



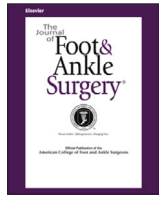
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## Epidemiological Survey of the Impact of COVID-19 on Telemedicine in the Practice of Foot and Ankle Surgery in the United States



Kayla Neville, MS<sup>1</sup>, Alexandra T. Black, DPM<sup>2</sup>, Robert Fridman, DPM, FACFAS, CWSP<sup>3</sup>

<sup>1</sup> Medical Student – Year 2, New York College of Podiatric Medicine, New York, NY

<sup>2</sup> PGY-3, Lenox Hill Hospital Northwell, New York, NY

<sup>3</sup> Attending Podiatrist, Columbia University Medical Center, Department of Orthopaedic Surgery, New York, NY

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## ABSTRACT

In response to loosened telehealth regulations and local restrictions on elective procedures during the coronavirus disease 2019 (COVID-19) pandemic, telemedicine use has dramatically increased. The goal of this study was to analyze patterns in telemedicine use among podiatric physicians during the COVID-19 crisis on a national level. Anonymous responses to a survey of practice metrics as well as subjective impressions of telemedicine efficacy were collected from 246 respondents, representing >1% of practicing podiatrists in the United States. Linear regression was performed to identify variables associated with COVID-19 prevalence and variables associated with higher self-reported likelihood of offering telemedicine visits post-COVID-19. Physicians in areas of lower COVID-19 prevalence were found to dispense durable medical equipment more frequently in-office and conduct more post-op telemedicine visits, with fewer visits for infections and trauma. Podiatrists in these regions also rated telemedicine more effective for medical and musculoskeletal pathologies. Additionally, fewer of their practices had modified office hours, and more of them advertised telemedicine services. Physicians more likely to offer telemedicine post-COVID-19 had significantly higher new patient volume and increased acuity of cases, with patient admission to the hospital after telemedicine visits. These physicians ranked the effectiveness of telemedicine more highly for every pathology surveyed. Of note, American College of Foot and Ankle Surgeons region and years in clinical practice were not statistically associated with likelihood of offering telemedicine visits post-COVID-19. This study represents the first systematic national assessment of telemedicine use in podiatry and highlights clinically relevant changes in practice and perception of telemedicine in response to the COVID-19 pandemic.

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Telemedicine has given patients an efficient and accessible means of extension for patient-physician interactions. One of the earliest reported uses of telehealth involves an article from 1879 discussing the use of telecommunications for patient-physicians in order to avoid unnecessary in-office visitation (1). The World Health Organization declared a national state of emergency concerning the coronavirus disease 2019 (COVID-19) outbreak on March 11, 2020. As of June 2020, there are 2.1 million cases with 116,862 associated deaths in the nation and 8.2 million cases with 445,535 deaths globally (2,3). The novel coronavirus pandemic drastically changed medical priorities for healthcare organizations on a global scale. These changes include careful surveillance of symptomatic and asymptomatic individuals, increasing

coronavirus testing numbers and maintaining social distancing with strict public health quarantine, all disrupting typical routine care for physicians and surgeons. Unless the clinical encounter was considered emergent, healthcare visits and nonemergent surgeries were suspended in the United States.

During the coronavirus pandemic response, the United States government loosened telehealth regulations and provided funding to expand telehealth services and reduce the risk of viral spread (4). The use of telemedicine by healthcare institutions dramatically increased (5,6). A multitude of disciplines adapted rapidly to implement telemedicine with the intention of preventing virus exposure and reducing the burden on the healthcare system (7-15). Recently, there has been a significant amount of sharing of expertise throughout the literature to improve application of telehealth with better outcomes. The orthopedic department at Johns Hopkins University described their experience with rapidly integrating a program by applying important factors: patient triage, technologic resources, credentialing, billing, and coding (16). Furthermore, 50% of the typical clinic volume was reached via online, synchronous, 2-way audiovisual communication, while the

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Address correspondence to: Robert Fridman, DPM, FACFAS, CWSP, Columbia University Medical Center, Department of Orthopaedic Surgery, 60 East 56 Street, New York, NY 10022.

E-mail address: [rf2256@cumc.columbia.edu](mailto:rf2256@cumc.columbia.edu) (R. Fridman).

remaining 50% were either postponed or treated with an asynchronous method of communication (16).

The diabetic patient population is a delicate one requiring close monitoring with routine wound care and surgical interventions and, if neglected, is at a higher risk of infection, amputation, and increased mortality (17–19). According to retrospective studies from Wuhan, China, a large proportion of patients infected with COVID-19 present with comorbidities including cardiovascular and cerebrovascular ones, and diabetes, and these studies suggest an increased mortality risk for these patients (20,21). Studies have proposed strategies for optimal podiatric care: Roger et al suggested a Pandemic Diabetic Foot Triage System in a “new pandemic standard of care” determining location for site of care based on the diabetic foot conditions and urgency of the situation (17). New paradigm shifts in the management of diabetic foot wounds have been described in the literature thus far, including physician-to-patient and physician-to-home nursing in order to perform proper wound care practices (22).

Literature suggests the useful application of telehealth during previous disease outbreaks, including the Ebola virus, Severe Acute Respiratory Syndrome, H1N1 influenza, H7N9, and the Middle-East respiratory syndrome Coronavirus (23). This paradigm shift in medical management and clinical practice can be expected to have relevance in future emerging infectious disease pandemics. The goal of this epidemiological study was to analyze the use of telemedicine among podiatric physicians during the peak of the COVID-19 crisis on a national level. In addition, we evaluated trends in certain regions of the nation with high vs low prevalence, with the intent of considering how the recent crisis may impact the future of telemedicine in podiatric practices. We suspect that the landscape of clinical medicine will change dramatically post-COVID-19, where telemedicine will have a lasting impact on all disciplines. We hope to contribute applicable data associated with an accelerated introduction of telemedicine for practical and fruitful continued use of podiatric medicine and surgery in the future.

## Materials and Methods

Podiatrists who utilized telemedicine during the COVID-19 pandemic were surveyed about their practice characteristics, volume, and experiences with telemedicine (Fig. S1). The survey questionnaire was designed by the study team and publicized by the authors' social media accounts and email newsletters from the American College of Foot and Ankle Surgeons (ACFAS) and New York State Podiatric Medical Association (NYSPMA) throughout the data collection period of May 8–June 9, 2020. Our study was administered using a cloud-based software platform, Survey Monkey. This observational study was conducted in accordance with the Declaration of Helsinki.

The questionnaire was primarily written by the senior author who had prior experience with telemedicine, and was reviewed by a committee consisting of multiple members of the ACFAS, the NYSPMA, and a public health graduate student, before the survey was administered. The construct of this survey aimed to assess clinical practice characteristics of podiatric foot and ankle surgeons in the United States in relation to their use of telemedicine before and after COVID-19, as well as subjective impressions of telemedicine efficacy. The questionnaire was formatted as a self-administered online survey for ease of distribution to large sample of clinical practices across the entire United States. The survey was administered as a combination of open-ended questions, multiple choice with write-in option, and Likert scales. Multiple-choice or write-in options were used to collect clinical practice characteristics, in order to capture a large range of possible responses, due to the predicted heterogeneity of the sample population. Each multiple-choice option and high frequency write-in responses were then converted into binary variables (e.g., used zoom for telemedicine), and numeric write-in options were treated as continuous variables (e.g., number of years in clinical practice). Likert scales were used to assess subjective ranking of telemedicine efficacy.

The prevalence of COVID-19 cases was determined for each of the 9 ACFAS regions. The reported cases and deaths from March 31 to April 7, 2020 are listed for the US jurisdictions by the Center for Disease Control and Prevention Morbidity and Mortality Weekly report (24). The total resident population for each ACFAS region was calculated according to population data provided by the US Census Bureau 2019, and the number of reported COVID-19 cases as of April 7, 2020 was divided by the population data (25).

Anonymous survey responses were collected and analyzed to capture the impact COVID-19 had on a wide variety of practice metrics and physicians' experiences with telemedicine. A total of 246 respondents were identified, and when reporting individual variables, those respondents who did not answer a question were excluded from that item's

analysis. Outliers were defined as any data point with measured response value more than 1.5 interquartile ranges below the first quartile or above the third quartile for each of the numerical responses and where noted were excluded from figures for improved readability.

All survey response variables were reported using n (%) for categorical data and mean  $\pm$  standard deviation for numerical data. Linear regression analysis was performed to identify variables statistically associated with COVID-19 prevalence and variables associated with self-reported likelihood of offering telemedicine visits post-COVID-19.

Variables reflecting age and geographical location were not included in the regression with COVID-19 prevalence because they are not mutable characteristics. To analyze likelihood of offering telemedicine visits post-COVID-19, reported importance of telemedicine post-COVID-19 was excluded as a tautological variable. In addition to the 61 survey variables, 3 additional constructed variables were created and included in the linear regression modeling: fold change in patient case load, proportion of office time lost due to COVID-19, and COVID-19 prevalence (state level). Each predictor variable was tested against the corresponding response variable by linear regression, and the *p* values of regression coefficients were computed by Student's *t* test and corrected for multiple testing by the Benjamini-Hochberg method. Variables were considered statistically significant in their association with COVID-19 prevalence or likelihood of offering telemedicine visits post-COVID-19 at *p* value  $\leq .05$ .

## Results

### Survey Responses

Responses to the survey were first analyzed according to practice characteristics and volume as shown in Table 1. The majority of respondents were from the Northeast and Mid-Atlantic ACFAS regions, but all ACFAS regions were represented in the sample (Fig. 1). During COVID-19, the average in-person office time decreased by 9% (Fig. 2) and the COVID-19 telemedicine practice volume decreased 86% on average from pre-COVID-19 in-person office volume (Fig. 3). Respondents were also characterized according to their objective experiences with telemedicine (Table 2). Overall, the most frequently reported percentage of telemedicine cases were musculoskeletal (27%), and the lowest percentage (4%) were pre-op consultations (Fig. 4). The most frequently used video platforms were Facetime, proprietary hospital/electronic medical record platform, and Zoom (Fig. 5). The most frequent telemedicine advertising method was direct telephone call to patients, then email and social media (Fig. 6). Factors related to respondents' subjective impressions of telemedicine were also profiled (Table 3). Telemedicine was rated most effective for prescribing medications (8/10), medical issues (7/10), and dermatologic conditions (7/10), and least effective on average for trauma (5/10) (Fig. 7). The estimated COVID-19 prevalence by state during the survey period was annotated and is shown in Supplemental Table S1. Fig. 8 is a heatmap of the estimated prevalence of COVID-19 by state, such that the estimated prevalence of COVID-19 was highest in New York using reported data from April 7, at 0.71% (26,27).

### Factors Associated With COVID-19 Prevalence

In linear regression analysis, high COVID-19 prevalence was significantly associated with several characteristics of the physician's practice, objective experience with telemedicine, and subjective impression of telemedicine (Table 4). In areas of high COVID-19 prevalence, practices had significantly increased frequency of modified office hours, a higher percentage of infections and trauma cases. Practices in these areas also less frequently informed patients about telemedicine, reported increased frequency of completely closed offices, and used Facetime as their telemedicine platform at a higher rate. In areas of low COVID-19 prevalence, practices were statistically more likely to dispense durable medical equipment in-office, had a higher percentage of post-op telemedicine visits, rated telemedicine more effective for medical and musculoskeletal pathologies, and had longer hours open during COVID-19.

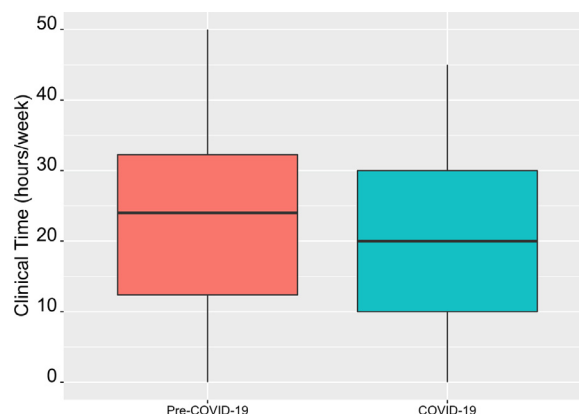
**Table 1**  
Practice characteristics and volume

Practice Characteristics and Volume	All Respondents n (%) or Average ± SD
ACFAS region	
Northeast	91 (38%)
Midatlantic	24 (10%)
Pacific	22 (9%)
Midwest	21 (9%)
Big West	19 (8%)
Tristate	18 (8%)
Great Lakes	18 (8%)
Southeast	13 (5%)
Gulf States	11 (5%)
Years in clinical practice	19 ± 11
Used telemedicine before COVID-19	13 (6%)
Office open during COVID-19	215 (90%)
Modified office hours	187 (84%)
Normal in-person office time (h/wk)	23 ± 12
Time open during COVID-19 (h/wk)	21 ± 12
Distributed durable medical equipment	172 (72%)
Dispensed in-person at office	74 (31%)
Patients ordered online or at store	67 (28%)
Drop shipped from a vendor or office	31 (13%)
Jan and Feb in-person (pts/wk)	108 ± 85
Mar and Apr telemedicine (pts/wk)	15 ± 21
Telemedicine new patients (pts/wk)	3 ± 5

Characteristics are expressed as n (%) or as the mean ± SD. For each variable, responses NA values were excluded from the analysis.

*Factors Associated With Likelihood of Offering Telemedicine Visits Post-COVID-19*

In linear regression analysis, higher self-reported likelihood of continued telemedicine use post-COVID-19 was significantly associated with physicians' subjective impression and objective experience of telemedicine (Table 5). Physicians who responded that they were more likely to offer telemedicine post-COVID-19 had significantly higher numbers of weekly new telemedicine appointments and had a higher frequency of admitting at least one patient to the hospital after a telemedicine visit. Additionally, for every pathology surveyed, physicians who were more likely to offer telemedicine post-COVID-19 ranked telemedicine as being more effective for that pathology. Interestingly, there



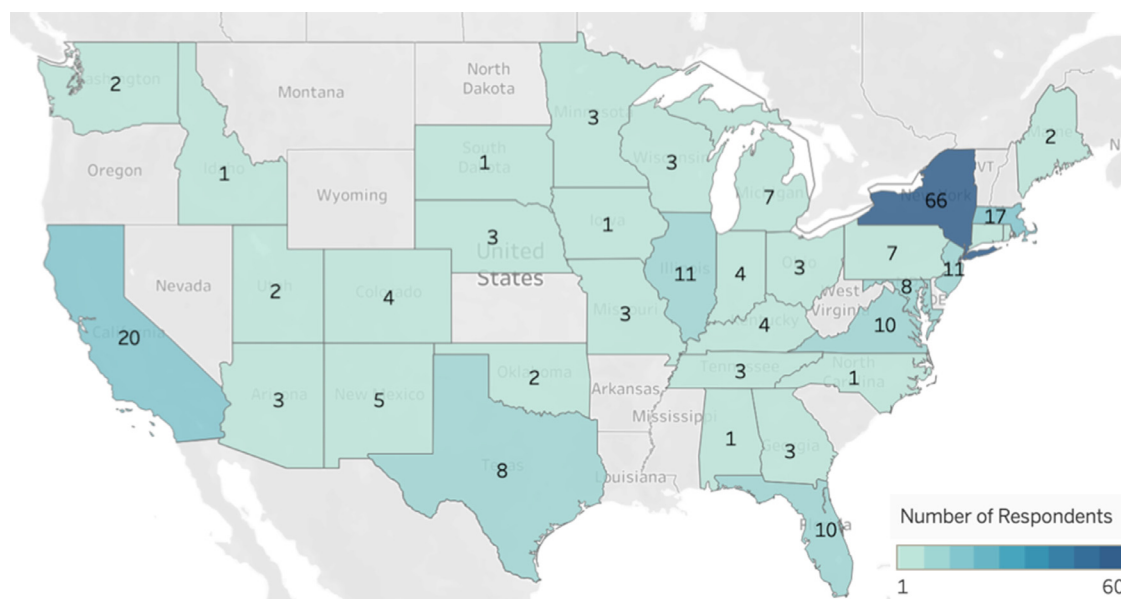
**Fig. 2.** Box plot of office hours. Comparison of in-person office time (h/wk) before and during COVID-19. Please note data were collected only from respondents whose office was open during COVID-19. Paired Student's t test: p value = .007.

was no statistically significant association between self-reported likelihood of continued telemedicine use and characteristics of the physician's practice such as ACFAS region and years in clinical practice.

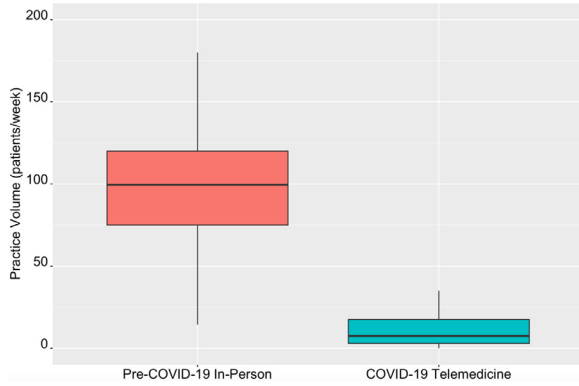
**Discussion**

This study represents the first systematic assessment of telemedicine use in podiatric clinics across the country and highlights changes in practice in response to the unprecedented COVID-19 pandemic. Our 246 respondents represent >1% of practicing podiatrists in the United States. Although we had higher response rates from New York than other states, our survey data included responses from all 9 ACFAS regions. We have characterized the volume of telemedicine usage and breakdown of pathologies treated, as well as physician's subjective assessments of telemedicine efficacy. This analysis has revealed that podiatrists rated telemedicine most effective for prescribing medications, medical issues, and dermatologic issues and reports the most popular telemedicine platforms and advertising mechanisms.

The prevalence of COVID-19 is shifting across the United States, and current telemedicine practices should subsequently prepare for a shift in their usage of telemedicine. Physicians in areas of high COVID-19



**Fig. 1.** Heatmap of survey respondents. Geographic location of survey respondents by state.

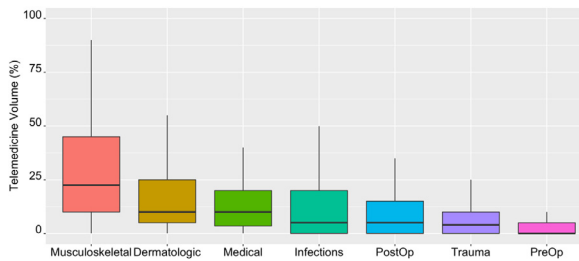


**Fig. 3.** Box plot of practice volume. Comparison of Jan and Feb in-person volume and Mar and Apr telemedicine volume (pts/wk). Paired Student's t test:  $p$  value  $<10^{-15}$ .

**Table 2**  
Telemedicine: objective experience

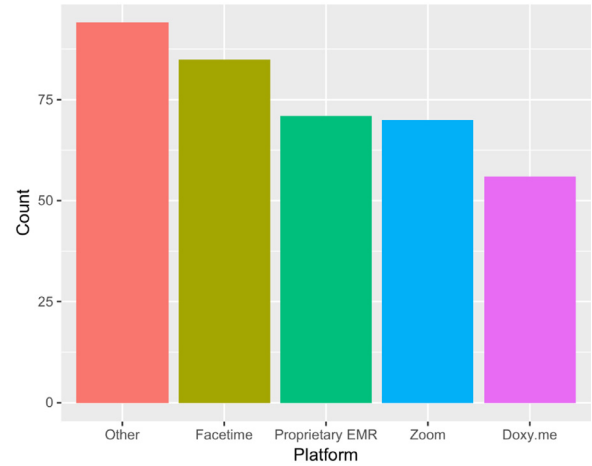
Telemedicine: Objective Experience	All Respondents n (%) or Average $\pm$ SD
Pathologies assessed via telemedicine (%)	
Musculoskeletal issues or tendinitis	27 $\pm$ 23
Dermatologic issues	19 $\pm$ 22
Medical issues	16 $\pm$ 18
Infections	14 $\pm$ 19
Post-op care	11 $\pm$ 16
Trauma	9 $\pm$ 13
Pre-op surgical discussions	4 $\pm$ 9
Video platform used	221 (92%)
Facetime	85 (36%)
Proprietary EMR or hospital platform	71 (30%)
Zoom	70 (29%)
Doxy.me	56 (23%)
Other platform	47 (20%)
WhatsApp	19 (8%)
Skype	14 (6%)
GoogleHangouts	11 (5%)
Informed patients about telemedicine	221 (92%)
Direct telephone call	142 (59%)
Email	78 (33%)
Social media	75 (31%)
Other	56 (23%)
Answering machine message	34 (14%)
Text	30 (13%)
Physical mailer	12 (5%)
Length of telemedicine appointment (min)	14 $\pm$ 6
Coordinated with a visiting nurse service	60 (25%)
Mar and Apr admitted telemedicine patient	59 (25%)

Characteristics are expressed as n (%) or as the mean  $\pm$  SD. For each variable, responses NA values were excluded from the analysis.

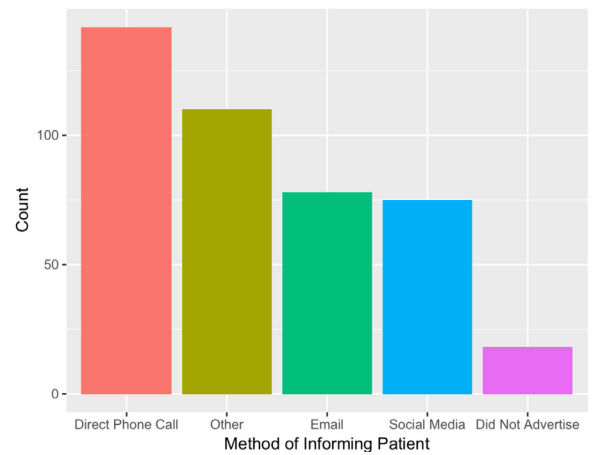


**Fig. 4.** Box plot of pathologies assessed via telemedicine (%): Distribution of reported percentage of total telemedicine volume for each pathology.

prevalence such as the Northeast and Tristate regions should prepare for a shift in their current telemedicine practice when prevalence of COVID-19 decreases in their area. Their practices are predicted to include more durable medical equipment dispensed in office, a higher



**Fig. 5.** Histogram of video platform used. Other includes WhatsApp, telephone, Skype, GoogleHangouts, and other platforms with  $<20$  respondents.



**Fig. 6.** Histogram of telemedicine advertising method. Other includes answering machine, text message, physical mailer, and other platforms with  $<50$  respondents.

**Table 3**  
Telemedicine: subjective impression

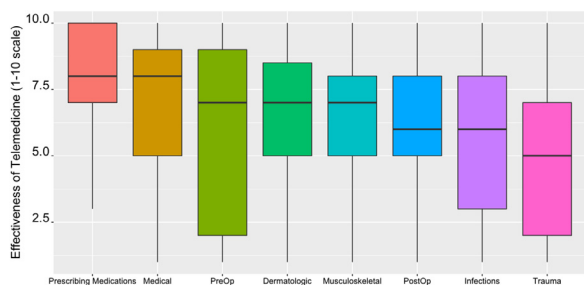
Telemedicine: Subjective Impression	All Respondents n (%) or Average $\pm$ SD
Effectiveness of telemedicine by pathology*	
Prescribing medications	8 $\pm$ 2
Medical issues	7 $\pm$ 2
Dermatologic issues	7 $\pm$ 2
Musculoskeletal issues or tendinitis	6 $\pm$ 2
Post-op care	6 $\pm$ 3
Pre-op surgical discussions	6 $\pm$ 3
Infections	6 $\pm$ 3
Trauma	5 $\pm$ 3
Likelihood of offering telemedicine visits post-COVID-19*	6 $\pm$ 3
Importance of telemedicine visits post-COVID-19*	6 $\pm$ 3
% telemedicine visits that prevented hospital admission	19 $\pm$ 30
Able to triage emergencies via telemedicine effectively	61 (52%)

Characteristics are expressed as n (%) or as the mean  $\pm$  SD. For each variable, responses NA values were excluded from the analysis.

\*Question was asked using a 10-point Likert scale, ranging from 1 (lowest) to 10 (highest).

percentage of post-op telemedicine visits, and longer hours open. Physicians in regions with lower COVID-19 prevalence also rate telemedicine more effective for medical and musculoskeletal pathologies. Additionally, their practices will have a decreased frequency of





**Fig. 7.** Box plot of effectiveness of telemedicine by pathology. Question was asked using a 10-point Likert scale, ranging from 1 (lowest) to 10 (highest).

modified office hours, decreased percentage of telemedicine appointments for infections and trauma, and will need to advertise telemedicine services more. Conversely, if physicians expect to have increased COVID-19 prevalence in their region, they should anticipate shifts in their telemedicine practices that are the reverse of the above. It is possible that these variables may have more to do with respondents' geographical area than COVID-19 prevalence, since COVID-19 disproportionately affected the Northeast and Tristate regions in this timeframe, and this should be noted as a limitation of this observational study.

Cronbach's alpha was not systematically assessed for the variables in this survey as they were not intended to query the same dimensionality. While certain variables assessed related concepts, such as telemedicine efficacy for different treatment indications, the aim of the study was not to intentionally test the same concept with multiple questions. Interrater reliability could also not be assessed for these data because there was only a single respondent from each clinical practice. Therefore, no two raters reported data from the same observation. Similarly, assessing intra-rater reliability with longitudinal observation is limited in this study as re-assessing the same respondents at a different point in time may change the responses as a result of a change in their clinical practice rather than unreliability of the test. The survey represents only a single cross section of respondents at a specific point in time rather than a longitudinal study. The survey administered in this study is entirely novel and aims to assess telemedicine use and impression of telemedicine among physicians. To our knowledge, there is no prior questionnaire with validity assessment targeted at the same research question. The clinical practice aspects of the questionnaire collect data that is directly

**Table 4**  
Factors associated with coronavirus disease 2019 prevalence

	Correlation Coefficient	p Value
Modified office hours	.23	.009
Dispensed DME at office	-.23	.009
% Telemedicine visits		
Infections	.22	.009
Trauma	.23	.009
Post-op	-.17	.04
Did not inform patients about telemedicine	.20	.02
Effectiveness of telemedicine*		
Medical	-.21	.02
Musculoskeletal	-.19	.03
Completely closed	.18	.03
Hours open COVID-19	-.19	.03
Video platform- Facetime	.17	.04

Abbreviations: COVID-19, coronavirus disease 2019; DME, durable medical equipment; Post-op, postoperative.

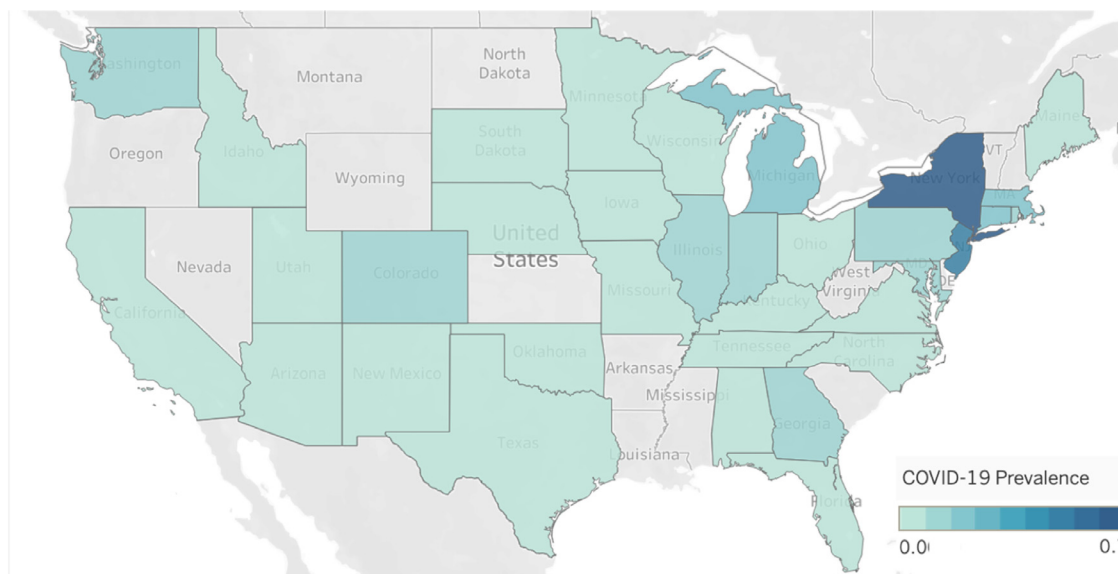
The relationship strength of the variables was determined via Pearson correlation coefficient and the statistical significance was determined using Student's *t* test. Positive correlation coefficient indicates association with high COVID-19 prevalence. Only significant variables (*p* value ≤ .05) were reported.

\* Question was asked using a 10-point Likert scale, ranging from 1 (lowest) to 10 (highest).

observable such as practice location and patient volume, which we rely on respondents to report accurately from internal data. The subjective element of the survey targeted at unobservable attributes uses the 10 point Likert scale to assess impression of telemedicine efficacy. The 10 point Likert scale has been extensively applied across surveys for a wide variety of research questions and has been used to assess subjective impression of treatment efficacy (26,27).

Limitations of our study included voluntary recruitment of respondents, which may lead to a degree of nonresponse bias. The study was also limited in assuming accuracy of self-reported data due to virtual self-administration of the questionnaire. This study design was used to sample clinical practices across the entire United States, with outreach efforts by ACFAS and NYSMA to reach a diverse pool of potential respondents. Despite the limitations of our investigation, we believe that the results of this study could be useful to help facilitate future integration of telemedicine in podiatric foot and ankle surgeon practices.

In conclusion, COVID-19 pushed the overwhelming majority (94%) of survey respondents into using telemedicine for the first time. We



**Fig. 8.** Heatmap of COVID-19 prevalence. Geographic location of COVID-19 prevalence by state. Only states with survey respondents were included in the heatmap.

**Table 5**  
What factors are associated with continued use of telemedicine

	Correlation Coefficient	p Value
Admit patient post telemedicine visit	.26	.0003
Weekly new telemedicine	.21	.006
Effectiveness of telemedicine*		
Medical	.51	10 <sup>-13</sup>
Musculoskeletal	.50	10 <sup>-13</sup>
Trauma	.51	10 <sup>-11</sup>
Prescribing medications	.46	10 <sup>-11</sup>
Pre-operative	.41	10 <sup>-9</sup>
Post-operative	.41	10 <sup>-7</sup>
Infections	.37	10 <sup>-7</sup>
Dermatologic	.37	10 <sup>-7</sup>
Triage emergencies	.26	.03

The relationship strength of the variables was determined via Pearson correlation coefficient and the statistical significance was determined using Student's *t* test. Only significant variables (*p* value ≤ .05) were reported.

\* Question was asked using a 10-point Likert scale, ranging from 1 (lowest) to 10 (highest).

characterized the distinguishing features of physicians who self-reported a high likelihood of offering telemedicine visits post-COVID-19 in an attempt to identify modifiable factors or perceptions that could influence new adopters to continue offering it as a service. Physicians who are more likely to offer telemedicine post-COVID-19 had significantly higher new patient volume and increased acuity of cases, as they were more likely to have admitted at least one patient after a telemedicine visit. Physicians who were more likely to offer telemedicine post-COVID-19 ranked the effectiveness of telemedicine more highly for every pathology surveyed. Of note, COVID-19 prevalence, ACFAS region, and years in clinical practice were not statistically associated with the likelihood of offering telemedicine visits post-COVID-19, arguing against a regional or generational gap in receptiveness to offering telemedicine visits. These findings could be considered when creating trainings and recommendations to physicians who want to have a better experience with telemedicine, or to identify who is most likely to have a positive experience with telemedicine if they incorporate it into their practice.

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### Supplementary Materials

Supplementary material associated with this article can be found in the online version at <https://doi.org/10.1053/j.jfas.2020.08.003>.

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