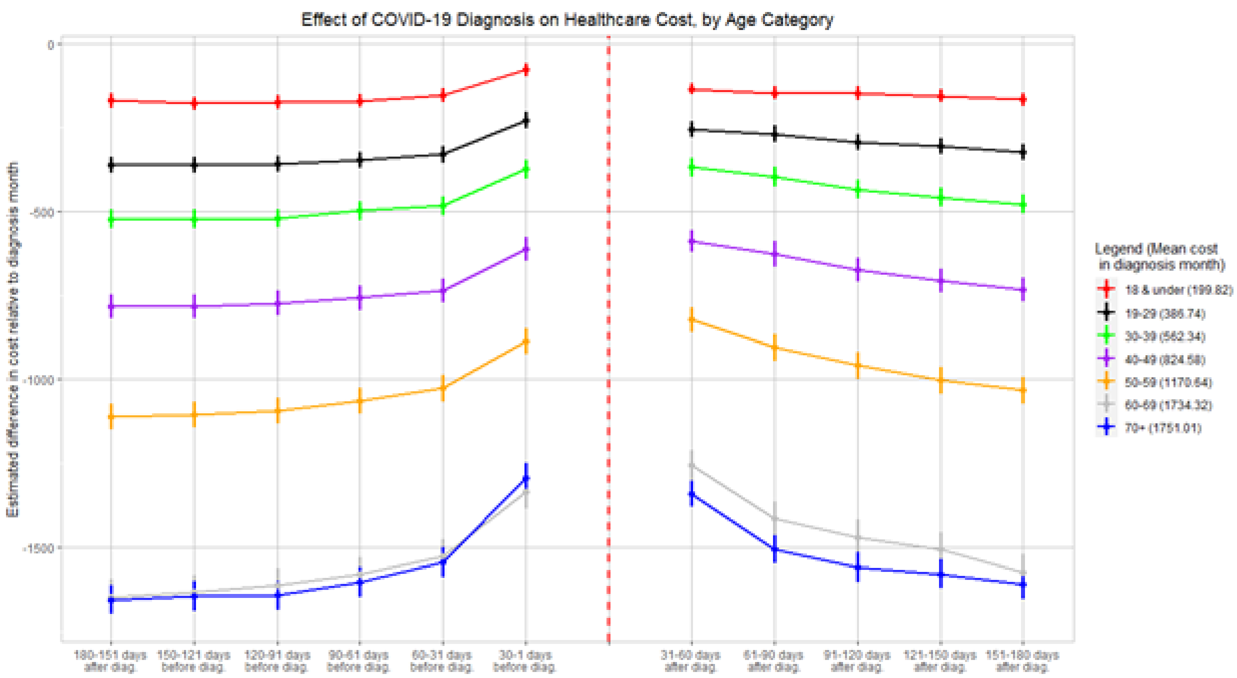

Figure 6

<u>Evolution of Healthcare Cost by Age</u>

Figure 6 demonstrates the heterogeneity of healthcare costs across the following seven age groupings: individuals 18 & under, 19-29, 30-39, 40-49, 50-59, 60-69, or 70+ years old.

The red line depicts the age group 18 & under, which registered an average cost of 199.82 in the diagnosis month.

The black line depicts the age group 19-29, which registered an average cost of 386.74 in the diagnosis month.

The green line depicts the age group 30-39, which registered an average cost of 562.34 in the diagnosis month.

The purple line depicts the age group 40-49, which registered an average cost of 924.54 in the diagnosis month.

The orange line depicts the age group 50-59, which registered an average cost of 1170.54 in the diagnosis month.

The grey line depicts the age group 60-69, which registered an average cost of 1734.32 in the diagnosis month.

The blue line depicts the age group 70+, which registered an average cost of 1751.01 in the diagnosis month.

Dots are the coefficient estimates and vertical bars represent confidence intervals at the 95% level.

Supplementary Files

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