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Temporal associations between emergency department and telehealth volumes during the COVID-19 pandemic: A time-series analysis from 2 academic medical centers

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ABSTRACT

Background: The COVID-19 pandemic compelled healthcare systems to rapidly adapt to changing healthcare needs as well as identify ways to reduce COVID transmission. The relationship between pandemic-related trends in emergency department (ED) visits and telehealth urgent care visits have not been studied.
Methods: We performed an interrupted time series analysis to evaluate trends between ED visits and telehealth urgent medical care visits at two urban healthcare system in Colorado. We performed pairwise comparisons between baseline versus each COVID-19 surge and all three surges combined, for both ED and telehealth encounters at each site and used Wilcoxon rank sum test to compare median values.
Results: During the study period, 595,350 patient encounters occurred. We saw ED visits decline in correlation with rising telehealth visits during each COVID surge.
Conclusions: During initial COVID surges, ED visits declined while telehealth visits rose in inverse correlation with falling ED visits, suggesting that some patients shifted their preferred location for clinical care. As EDs cope with future staffing during the ongoing COVID pandemic, telehealth represents an opportunity for emergency physicians and a means to align patients desires for virtual care with ED volumes and staffing.

1. Introduction

The emergence of COVID-19 as a global health threat in early 2020 suddenly and dramatically changed both health needs and the delivery of care. In response to the growing infectious threat, healthcare systems began planning for local outbreaks by identifying anticipated challenges, including decreasing patient volume and the inability to provide some care by traditional means [1]. In February 2020, the Centers for Disease Control and Prevention (CDC) responded to the growing COVID threat and advised healthcare systems to adopt safety protocols, such as telehealth, that reduce or eliminate potential infectious exposure [2].

Telehealth is the use of two-way telecommunication technology that allows clinicians to provide care remotely. Telehealth showed rapid expansion through the initial portion of the pandemic with telehealth visits in some healthcare systems growing by over 50% in the first quarter of 2020, as compared to 2019 [3,4].

Concurrently with telehealth's increasing adoption in early 2020, emergency department (ED) visits decreased substantially. This decline was caused by at least three types of behavioral change: (1) exposure to all types of disease and injury was reduced, as schools and workplaces closed and most non-essential travel was suspended; (2) sick and injured patients avoided seeking medical care due to concerns for contracting COVID-19; and (3) routine or elective care was postponed [5,6].

While evidence suggests that telehealth volume increased nationally during the COVID-19 pandemic, it's unclear how much of this increase was from acute unscheduled healthcare, and how much was from a transition of routine outpatient care to a telehealth model to reduce infectious exposure [3,4]. The correlation with telehealth use and ED volumes has not yet been established.

The goal of this study was to evaluate the temporal association between emergent/urgent telehealth utilization and ED volume throughout three COVID surges in Colorado.

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2. Methods

2.1. Study design

We performed an interrupted time series analysis to evaluate associations between COVID-19 case surges and number of daily ED and telehealth encounters in two large, urban healthcare systems in Colorado from January 1, 2019 through December 31, 2020. The study was approved by the Colorado Multiple Institutional Review Board and granted a waiver of consent, and is reported in accordance with the Transparent Reporting of Evaluations with Nonrandomized Designs guidelines.

2.2. Setting

Denver Health (DH) is a large, urban public health care system in Denver, Colorado whose main hospital, Denver Health Medical Center, includes both adult and pediatric EDs and urgent cares with >125,000 combined annual patient encounters. Denver Health also provides the NurseLine, a free, 24-h acute unscheduled call-in medical service available to all Colorado residents. NurseLine calls are received by trained nurses who can: (1) treat lower-risk conditions via protocolized care (e.g. antibiotics for uncomplicated urinary tract infections); (2) refer for urgent or emergent in-person follow-up; or (3) consult the NurseLine on-call emergency physician.

UCHealth is a large, urban academic health care system in Aurora, Colorado whose main hospital, University of Colorado Hospital (UCH), includes an adult ED, which has >100,000 annual patient encounters. UCHealth offers a fee-for-service, 24-h video-based Virtual Urgent Care to all Colorado residents. Encounters are staffed by advanced practice providers and emergency physicians, who can treat a variety of lower-risk conditions, or refer patients for in-person follow-up.

Both the Denver Health NurseLine and UCHealth Virtual Urgent Care served to triage calls relating to urgent medical needs during the COVID-19 pandemic, resulting in medical advice and referrals for testing and in-person urgent and emergent follow-up.

2.3. Study sample

All ED and telehealth encounters from January 1, 2019 through December 31, 2020 were included, regardless of age. There were no exclusions.

2.4. Time series

COVID-19 case surges were chosen as interruptions of the time series and were identified by upward inflection points in Colorado's COVID-19 epidemiological case data to correspond with the following four distinct time intervals: [1] January 1, 2019 through March 24, 2020 (pre-COVID-19 baseline); (2) March 25, 2020 through June 15, 2020 (first surge); (3) June 16, 2020 through September 12, 2020 (second surge); and (4) September 13, 2020 through December 31, 2020 (third surge). The study period was chosen to begin on January 1, 2019 to measure a pre-COVID-19 baseline with an adequate duration to account for secular trends. The first interruption was identified as March 25, 2020, where an upward inflection point of reported cases in Colorado was demonstrated, and also the date when a state-wide stay-at-home order was implemented. Second and third surge time periods were chosen based on the transition point from downward to upward inflections in the case data [7]. Date of encounter, age, and gender were extracted from each electronic health system (Epic, Epic Systems Corporation, Verona, WI).

2.5. Statistical analysis

Descriptive statistics were used to summarize the demographic characteristics of patients and stratified by visit type and time period. Median values with 95% confidence intervals (CIs) were reported for each time series. We further performed comparisons between baseline versus each COVID-19 surge and all three surges combined, for both ED and telehealth encounters at each study site [8]. We used the Wilcoxon rank sum test to compare median values, while also estimating the differences between medians with 95% CIs. Medians were chosen as the comparator for the effect estimates, as opposed to level (y-intercept of each series) and trend (slope), because our intention was to compare the overall effect of COVID-19 on each time series rather than the immediate effects or rates of change. We also estimated the differences between the changes in baseline versus each COVID-19 surge and all surges combined of median daily encounters between ED and telehealth visits at each institution [8]. This method of analysis was utilized in order to compare the effect of COVID-19 on two unscheduled, conceptually inverse encounter types, within two geographically similar but operationally distinct healthcare systems. All analyses were performed using SAS Enterprise Guide Version 7.1 (SAS Institute Incorporated, Cary, NC).

3. Results

3.1. Study sample characteristics

During the study period, 595,350 total encounters occurred. Stratification by time series and setting, including baseline characteristics, are summarized in **Appendix A**.

3.2. Main results

Results of the interrupted time series analysis demonstrated significant differences (all $p < .0001$) of median daily encounters between baseline versus each COVID-19 surge, and baseline versus all surges combined, in both ED and telehealth visits at Denver Health and UCHealth (Table 1).

Table 1
Interrupted time series analysis comparing differences of median daily encounters between baseline and COVID-19 surges, stratified by setting.

	Daily encounters					
	n	Median	(95% CI)	Δ	(95% CI)	*p*
Denver Health						
ED						
Baseline	154,963	346	(342–349)	Ref		Ref
1st Surge	18,026	219	(205–229)	−127	(−139 to −115)	<0.0001
2nd Surge	24,957	281	(275–289)	−65	(−73 to −57)	<0.0001
3rd Surge	30,898	284	(279–293)	−62	(−70 to −54)	<0.0001
All surges	73,881	269	(261–276)	−77	(−91 to −59)	<0.0001
Telehealth						
Baseline	79,613	181	(176–184)	Ref		Ref
1st Surge	21,341	257	(248–269)	76	(65–87)	<0.0001
2nd Surge	20,484	227	(222–240)	46	(35–57)	<0.0001
3rd Surge	26,415	241	(224–253)	60	(45–71)	<0.0001
All surges	68,240	243	(236–251)	62	(44–80)	<0.0001
UCHealth						
ED						
Baseline	123,244	276	(274–279)	Ref		Ref
1st Surge	17,157	207	(198–212)	−69	(−77 to −62)	<0.0001
2nd Surge	21,516	243	(237–247)	−33	(−40 to −26)	<0.0001
3rd Surge	26,898	245	(241–250)	−31	(−37 to −25)	<0.0001
All surges	65,571	233	(229–240)	−43	(−55 to −25)	<0.0001
Telehealth						
Baseline	7227	9	(8–10)	Ref		Ref
1st Surge	8859	97	(82–113)	88	(73–103)	<0.0001
2nd Surge	5331	60	(56–64)	51	(48–55)	<0.0001
3rd Surge	8381	74	(69–78)	65	(61–69)	<0.0001
All surges	22,571	70	(67–73)	61	(54–73)	<0.0001

Abbreviations: CI = confidence interval; ED = emergency department; IQR = interquartile range; Ref = reference.

Table 2
Difference-in-differences of median daily ED and telehealth encounters from baseline to each COVID-19 surge, stratified by setting.

	Difference in differences (encounters)	(95% CI)	*p*
Denver Health			
Baseline vs 1st surge	−51	(−55 to −47)	<0.0001
Baseline vs 2nd surge	−19	(−23 to −15)	<0.0001
Baseline vs 3rd surge	−2	(−6–1)	0.2113
Baseline vs all surges	−15	(−19 to −11)	<0.0001
UCHealth			
Baseline vs 1st surge	19	(15–23)	<0.0001
Baseline vs 2nd surge	18	(14–22)	<0.0001
Baseline vs 3rd surge	34	(30–38)	<0.0001
Baseline vs all surges	18	(14–21)	<0.0001

Abbreviations: CI = confidence interval; vs = versus.

The difference-in-differences analysis showed that changes in median daily ED versus telehealth encounters at Denver Health differed between baseline versus 1st surge ($p < .0001$), baseline versus 2nd surge ($p < .0001$), and baseline versus all surges combined ($p < .0001$), but not between baseline versus 3rd surge ($p = .21$). Results of the difference-in-differences analysis of UCHealth were all significant (all $p < .0001$) (Table 2).

Fig. 1 illustrates the results of both the interrupted time series and difference-in-differences analyses, using multiple line graphs with 95% CIs of median daily ED and telehealth encounters at Denver Health and UCHealth. Across both institutions, an inverse directionality existed between median ED versus telehealth encounters from the pre-COVID-19 baseline to the first surge, as ED encounters decreased, while telehealth encounters increased. The first to second surge demonstrated the same inverse relationship between ED and telehealth encounters, but in the opposite directions, as ED encounters increased, while telehealth encounters decreased. From the second to third surge, all ED and telehealth encounters increased. Scatter plots demonstrating total encounters per day, stratified by time series, in each of the four study settings, is included in **Appendix B**.

4. Limitations

The study period ended during the third COVID-19 case surge, and while it included the period of greatest incidence in the third surge and overall, incorporating the end of third surge, in addition to later surges, could have identified additional longitudinal trends in encounter volumes. Our analysis included descriptive statistics of age and gender, but did not evaluate associations between these or other demographic nor socioeconomic variables (e.g. insurance type, zip code) with changes in ED or telehealth encounters. In addition, our analysis did not include encounter-level variables, including chief complaint, duration of encounter, and telehealth encounter disposition (e.g. advised to go to ED).

5. Discussion

Our study demonstrated that significant changes occurred in acute unscheduled in-person and telehealth encounter volumes within two unique healthcare systems during the COVID-19 pandemic. We identified immediate and overall decreases in ED volumes, consistent with previously described data [6]. Reasons for this drop in visits are likely

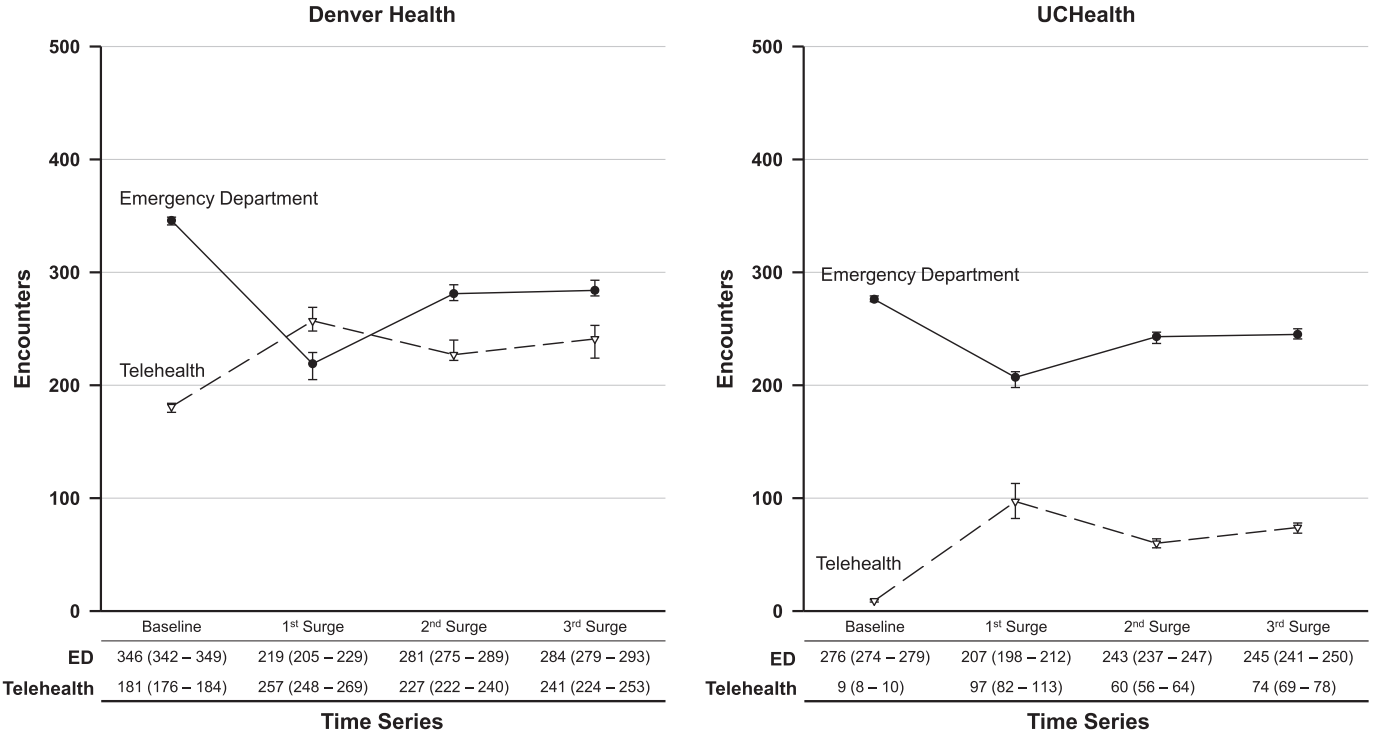

Fig. 1. Median (95% confidence intervals) daily emergency department (ED) and telehealth encounters at baseline and each COVID-19 surge, by institution.

multifactorial. Stay-at-home orders may have contributed to a decreased spread of other community acquired illnesses, a reduction in some injuries (e.g. car accidents), and a desire for patients to avoid emergency departments for fear of contracting COVID. Of note, certain types of violence including firearm and domestic violence rose during stay-at-home orders [9]. Cancelling of surgical procedures likely resulted in decreased post-operative visits.

While ED volumes decreased, this study showed concurrent 34% and 678% increases in median acute unscheduled telehealth volumes across the two sites. This is noteworthy, as it indicates that patients still sought emergency and urgent medical care, but rapidly transitioned from the ED to telehealth models. Of note, these visits were independent of any ambulatory clinic visits that transitioned to telehealth as they served urgent and acute medical needs. Additionally, staffing this surge was sourced solely by ED providers.

As a result, acute unscheduled telehealth presents a unique opportunity for EDs, both in terms of managing patient influx, and to dynamically manage staffing. With the ongoing COVID-19 pandemic and with future pandemics, patient volumes may continue to fluctuate. Telehealth can be used to rapidly change staffing models, transitioning physicians to and from a virtual setting as needed to meet patient demand and ensure appropriate staffing in the ED. Many EDs decreased staffed shifts during the initial surges of the pandemic, and telehealth shows that physicians can be transitioned to alternative clinical sites to decrease staffing cuts [10].

Emergency physicians have been readily adaptable in clinical practice due to the evolving and unpredictable nature of the ED, highlighted by the growing adoption of acute telemedicine services at many hospitals. Despite this adaptability, the emergency medicine workforce will likely face a physician surplus over the next decade and reduced patient volume from events like the COVID-19 pandemic could exacerbate this oversupply. Emergency medicine physicians, with their inherent adaptability are uniquely poised to understand and adjust to changing clinical care technology.

Author contributions

All authors conceived the study. CD, ME obtained data. BL, JH analyzed data and performed statistically support. ER and BL drafted the manuscript. BS provided project oversight. All authors contributed to the revision of the manuscript.

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Credit authorship contribution statement

Elaine M. Reno: Conceptualization, Data curation, Project administration, Supervision, Writing – original draft, Writing – review & editing. **Benjamin Li:** Writing – review & editing, Formal analysis, Data curation, Conceptualization. **Morgan Eutermoser:** Conceptualization, Data curation, Supervision. **Christopher B. Davis:** Supervision, Data curation, Conceptualization. **Jason S. Haukoos:** Writing – review & editing, Formal analysis, Supervision. **Bradley Shy:** Writing – review & editing, Writing – original draft, Supervision, Resources, Investigation, Data curation, Conceptualization.

Declaration of Competing Interest

The authors report no conflicts of interest as it pertains to this project.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ajem.2022.01.046.

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