Title: Geospatial Analysis of Telehealth Patient Distances within a Student-Run Free Clinic

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Abstract

Background: Telehealth services within SRFCs have been shown to be effective; however, no previous studies within SRFC research have utilized geospatial analysis to assess the reach of telehealth services. The aim of this cross-sectional study was to visually and numerically assess the reachof telemedicine services at the Interprofessional Community Clinic and contrast it with the reach of our in-person clinic.

Methods: All unique patients seen for their first primary care clinic visit during 2023 and 2024 were classified as receiving care via telehealth or in-person. Google Maps was used to estimate the exact, average road mile distance at the most typical patient visit time of Thursday at 6:30pm for each year from the ICC to the patient's home address. Using geospatial software, the clinic location and centroids of each unique zip code were geocoded. Next, using Illinois road data, the shortest paths were summarized from centroid to ICC and visual geographical spread was depicted.

Results: In 2023, the ICC saw 69 unique patients - 16 utilized telehealth and 53 in-person. On average, those who utilized telehealth services lived 12.1 miles away from the clinic, while those who visited in-person lived 7.8 miles away. In 2024, the ICC saw 101 unique patients - 10 via telemedicine and 91 in-person. On average, those who utilized telehealth services lived 12 miles away from the clinic, while those who visited in-person lived 11.3 miles away. None of the differences were statistically significant.

Discussion: In 2023, patients seen by the telehealth service, on average, lived farther away from the ICC than the patient seen in person for their first visit. The farthest patient being in the telehealth group illustrates how SRFCs can use telehealth services to expand their reach to patients in need who may not be able to travel to the clinic.

Introduction

Student-Run Free Clinics (SRFCs) offer free healthcare services to individuals who may have limited access to traditional healthcare systems. Staffed primarily by student volunteers under faculty supervision, SRFCs serve uninsured and underrepresented populations.[1] Each SRFC is unique and offers various services ranging from primary care to specialty care such as ophthalmology.[2] Telehealth is a format in which healthcare services are offered remotely and has become more prominent in health centers, especially since the COVID-19 pandemic.[3] Utilizing telehealth options have several advantages and disadvantages within the patient-provider framework. These options include benefits such as decreasing travel time, increasing communication, reducing costs and shorter wait times, as well as barriers such as accessing physical devices and having an adequate internet connection.[3,4]

The Interprofessional Community Clinic (ICC) at Rosalind Franklin University offers pro bono care to uninsured patients in Lake County, many of whom experience health disparities at a disproportionate rate. In March 2020, the ICC created the telehealth clinic in response to the COVID-19 pandemic to continue to provide virtual care. Since the pandemic, telehealth services have continued with the goal of addressing barriers to care within Lake County by eliminating physical distance and limited resources around transportation while facilitating patterns of long-term communication, including full interpreter services offered during our in-person clinics.[5] One Thursday every month, student volunteers from the ICC coordinate telemedicine encounters with patients within the primary care clinic.

Telehealth services within SRFCs have been shown to be effective for delivering quality care while improving access among underserved populations; however, it is unclear whether telehealth services have expanded the geographical reach of the ICC. Recent research suggests that telehealth services may allow increased access to care by reducing spatial barriers, thereby extending to patients who may otherwise forgo treatment.[7] The aim of this cross-sectional study was to investigate whether mean patient distance to the ICC differed if they were seen via telehealth or in-person primary care ICC clinic visit.

Methods

Patient appointment data from the ICC calendar within the Athena electronic medical record (EMR) system was retrospectively reviewed to identify each patient's first primary care visit during calendar years 2023 and 2024. Visits were then classified as either in-person or telemedicine. Each patient was counted once per calendar year based on the first visit, regardless of whether they were a new patient to the clinic that year or if they had been seen previously. The patient's address, age, gender, and race/ethnicity were also extracted from the EMR. Chi square, independent-sample t-tests, and ANOVA were used to compare the groups with regards to demographic statistics.

Geospatial intelligence services (GIS) were used to evaluate geographic spread of patient locations. GIS is the transformation of a text address into a latitude and longitude coordinate point. Normally, a GIS will use an address database to match a text address to a point on earth's surface. Consistent with well-established methods, we utilized GIS software to geocode the location of the ICC and the centroids of each unique zip code that patients travelled to the clinic from to help visualize the clinic reach.[8,9] Centroids were used for geocoding instead of patient addresses to protect patient privacy. The last step of the visualization included using the Illinois Department of Transportation's public roads data as a network layer within the GIS software to visualize the roads the patients from each zip code would use to get to their clinic appointments.[10] Using Google Maps, we extracted the mileage distance for each patient from the ICC by estimating time of travel for a Thursday night in December at 6:30 pm. This time period was chosen because all ICC clinic days occur on Thursday between 4:30-8:30pm and December is around the halfway point of our school year. Standardizing this aspect of the data collection allows Google Maps to incorporate traffic data to mimic what the most likely road path a patient would take to the clinic. Google Maps would display the best route from patient location to the ICC and then the route distance displayed was extracted for the primary analysis. A Wilcoxon rank-sum test was used to ascertain statistical significance between computed distance for the telehealth and in-person groups by year. All statistical analyses were performed in R and RStudio, while the open-source geospatial software QGIS was used for geospatial localization and visualization.[11-13] This study was approved by the Rosalind Franklin University Institutional Review Board.

Results

Table 1 shows the demographic characteristics of each group for both years. Overall, 138 unique patients were seen across CY 2023 and 2024. The majority of patients seen were of Hispanic ethnicity (n=75, 54%).

For CY 2023, the ICC saw 68 unique patients - 16 via telemedicine and 52 in-person for their first visit of the year. The telehealth group had a slightly higher average age (49.9 years) compared to those seen in-person (47.9 years). A higher proportion (62.5%) of telehealth visits were with females, as compared to those seen in-person (40.4%). There was also a slightly higher proportion of Hispanic patients seen via telehealth (68.8%) as compared to in-person (63.5%). However, none of these differences were statistically significant.

For CY 2024, the ICC saw 101 unique patients - 10 via telemedicine and 91 in-person for their first visit of the year. The telehealth cohort had a lower average age (41.6 years) compared to those seen in-person (47.4 years). Again, a higher proportion (60%) of telehealth visits were with female patients, as compared to those seen in-person (49.5%). There was also a slightly higher proportion of Hispanic patients seen via telehealth (70%) as compared to in-person (53.8%). However, none of these differences were statistically significant.

According to Google Maps distances, for CY 2023 those who utilized telehealth services lived on average 12.1 miles away from the clinic, while those who visited in-person lived 7.8 miles away. For CY 2024, those who utilized telehealth services lived on average 12 miles away from the clinic, while those who visited in-person lived 11.3 miles away. However, for both years, none of these differences were statistically significant. **Figure 1** represents the visual distribution of unique patient zip codes for both years by telehealth and in-person groups.

Discussion

Based on 69 unique patients seen in the ICC in 2023, findings indicated that the Zip Code centroids for the telehealth services group were, on average, non-significantly different than those who came in person. This group was notable for a patient who used telehealth services from more than 50 miles from the clinic**.** This patient being in the telehealth group illustrates how SRFCs can use telehealth services to expand their reach to patients in need who may not be able to travel to the clinic.[14]

Compared to 2023, the ICC increased its capacity to see patients in 2024 (from 1104 to 1351), as reflected by the larger number of unique patients, the increase in net encounters (Table 1), as well as the general visual spread of zip codes served in and around Lake County (Figure 1). Using the more accurate Google Maps data, there were more than four miles of commute distance saved per telehealth visit in 2023 compared to less than one mile in 2024, although this difference was not significant. This geospatial analysis underscores that telehealth may help to address certain social determinants of health (SDOH), such as transportation and geographical barriers.[15] The non-significant difference in distance saved between CY 2023 and 2024 could be attributable to a higher number of patients, such as an increase in a Mongolian-speaking patients and a new partnership with the local Providing Advocacy, Dignity, and Shelter (PADS) Lake County shelter. As the clinic expands its services and forms additional community partnerships, more patients may have the opportunity to access in-person care for the first time. This could account for the decrease in unique telehealth patients in 2024 compared to 2023 despite net encounter increase, as former telehealth patients transition to in-person visits or new patients engage with the clinic in person for their initial appointment.[16]Other possibilities for shifting away from telehealth include technological difficulties, lack of reliable internet access, and recommendation for in-person services through word-of-mouth communication. A likely additional significant factor is privacy given the sensitive nature of these healthcare visits. A patient's home environment is not always guaranteed to allow them the benefit of speaking with a provider in private. Moreover, subtle cultural differences preferring in-person community-based treatment, less willingness to bear the further logistics of virtual interpretation, and even institutional distrust manifesting from privacy concerns. Additionally, the low telehealth uptake as compared to in-person was generally expected given that the ICC hosts a telehealth clinic one Thursday a month.

The majority of patients in both groups were Hispanic, aligning with national trends that highlight significant health inequities within this community - such as language barriers, limited insurance access, and systemic bias - which contribute to poorer health outcomes and higher rates of chronic disease.[17] Future research may benefit from evaluating longitudinal patient engagement, specifically examining whether the availability of telehealth increases long-term follow-up and retention of patient care. Additionally, although the difference in utilization of telehealth based on age was not significant, tracking this data longitudinally would provide further insight into any age differences as our telehealth service grows. Understanding the factors influencing the use of in-person and telehealth services can inform the development of community-driven and individual interventions aimed at minimizing barriers to care in an increasingly technology-driven healthcare system.[18] Moreover, further analysis is needed to examine the extent of overlap between patients who use in-person versus telehealth services - such as shared demographic or socioeconomic characteristics - as well as unique profiles that may differentiate the two groups.

To our knowledge, this is the first study to utilize GIS to analyze telehealth service reach within the context of SRFCs. Previous studies have utilized geospatial methods in analyzing telehealth services. Khairat et al used Census Bureau data to gather relevant SDOH metrics (mobility, insurance, etc) to analyze the reach of a virtual urgent care clinic in North Carolina; their results showed that rural communities with a higher SDOH burden had increased access to healthcare through the clinic.[19] Soares et al used GIS to show that implementation of a telehealth developmental-behavioral pediatric clinics would save families a median travel time and distance of 66.9 minutes and 63.8 minutes, respectively. This study also utilized road data to predict route paths instead of straight-line distances to avoid underestimating total time and distance by about 25%.[20] These studies had much larger sample sizes than available for the 2-year analysis presented in this report. Advanced geospatial techniques, such as the Enhanced 2-Step Floating Catchment Area and traffic data forecasting, can be used to more precisely estimate telehealth service reach.[21,22] Combining our focus on SDOH and geospatial analysis, future ICC iterations of this study could incorporate validated SDOH metrics (e.g., social vulnerability index) that could overlay our zip code mapping and reveal areas of Lake County and beyond that may benefit from care provided by our clinic.[23,24]

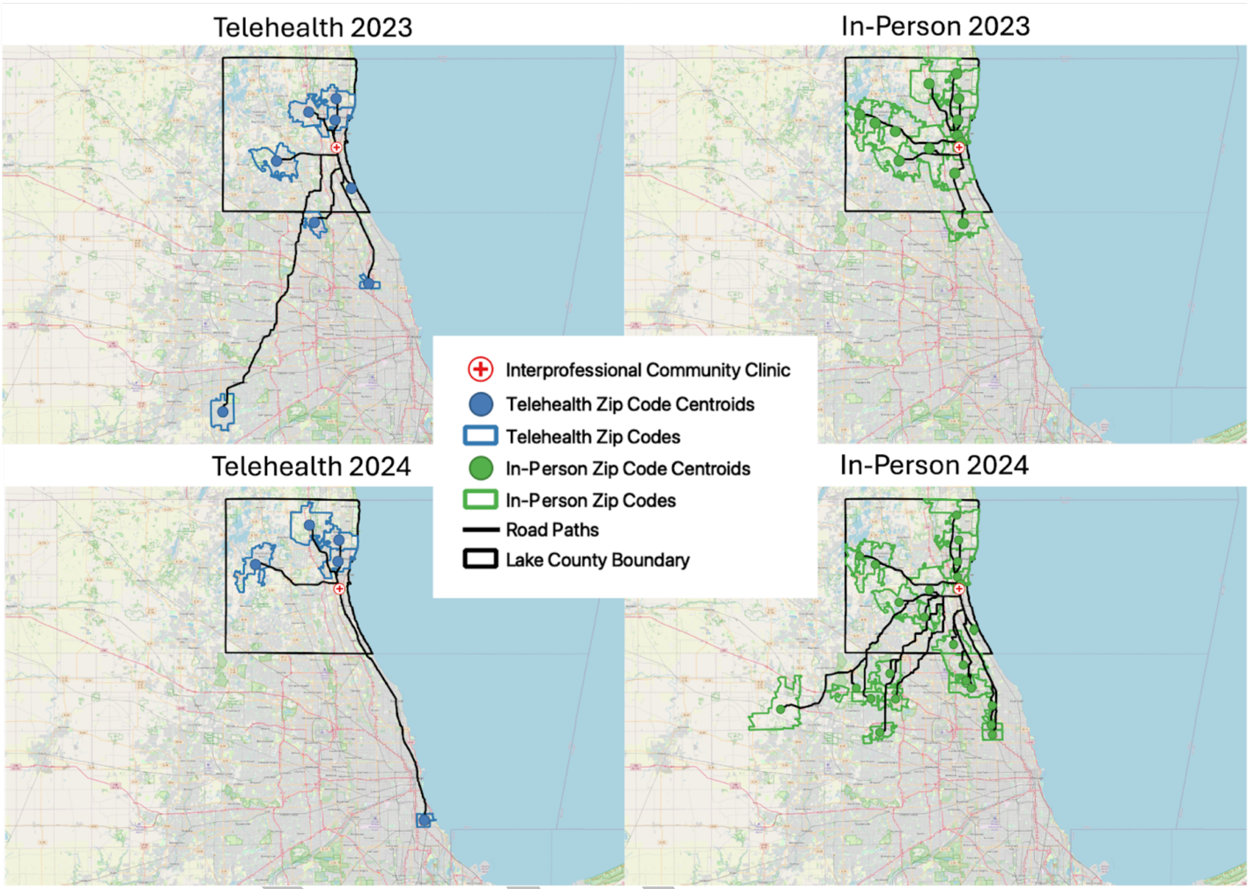
In summary, this was the first project to use GIS and open source data from a student-run free clinic to assess the potential reach of telehealth services. The present findings underscore the benefit of virtual healthcare in terms of increasing accessibility of this SRFC- even in a non-pandemic setting- to patients and especially those who may already face significant barriers to health equity.[25] Furthermore, the GIS software was publicly available at no cost. This highlights the potential utility and cost-effectiveness of similar research that can be used by other SRFCs to visualize and improve telehealth services. This approach can also be used to visually assess if SRFCs are providing care to the communities they set out to serve.

Table 1. ICC Patient Demographics and Distance Travelled to Clinic by Group and Year*

	2023 and 2024	2023			2024		
		OVERALL	TELEHEALTH	IN-PERSON	OVERALL	TELEHEALTH	IN-PERSON
Total Encounters		1104			1351		
Unique Patients Seen	138	68	16 (23.5)	52 (76.5)	101	10 (9.9)	91 (90.1)
Age (years)	46.6	48.4	49.9	47.9	46.8	41.6	47.4
Female Sex	66 (47.9)	31 (45.6)	10 (62.5)	21 (40.4)	51 (50.5)	6 (60.0)	45 (49.5)
Race/Ethnicity							
White	10 (7.2)	8 (11.8)	2 (12.5)	6 (11.5)	3 (3.0)	0 (0)	2 (3.3)
Hispanic	75 (54.3)	44 (64.7)	11 (68.8)	33 (63.5)	56 (55.4)	7 (70.0)	49 (53.8)
Black	6 (4.3)	5 (7.4)	2 (12.5)	3 (5.8)	2 (2.0)	1 (10.0)	1 (1.1)
Asian	19 (13.7)	6 (8.8)	1 (6.3)	5 (9.6)	13 (12.9)	0 (0)	13 (14.3)
Unknown/Declined	28 (20.3)	5 (7.4)	0 (0)	5 (9.6)	27 (26.7)	2 (20)	25 (27.5)
Average Distance Travelled to Clinic (mi)	10.9	8.8	12.1	7.8	11.3	12	11.3

*all values are n or n(%) unless otherwise specified

Figure 1. Visualization of Unique Patients seen in-person and telehealth by year



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