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BRIEF REPORT

General Medicine

Relationship between on-demand telehealth visits and emergency department and hospital surge during the COVID-19 pandemic

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Abstract

Objectives: The relationship between COVID-19-related telehealth calls could be used to predict emergency department visits and hospital surges 3 days later potentially facilitating staffing adjustments in advance of patient arrivals. The purpose of this research was to study the temporal association between frequencies of on demand telehealth calls and emergency department surges during the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic.

Methods: This cohort study examined patients who self-initiated synchronous audio-video on-demand telehealth calls between January 1, 2020 and June 30, 2022, and compared these to emergency department arrivals. The exposure in question was a synchronous audio-video on-demand telehealth visit. Our main outcome measured was frequency of emergency department visits. After autocorrelation, a multivariate linear regression model was utilized to determine temporal relationships between the two variables.

Results: This cohort study examined 42,429 synchronous audio-video on-demand telehealth calls, of which 43.6% were COVID-19 related, and 540,686 emergency department visits, of which 3.9% were diagnosed with COVID-19. COVID-19-related telehealth calls 3 days prior were predictive of emergency department encounters ($r^2 = 0.85$, $p < 0.001$). Emergency department encounters were strongly correlated with hospital admissions ($r^2 = 0.71$, $p < 0.001$).

Conclusions: Our results demonstrate that telehealth calls related to COVID-19 were an accurate predictor of emergency department encounters 3 days later, and emergency department encounters are highly correlated with hospital admissions. Limitations include that we only assessed a single health system in the region covered by the telemedicine healthcare professionals. We did not examine direct links between these two encounter types nor severity of illness at the patient level. Understanding

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that telehealth calls related to COVID-19 are highly predictive of emergency department encounters within 3 days may provide a brief but important window to upstaff hospitals at the beginning of future COVID-19 surges.

KEYWORDS
COVID-19, emergency medicine, hospital surge, telehealth

1 | INTRODUCTION

1.1 | Background and importance

The SARS-CoV-2 pandemic that causes COVID-19 began in 2019 and quickly progressed to one of the deadliest pandemics in history.[1] The pandemic had several waves of increasing infections resulting in emergency department overcrowding and strained hospital bed capacity.[2] During the pandemic, telehealth exhibited an increase in utilization.[3,4] Our health system had a pre-established on-demand program and performed 100,000 synchronous audio-video visits prior to the pandemic, and we were able to rapidly expand at the onset of the pandemic.[5]

The ability to accurately predict increased volumes in the emergency department and subsequent need for increased inpatients beds could allow for pre-planning to combat the unfavorable consequences of overcrowding and resource deficiencies. Several mathematical models exist to determine the impact of future surges including ways to estimate surges in patient needs for hospital services.[6]

1.2 | Goals of this investigation

The objective of this study was to determine if patient self-initiated synchronous audio-video call volumes could be utilized to aid in predicting surges during the COVID-19 pandemic. We hypothesize telehealth calls are a useful predictor of emergency department visits and admissions within a specific time interval.

2 | METHODS

2.1 | Study design

This retrospective cohort analysis was deemed exempt from IRB review at Thomas Jefferson University and follows the STROBE reporting guidelines.

2.2 | Selection of participants and measurements

Clinical data were generated by our enterprise electronic health record (Epic Systems) and extracted from our organizations clinical data warehouse via third-party analytics software (Qlik). The study included two cohorts: daily volumes of arrivals for those who initiated on-demand synchronous audio-video telehealth visits and those who presented to one of five emergency departments between January 1, 2020 and June 30, 2022. For telehealth presentations, we examined all comers as well as those who called with a COVID-19-related complaint based on clinical documentation of the "reason for visit" from the encounter healthcare professional. For emergency department presentations, we examined all comers as well as those who received a COVID-19-related ICD-10 diagnosis code (U07.1, Z20.822, Z11.52). We also examined those who required inpatient care during their encounter.

2.3 | Analysis

We performed an autocorrelation function assessment among three time series with daily all cause emergency department visits: (1) all cause telehealth calls, (2) COVID-19-related telehealth calls, and (3) COVID-19-related emergency department visits. We also compared COVID-19-related telehealth calls with COVID-19-related emergency department visits. Based on autocorrelation results, we selected all time intervals beyond the confidence interval of uncorrelated series and prepared features accordingly; for example, when autocorrelation analysis between all cause telehealth calls and all cause emergency department visits found negative correlation between the two time series with telehealth calls leading emergency department visits by 1–26 days, 26 features are created from telehealth calls with time intervals ranging from 1 to 26 days prior to emergency department visits. We then created a multivariate linear regression model based on all the curated time series, including (1) all cause telehealth calls, (2) COVID-19-related telehealth calls, (3) COVID-19-related emergency department visits, and (4) all cause emergency department visits, with various lead time intervals, to predict future emergency department visits. This range was chosen to reflect the various periods of time thought to impact transmissibility at the time of the data analysis. Eighty percent of the study period is utilized as training data, and 20% of the latest study period is utilized as test data. In addition to the linear regression model, we also experimented with other regularized linear regression models including Ridge, Lasso, and Elastic Net. Linear regression is chosen because of its best in-sample and out-of-sample performance in terms of R square and root mean square error. A Spearman's rho calculated correlation between emergency department visits and admissions.

3 | RESULTS

3.1 | Characteristics of study subjects

During the study period there were 42,429 telehealth calls, of which 18,492 (43.6%) were COVID-19 related. There were 540,686 emergency department encounters, of which 21,218 (3.9%) had COVID-19-related diagnoses (see Figure 1). Of these emergency department encounters, 133,839 (24.8%) were admitted.

The Bottom Line

This retrospective cohort study looked at ability of telehealth visits to predict emergency department (ED) visits during the 2020 to 2022 COVID-19 outbreak. Among five EDs, regional telehealth calls related to COVID-19 at 2 to 3 days prior predicted ED encounters and subsequent admission. Such modeling may help predict future surges and staffing needs.

3.2 | Main results

The linear regression model was statistically significant ($R^2 = 0.85$, $p < 0.001$), as shown in Figure 2. COVID-19-related telehealth calls 3 days prior and 2 days prior were predictive of emergency department encounters ($p = 0.011$ and $p = 0.026$, respectively). Emergency department visits looking back 3 weeks ($p < 0.001$), 2 weeks ($p < 0.001$), 1 week ($p < 0.001$), and 1 day ($p < 0.001$) were also highly predictive of emergency department visits overall (see Table 1). Spearman's rho demonstrated a statistically significant correlation between emergency department encounters and hospital admissions ($R^2 = 0.71$, $p < 0.001$).

4 | LIMITATIONS

This study had some noteworthy limitations. First, although the largest health system in the region with a well-established telehealth program, it was still a single health system and we only examined five emergency departments. Other systems with different telehealth features may experience different relationships between the two services. Second, we only examined frequency data and did not include demographic data to assess relationships between individual patients calling telehealth and we did not control for severity of illness, co-morbidity, or social determinants of health. We also did not assess any associated details of the clinical encounters (ie, symptoms, exposures, and durations) in the on-demand or emergency department visits. Therefore, it is impossible to determine if there is any association between the progression of symptoms where initial telehealth calls result later in ED visits for more severe late-stage symptoms. Additionally, we did not assess if patients had confirmed COVID-19, though perceived illness is what drives emergent and on-demand visits. Finally, the study was conducted before the wide-spread use and government distribution of rapid antigen testing for COVID. Many of the telehealth calls were for polymerase chain reaction (PCR) testing. As testing becomes more widely available, the same patterns of use may not persist. Alternatively, as more robust treatment options become available, telehealth usage may be driven higher. Most notably, this study was meant to assess if telehealth calls demonstrated a relationship with ED surges and was not meant to be considered a sole predictor of ED overcrowding. Future research should explore how telehealth calls can play a role in multivariate predictive models and explore other nontraditional data sources to promote high-quality ED care.

5 | DISCUSSION

There have been multiple waves of the SARS-CoV-2 pandemic.[7] Surges can overwhelm hospital capacity and excess capacity has a well-documented association with adverse outcomes. Real-time predictors

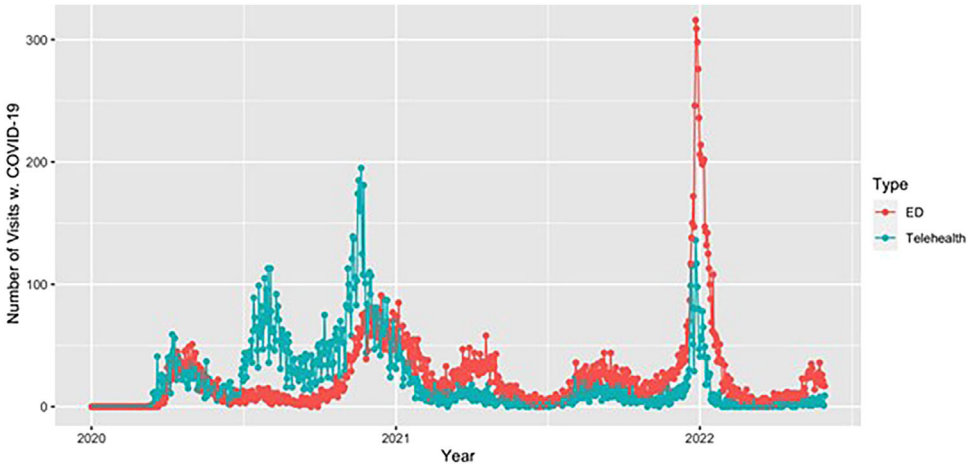

FIGURE 1 Frequencies of COVID-19-related telehealth calls and COVID-19-related emergency department visits.

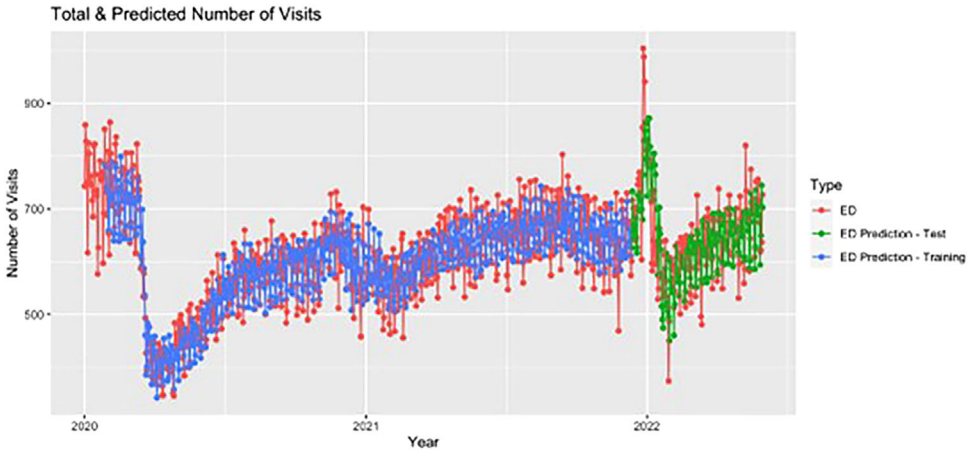

FIGURE 2 Predictive model compared to total emergency department visits.

TABLE 1 Linear regression model coefficients.

Variable	Estimate	SE	*t* Value	Pr (>|t|)	Significance
Intercept	600	1.402	427.683	0.000	***
Number of telehealth visits 3 days ago	−24	8.319	−2.881	0.004	*
Number of telehealth visits with COVID chief complaint 3 days ago	19	7.347	2.543	0.011	**
Number of telehealth visits with COVID chief complaint 2 days ago	10	4.570	2.232	0.026	**
Number of emergency department visits 22 days ago	−7	3.931	−1.892	0.059	
Number of emergency department visits 3 weeks ago	17	3.895	4.385	<0.001	***
Number of emergency department visits 2 weeks ago	21	3.844	5.431	<0.001	***
Number of emergency department visits 1 week ago	26	3.900	6.653	<0.001	***
Number of emergency department visits yesterday	18	3.827	4.584	<0.001	***

Abbreviations: SE, Standard Error.
*$p < 0.01$;
**$p. < 0.05$.
***$p < 0.001$;

of surges are useful for planning hospital operations.[2] While several mathematical models exist that attempt to predict the impact of COVID-19 surges on hospitals,[6] none of these incorporate telehealth call frequencies as a predictor of hospital surges.

These results demonstrate that regional telehealth calls related to COVID-19 were a significant predictor of emergency department encounters at 2 and 3 days' leading time intervals, and that increasing rates of emergency department encounters are highly correlated with increased hospital admissions. It is well documented that symptom severity of COVID-19 infection increases with time, usually with hospital admission occurring in 7 days after symptom onset,[8] though more recent variants have shorter durations.[9] The observations described above are biologically and clinical plausible, assuming patients call telehealth earlier in their disease progression when symptoms are milder, seeking testing and/or confirmation. Then, when the symptoms progress patients may seek in person treatment in the emergency department. Incidentally, it was also observed that emergency department encounters themselves were highly predictive of more future emergency department visits for up to 3 weeks. This may be representative of individual waves of the pandemic as emergency department utilization increased with each day of the surge.

Telemedicine has become an important healthcare modality in the post-pandemic healthcare space. This study demonstrated that telehealth calls related to COVID-19 are highly predictive of emergency department encounters within 2–3 days, a metric previously unused in surge modeling. Emergency department encounters were highly

correlated with admissions implying COVID-19-related telehealth calls may also predict surges in hospitalization. This brief but critical window could be utilized to prepare for potential surges. Additional personnel could be scheduled, resources could be redistributed, and attempts could be made to redirect to alternative care opportunities (Urgent Care), and Emergency Medicine Services could appropriately plan for rerouting. Our results are not completely conclusive, but should spark interest in including uncommonly used variables, such as telemedicine call frequencies, in new developments of surge models for COVID-19. Further research and development of predictive models for COVID-19 surges that include telehealth calls could improve the predictive value of these tools.

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