Title:
The Effect of Covid-19 on Length of Stay for Non-Covid-19 Patients: A Single Center Study.

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Abstract:

Research Question: How does the number of admitted Covid-19 patients affect the length of stay (LOS) for non-Covid-19 patients in acute care and intensive care units?

Introduction and Significance: Covid-19 had a large impact on healthcare systems and various populations. US hospitals saw reduced admissions during the height of the pandemic that had severe repercussions. More research examining specific populations could be used to guide how to best serve a healthcare system's patient population.

Materials and Methods: We compiled deidentified patient information from the EMR of a large, single center in North Texas and grouped the information into two timeframes – Pre and Post Covid-19.

Results: The number of diagnoses was found to be higher in the 2020-2021 timeframe than the 2019-2020 timeframe ($p < 0.001$). Comparing LOS across quarters, October through December was found to be statistically significant ($p=0.0363$). A regression model for the 2019-2020 dataset, the number of diagnoses, age, and being of an unknown or declining to list race were statistically significant ($p<0.05$). The regression for the 2020-2021 dataset had age, being female, having race listed as unknown/ other, African American, or Asian, being Hispanic, number of diagnoses, and Covid-19 census as all statistically significant ($p<0.05$). Overall, there was not an overall statistically significant difference between the 2019-2020 population and the 2020-2021 non-Covid-19 population LOS ($p=0.2837$).

Conclusions: Our article finds that length of stay for non-Covid-19 patients was not affected by the Covid-19 inpatient census.

Research Question:

Our research wanted to see how Covid-19 affected care for individuals who did not have Covid-19 while being in an acute care or intensive care setting. Fort Worth was hit hard with Covid-19 cases and had reduced vaccine uptake along with high prevalence of Covid-19 during the height of the pandemic. The implications of how care was affected for non-Covid-19 patients during the pandemic is necessary to determine how our systems handled the crisis in addition to determining what next step should be taken for the next one. All levels of healthcare, from patient facing staff to healthcare executives, could find this information useful in developing future strategies in pandemic management. Thus, for patients admitted to a large, single hospital in North Texas, how does the number of admitted Covid-19 patients affect the length of stay for non-Covid-19 patients in acute care and intensive care units?

Introduction, Significance, and Rationale

Extensive research continues to go into the pathophysiologic effects and societal ramifications of SARS-CoV-2, also known as Covid-19. The discovery and spread of this virus soon took the world by storm. Within the first 8 months of discovering Covid-19, there were 23,634 unique publications across major databases and scientific journals [1]. While a significant portion of this research went into the effects and treatment of the viral sequela, other facets of this nascent pandemic were studied too. Included in this research pool is information that can guide hospital administration decision making. These works show the extent to which Covid-19 affected hospitals and patient populations across the country via quality metric research. Many studies have examined various quality metrics including hospital admission, readmission, resource use, in-hospital mortality, and length of stay of Covid-19 patients specifically [2, 3, 4, 5]. Across the country during the early pandemic, non-Covid-19 and Covid-19 admissions began to drop starting in March of 2020 [2]. This was due to implementation of country wide stay at home orders and masking policies that would continue for years to come. However, admissions slowly began to increase in April into July 2020 eventually leveling off.

Concurrently with reduced admissions, which occurred from fear of going to the hospital and encouragement to avoid them unless severely ill, a reduction in elective surgeries occurred. Specifically, in Texas, Governor Greg Abbott signed an executive order stating elective procedures be postponed until April 21, 2020 at the earliest [6]. This trend was common across the country as seen in a report by Becker's Hospital Review on 116 hospitals also canceling elective surgeries [7]. While an essential public health decision, the effects of canceling operations were not without its financial consequences. Given that surgical procedures are an essential part of a health system's revenue stream, many hospitals faced financial hardship resulting in bankruptcy

and closures – especially in rural settings. A report in Becker's Hospital Review listed 47 hospitals either facing bankruptcy or closure since the beginning of the pandemic [8]. Hospital closures and the uncertainty of a global pandemic are two factors that could make someone delay seeking healthcare. Dr. Lisa Rosenbaum wrote an anecdote on how Covid-19 has affected care for non-Covid-19 patients; explaining how reductions in cancer care and interventional cardiology procedures have resulted in poor patient outcomes and more severe acuity at time of admission for people in New York City and California [9]. She offers a quote from the director of the Structural Heart Disease program at St. Joseph Hospital that sums up the situation:

"'A lot of procedures deemed elective are not necessarily elective.' Two patients in his practice whose transthoracic aortic valvular replacements were postponed, for example, died while waiting. 'These patients can't wait 2 months… Some of them can't wait 2 weeks. [9]'"

As the pandemic progressed, new research findings demonstrated that Covid-19 was directly impacting non-Covid-19 patients [10, 11, 12]. However, data was limited and focused to areas outside the United States. However, some interesting trends appeared: such as patients presenting with more severe disease burden than before the pandemic which supports anecdotal evidence from early during the pandemic [13]. However, length of stay (LOS) itself seemed to be dependent on country, patient population being examined, and Covid-19 burden in the area [14, 15, 16, 17, 18, 19]. Given these constraints, there is merit in evaluating whether Covid-19 directly affected non-Covid-19 patients in a localized population, specifically the North Texas area.

We have several objectives for this project. Our primary objectives include determining if a difference in LOS exists between pre-Covid-19 and post Covid-19 non-Covid-19 patients. Several secondary objectives exist for this project too. We hope to determine the extent Covid-19 inpatient census affects LOS through regression modeling. We also want to determine any

statistical differences between the two populations of this project. Additionally, we want to ensure that all patient information is removed from the data set and handled correctly. Lastly, we hope to present this information in a manner which administrative leadership at the medical center can use to gain insight into the early pandemic. Ideally, this would help guide future decision making.

This type of research and other information have proven pivotal to adapting during the pandemic and beyond. It offers insight into how reduced access to care for all patients affected communities across the country. This project hopes to further explore the pandemic's effects on patients without Covid-19 admitted to the hospital during the height of the pandemic in North Texas with validated quality metrics. Specifically, this project will examine LOS which serves an important role clinically and administratively. For clinicians, it provides a proxy for quality of care and patient outcomes. For administrators, it can guide resource allocation to areas needing additional assistance. Since these parameters can be indicative of healthcare quality and outcomes, filling this knowledge gap would allow for improved administrative and clinical strategy to better serve all patients during this pandemic and beyond. At a time when quality metrics are king in healthcare, this sort of information proves invaluable for leadership in ensuring that they stay ahead of the curve in providing high quality care. By determining any shortcomings, they can be addressed in an early and controlled manner. Conversely, potential strengths may be discovered. Those strengths can then be studied and be applied to other parts of the hospitals or other healthcare systems. Ensuring quality care for all patients despite the circumstances is vital to any healthcare system. Thus, for patients admitted to a large, single hospital in North Texas, how does the number of admitted Covid-19 patients affect the length of stay for non-Covid-19 patients in acute care and intensive care units. Due to cancellations of

elective surgeries, this project will examine acute and intensive care units in the hopes of minimizing confounding variables. Both types of units remained heavily in use before and after the start of the pandemic.

The impact of this project is its ability to determine how Covid-19 affected non-Covid-19 patients in a major North Texas medical center. Additionally, it could open the door to other future projects that examine how the Covid-19 pandemic affected every type of patient during the pandemic. The ramifications of this virus will continue to be studied for years to come. This project offers a new direction that is not fully explored in the literature.

Materials and Methods Approach

We compiled our data from a single medical center's electronic medical record system, Epic. Patient information was deidentified and grouped into two timeframes. The first is a pre-Covid-19 timeframe that acted as our control which ran from April 2019 to March 2020. This was deemed to be a good control since Covid-19 was not discovered until late 2019. While there is some overlap into 2020 in the control population, the increase in cases and effects on healthcare systems did not begin until March 2020. Thus, we deemed that any possible effects on LOS in the first few months of the pandemic would be negligible. The second is our post Covid-19 timeframe which ran from April 2020 to March 2021. This proved to be a good time frame to study given that it was the same duration of time as the control. Additionally, this timeframe included several spikes in inpatient census of Covid-19 which could prove useful to our analysis. LOS may be different between the different spikes after a hospital has had time to adjust responses from lessons learned in the past.

We determined eligibility to be all people admitted to this hospital's acute care or intensive care units. Since there was a reduction in hospital services, we needed units that stayed busy. Acute care and intensive care services remained in high demand during the pandemic despite reduction in elective care. This made these service lines an optimal choice. This decision was further strengthened by the fact that these units had high patient volume thus giving us a great sample size with which to run our analysis on. Patients also needed to be 18 years or older. Our age cut off was determined mainly to rule out hospital visits for deliveries which continued during the pandemic. We also felt that studying pediatric and obstetric LOS were beyond the scope of this project.

The data from Epic included basic demographic information, ICD-10 diagnostic information, and quality measures such as LOS. All information was de-identified to ensure that privacy was maintained. This included removing information such as names, dates of birth, addresses, and other personal health information. After taking these steps to remove the identifying information, the medical center deemed the information non-identifiable. We compiled a total of 11,507 patient encounters during the 2019-2020 timeframe and 11,659 patient encounters during the 2020-2021 timeframe. These encounters span a multitude of diagnoses. This information was organized into an Excel spreadsheet for export to SPSS for analysis.

To do a preliminary analysis of our variables, including basic demographic information such as race, age, and gender, a pivot table was created in Excel for each dataset. In addition to total values of each variable, total averages and monthly averages were calculated using these pivot tables. In the 2020-2021 dataset, we also created a Covid-19 variable that indicated someone was in the hospital with a primary diagnosis of Covid-19. Someone qualified as having Covid-19 as a primary diagnosis if it was listed in one of their top five diagnoses in Epic for that encounter. This number was compared against a running total Covid-19 census for each month collected by the hospital and was consistently found to be comparable across all time frames. To assess LOS differences between the 2019-2020 patient population and the 2020-2021 non-Covid-19 patient population, we conducted several t-tests to determine if a statistically significant difference existed between the two datasets. These t-tests were broken down in an annual and quarterly timeframe to assess at what point, if any, a difference became apparent. Excel was used to run the t-tests themselves. We used a p-value of 0.05 as a benchmark of statistical significance.

In parallel to conducting these t-tests, we also ran several regressions to determine what factors were most contributing to any differences of LOS in the two datasets. The independent variables chosen included: age, sex, race, Hispanic status, Covid-19 census, and number of diagnoses. The variables were put into an ANOVA linear regression model in SPSS. LOS acted as our dependent variable. A separate regression was run for each dataset with the same variables to try and determine differences across the two datasets. We chose to run regression models because we wanted to know what factors specifically were affecting LOS between the two time frames. LOS may prove to be different between the two populations, but that could be attributable to something else (i.e. demographic differences or severity of illness on presentation). Thus, by doing a regression, we hope to get a better idea of what factors are most significant in affecting LOS.

A power analysis with a preset power of 0.8 and a significance level of $\alpha = 0.05$ shows that for a regression analysis, we would need at least 50 people per group to achieve a strong enough sample to detect with confidence small changes between the different populations. Given the size of our sample data, we met this threshold with ease. We conducted a power analysis to ensure that we would minimize our chances of type 2 error by having as large of a data set as possible. Again, choosing busy service lines in the hospital ensured that we were able to have adequate data to pull from.

Finally, to ensure that the two populations being examined were similar demographically, we used ChatGPT to run a Pearson Chi Squared analysis for each demographic variable from our Excel data. ChatGPT was chosen for the ease with which it could run a test. Those test results were verified in Excel after it was conducted. To be frank, it seemed like a

novel way to include emerging technology into this study while also slightly reducing the workload for this project.

Neither the public nor patients were involved in the design, conduct, reporting, nor dissemination plans of this project. This is because this was deemed a quality improvement project by the medical center.

Results

We found that the two populations, in terms of demographics, were similar between the two datasets after conducting a Pearson Chi Squared analysis. Being Hispanic, having an unknown or unlisted race, and the number of diagnoses were the only statistically significant differences between the two populations ($p<0.05$). Basic demographic information can be seen in **Exhibit 1**. It is worth noting that there was a slight change in the methodology of collecting race between the two time frames. In the Covid-19 time frame, "other" was listed as its own category which was not done in the control timeframe. We do not feel that this change affected our analysis in a significant way, but was worth mentioning.

The Covid-19 inpatient census was found to wax and wane in a similar pattern to the national averages with January 2021 being the highest data point in the dataset at n=459. April 2020 was found to have the lowest Covid-19 census at n=47. Of note, the average number of diagnoses was found to be higher in the 2020-2021 timeframe than the 2019-2020 timeframe ($p <0.001$). We did not conduct a breakdown of which diseases were more prevalent between the two time frames.

When looking at LOS, we found that there was not a statistically significant difference overall between the 2019-2020 population and the 2020-2021 non-Covid-19 population ($p=0.2837$). However, we did note a statistically significant change when examining the data for smaller portions of time. When comparing LOS across quarters, April through June, July through September, and January through March were not statistically significant ($p=0.2063$, $p=0.4678$, and $p=0.3518$, respectively). However, October through December was found to be statistically significant ($p=0.0363$). **Exhibit 2** shows a graph that has the Covid-19 inpatient census, 2019-2020 LOS, and 2020-2021 LOS superimposed on each other.

The regression analyses showed several variations between the datasets. For the 2019-2020 dataset, the R value was 0.554. Here, several variables were statistically significant including age ($p<0.001$ and $B = -0.034$), having a race listed as unknown/ declined/ blank ($p<0.001$ and $B = 1.136$), and number of diagnoses ($p<0.001$ and $B = 0.358$). The regression for the 2020-2021 dataset proved to yield slightly different results. The R-value for this dataset was 0.551. Again, age ($p<0.001$ and $B = -0.036$), having an unknown/ declined/ or blank race ($p<0.001$ and $B = 1.367$), and number of diagnoses ($p<0.001$ and $B = 0.369$) were statistically significant. This time, however, sex ($p<0.001$ and $B = -0.477$), being African American ($p<0.044$ and $B = 0.260$), Asian ($p<0.001$ and $B = 1.392$), or Hispanic ($p<0.001$ and $B = 1.27$), and Covid-19 census ($p<0.001$ and $B = 0.002$) were also statistically significant. **Exhibit 3** has the two regression results side by side for comparison.

Discussion

This project sought to examine the effects of the Covid-19 pandemic beyond the scope of people directly suffering from Covid-19. Specifically, it hopes to better understand how length of stay, and potentially healthcare quality and outcomes, have been affected by the re-shuffling of resources and reduction in hospital services in the early pandemic.

The demographics did not change significantly between the two time periods. There were more encounters with people who had unknown/ declined listed for their race in the post Covid-19 data set. Additionally, there were more people who were Hispanic in the post Covid-19 data set. This could be due to the fact that certain minority populations were affected more during the pandemic than others[20].

Two general areas of discussion are how LOS changed between the two timeframes and the acuity with which patients presented to the hospital. Overall, there was no statistically significant difference in length of stay for non-Covid-19 patients compared to patients pre-Covid-19. This is reassuring in that the pandemic did not seem to alter the hospital course of non-Covid-19 patients during the timeframe. Concerns were rampant during the height of the pandemic on how care was affected from supply chain issues, personnel shortages, and the unknown health effects of Covid-19 itself. While these challenges were present, they did not appear to affect patient LOS. There was a statistically significant difference when looking at a quarter level timeframe rather than the whole year. Specifically, October to December in 2021 had a statistically significant increase in LOS compared to the same period in 2020. This timeframe was notably when there was the greatest acceleration in the Covid-19 census. It's possible that the Covid-19 census itself was not a concern, but the rate of growth of the Covid-19 census may have played a significant role. Yet there was no statistical significance overall which

indicates that this smaller scale statistical finding did not play a major role in the larger timeframe.

In the regression analysis, there was notable change in the weight of certain variables in the regression analysis in the pre and post Covid-19 periods. Both regression analyses showed that age, having an unknown or unlisted race, and the number of diagnoses a patient had were statistically significant in affecting LOS. However, the post Covid-19 analysis had additional variables that affected LOS in a meaningful way too. Specifically, sex, being African American, being Asian, being Hispanic, and the Covid-19 census began to have a statistically significant effect. Age's negative B value could be explained by shorter LOS from younger patients being generally healthier and rebounding more quickly or older people having a higher mortality rate in the hospital. Both instances would account for a reducing effect on LOS that we see in both models. Similarly, the more diagnoses a patient has, the sicker and more medically complicated they theoretically are. As such, a more complex patient would require a longer LOS. This is reflected in both regression models. Multiple factors could be affecting the statistically significant effect on LOS caused by being listed as having a race of Other/Unknown/ Declined. One possible explanation is that rather than this whole group influencing LOS, there is a smaller subpopulation within this group that is not being effectively examined. Possible explanations for this include acuity of the encounter, mistrust of the healthcare system, or simply not having the capability on Epic to elaborate further. More research is needed to explore this area.

In the post Covid-19 regression, it is notable that being Hispanic, Asian, or African American led to an increase in LOS. This increase could be due to several reasons. Minority populations could have been delaying care out of mistrust in the healthcare system causing them to present with more severe disease processes than if they had sought care earlier[20]. Additionally,

these populations could have been more affected by Covid-19 or by reduced access to care than other populations leading to an increase in LOS. Had these populations been more represented in the data sets then perhaps LOS would have been statistically different between the two time periods overall.

The Covid-19 census did have a positive effect on LOS too. This could be due to more resource allocation towards the pandemic thereby influencing LOS overall in a hospital. Being female also had a reducing effect on LOS in the post Covid-19 period. One possibility for this variation is a difference in healthcare consumption between sexes or general differences in disease severity at presentation. Overall, none of these effects listed above were enough to significantly affect LOS in the overall t-test results.

There are several limitations to this study. First, it is a single center study. While there could be applicability to other hospitals in the area, our findings may not apply to US hospitals in general due to variations in Covid-19 policy response. Additionally, the medical center we drew our data from was in an area heavily affected by Covid-19 during the height of the pandemic. Other areas with less drastically affected or with higher rates of vaccination could also have seen different results. Supply chain issues affected the hospital, but other areas that were more impacted by shortages, such as rural settings, could also have different results.

Conclusion and Future Directions

Non-Covid-19 patients during the first part of the pandemic experienced no overall difference in LOS compared to before the pandemic. However, patients in general presented to the hospital with higher disease burden. Additionally, factors such as race and sex played a role in non-Covid-19 LOS whereas before the pandemic they did not have a statistically significant effect. Despite Covid-19 having a drastic effect on the healthcare system and patient health overall, this project determined that LOS was largely unaffected by the virus. This hopefully is one way of demonstrating that people who did not have Covid-19 received the same level of care and would have similar outcomes as they would have prior to the pandemic.

This project impacts healthcare leadership, both administrators and clinicians, in making decisions in a resource strained environment. This health system seems to have managed the resources well during the early pandemic without sacrificing patient outcomes, as measured by LOS here. This can help guide future decision making should another situation emerge that requires tough decisions about how to manage the hospital. Additionally, it showed some areas that might need to be reexamined, such as racial differences and how they affect LOS since they became significant, according to our regression, during the pandemic. Leadership could take this opportunity to reduce healthcare disparities through further research and root cause analyses. The implications of this project are that this healthcare system managed to keep business at baseline despite the strain on the hospital. Other implications include that racial factors and social conditions outside of the hospital likely played a role in how patients presented to the hospital during the pandemic. People were sicker and race become significant in our regressions – all of which should prompt further research into just why this was the case.

There are lots of future directions this project opens. First, this same design can be applied to other specialties. A study on pediatric, obstetric, surgical, and many other populations could yield different results. Each specialty and service line would no doubt have similarities in the challenges they face, but could also have different barriers that might affect LOS. This could prove useful for more specific specialties and can have useful lessons for administrators who work with said specialties. Additionally, this project looked at a very superficial level and did not do a deep dive into the process that could affect LOS. In-depth analysis on differences in policy in the pre-Covid-19 timeframe and post Covid-19 timeframe would prove useful in why it was that LOS was similar. It could also provide insight into other differences this paper found such as higher number of illnesses on presentation. Furthermore, this study was limited to one medical center. Examining other medical centers in the area could offer a better idea of how the city handled the early pandemic. Similar studies could be conducted with hospitals across the state and country possibly highlighting regional differences. Examining and comparing policy, demographic, and medical practice differences would all be useful in guiding future decision making to ensure patients receive the best possible care during a resource straining scenario.

Separate from LOS, it would prove useful to gain a broader picture of patient outcomes by examining other quality metrics. Some examples would include mortality, morbidity, 30-readmission, hospital infection rates, and many others. This could be done at a single center study as this project was or broadened to include other centers in the state and country. This could highlight that while LOS was unaffected, other quality metrics were changed by the pandemic. It would be interesting to see a regression model too to determine if the factors that affected LOS were the same ones that affected other quality metrics being measured. This could give hospital leadership areas to target to improve the outcomes of their patients.

Compliance Plan

We received a quality improvement designation for this project that exempted us from gaining IRB approval. This was done by completing a form an institution that helped determine if a project was a quality improvement project or research. After completing the form, it was submitted to the proper research representative. After reviewing the form, we were told our project was exempt. Their only requirement was that patient information as deidentified. We ensured that it was and received approval to proceed with the project to completion.

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Exhibit 1: Demographics

	2020-2021	2019-2020	P-Value
Total Encounters, No.	11660	11508	
Age, Avg.	61.67	61.52	0.246
Sex, %			
Female	51.30%	50.30%	0.117
Race, %			
American Indian or Alaskan Native	0.09%	0.23%	0.378
Asian	1.52%	1.50%	0.769
African American	18.87%	19.29%	0.568
Hawaiian / Pacific Islander	0.14%	0.05%	0.051
Other/ Unknown/ Declined	**3.13%**	**2.44%**	**0.001**
White	76.24%	76.48%	0.367
Hispanic, %	**22.82%**	**17.14%**	**<0.001**
Average Number of Diagnoses, Avg.	**20.65**	**17.79**	**<0.001**

Bolding Denotes P < 0.05

Exhibit 2: LOS of Covid-19 Patients Compared to Non-Covid-19 Patients.

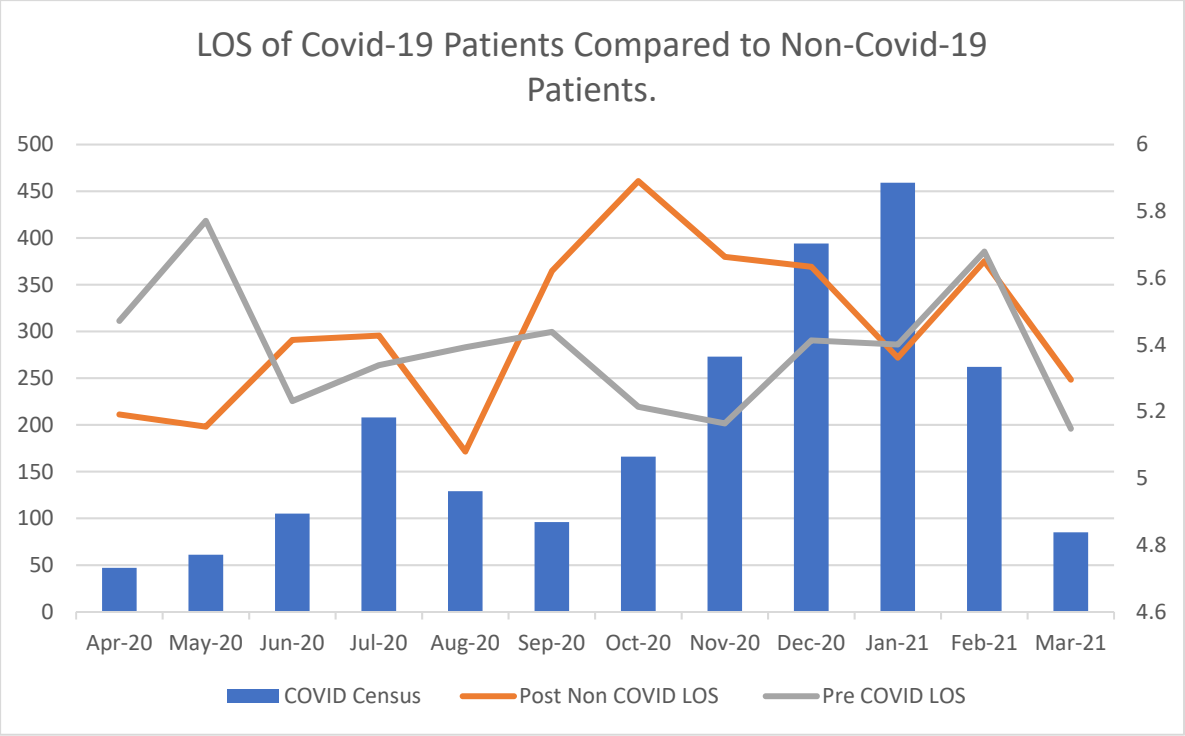

Exhibit 3: Regression Analysis Comparing LOS Across Pre-Covid-19 and Post-Covid-19 Timeframes.

	Model I, Pre-Covid-19 (2019-2020)	Model II, Post-Covid-19 (2020-2021)
R	0.554	0.551
R Squared	0.307	0.303
Adjusted R Squared	0.306	0.303
Standard Error of the Estimate	4.594	5.228
F	508.982	506.72
Significance	0.000	0.000
Constant		
B	**1.087**	0.097
Significance	**0.000**	0.669
Age		
B	**-0.034**	**-0.036**
Significance	**0.000**	**0.000**
Sex		
B	-0.078	**-0.477**
Significance	0.366	**0.000**
American Indian or Alaskan Native		
B	0.275	0.192
Significance	0.761	0.903
Asian		
B	0.325	**1.392**
Significance	0.357	**0.000**
African American		
B	0.099	**0.260**
Significance	0.378	**0.044**
Hawaiian or Pacific Islander		
B	2.128	-1.065
Significance	0.257	0.416
Other		
B	0.215	
Significance	0.711	X
Unknown/ Declined/ Blank		
B	**1.136**	**1.367**
Significance	**0.000**	**0.000**
Number Of Diagnoses		
B	**0.358**	**0.369**
Significance	**0.000**	**0.000**
Hispanic		
B	-0.027	**1.217**

	Significance	0.816	**0.000**
Covid-19 Census			
	B		**0.002**
	Significance	X	**0.000**

Bolding denotes P < 0.05