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MAJOR ARTICLE

HIV Treatment Outcomes in Rural Georgia Using Telemedicine

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Background. The increasing shortage of specialized health care services contributes to the ongoing HIV epidemic. Telemedicine (TM) is a potential tool to improve HIV care, but little is known about its effectiveness when compared with traditional (face-to-face [F2F]) care in rural populations. The objective of this study was to compare the effectiveness of HIV care delivered through TM with the F2F model.

Methods. We conducted a retrospective chart review of a subset of patients with HIV who attended a TM clinic in Dublin, Georgia, and an F2F clinic in Augusta, Georgia, between May 2017 and April 2018. All TM patients were matched to F2F patients based on gender, age, and race. HIV viral load (VL) and CD4 count gain were compared using *t* test and Mann-Whitney *U* statistics.

Results. Three hundred eighty-five patients were included in the analyses (F2F = 200; TM = 185). The mean CD4 in the TM group was higher (643.9 cells/mm^3) than that of the F2F group (596.3 cells/mm^3; $P < .001$). There was no statistically significant difference in VL reduction, control, or mean VL (F2F = 416.8 cp/mL; TM = 713.4 cp/mL; $P = .30$). Thirty-eight of eighty-five patients with detectable VL achieved viral suppression during the study period (F2F = 24/54; TM = 14/31), with a mean change of 3.34×10^4 and -1 to 0.24×10^4, respectively ($P = 1.00$).

Conclusions. TM was associated with outcome measures comparable to F2F. Increased access to specialty HIV care through TM can facilitate HIV control in communities with limited health care access in the rural United States. Rigorous prospective evaluation of TM for HIV care effectiveness is warranted.

Keywords. HIV; HIV outcomes; HIV treatment; rural medicine; telemedicine.

In the United States, there are about 1 173 900 people above age 13 with HIV, with an estimated 13.8% of them undiagnosed [1]. More than 86% of newly diagnosed persons were linked to care within 3 months of diagnosis in 2017. By the beginning of 2017, only 57.6% of newly diagnosed patients with HIV were retained in care for all of 2016, and only 61.5% of those retained achieved viral suppression [2]. This rate of change is not on track to end HIV by 2030 [3, 4].

As with many chronic ailments, the challenges to HIV care and control are multifaceted. These challenges include social, geographical, health systems, and economic factors [5]. Access to health care by patients can be easily impacted by policies that translate to limited funding, limits to spending options or services covered as adjunct to health care such as transportation. The negative effects of location on health care utilization are well documented for persons in difficult-to-reach regions with a poor health care infrastructure [6, 7]. A study reviewing 15 articles published between 1997 and 2010 reported multiple barriers to HIV care, with transportation being among the most commonly reported barriers [8]. Multiple innovations have been employed to bridge the gaps, such as using drones and empowering lower-level providers with or without telemedicine support [9].

Geographical and transport constraints continue to play an important role in access to care across the United States. This constraint plausibly has greater impact in the Southern states, which have higher proportions of rural dwellers. Travel time to access health care has been shown to reduce the use of specialty care in rural-dwelling veterans and to impact their health negatively [10, 11]. At Augusta University facility HIV clinic, some of our patients commute up to 3 to 4 hours 1-way to receive the care they need. In 2018, the rate of new diagnoses in the Southern states was 18.4 per 100 000, about 5 percentage points higher than the national average of 13.3% [1]. The Southern states accounted for 52% of new HIV cases nationwide. Furthermore, 23% of new HIV diagnoses were in rural and suburban areas in 2017 [12]. Rural dwellers have inferior outcomes due to delays

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in diagnosis and linkage to care, as well as poor retention and adherence, which are also recorded at higher rates in these areas [13–15]. Of the commonly reported barriers to care, particularly in patients with HIV, distance and transportation remain high on the list. Women with HIV in the rural Southeast United States strongly endorsed transportation-related issues with long distances as primary barriers to maintaining HIV care and appointments [16].

Telemedicine has enhanced ease of collaboration and support to improve health care access and delivery across the world [17]. In the United States, telemedicine has been shown to be effective to reduce travel distance, time, and cost of care in postvascular surgery follow-up [18]. More importantly, telemedicine has enabled global collaboration to close gaps in health care delivery. Resource-poor countries have benefitted from specialty care with physician-to-physician connections or physician-to-patient connections to deliver essential health care to remote and rural dwellers [19]. Countries with advanced health care have also demonstrated how telemedicine can reduce the burden of time on patients, and in some cases provide or improve privacy for patients with HIV [20]. The effectiveness of telemedicine has been demonstrated in acute care to reduce the rates of urgent referral. It has also been effective for specialty consultation in ophthalmology cases managed by virtual consultation in Queensland and HIV/AIDS case consultations and discussions [21].

Infectious Diseases specialists and HIV-trained "generalists" have been documented to deliver superior HIV care when compared with non-HIV-trained generalists in traditional outpatient settings [15, 22]. A study examining quality of care delivered by physicians vs a multidisciplinary Infectious Diseases team delivered by telemedicine in a prison population showed higher rates of virologic suppression in the telemedicine cohort [23]. Using a physician–patient home care telemedicine model with stable and virally suppressed patients with HIV, a randomized trial in Spain showed that 85% of participants endorsed savings with time and money. Additionally, there was a high (81%) acceptance rate, and the clinical parameters were equivalent in both groups [20]. Despite existing evidence of the potential value of telemedicine in improving access to specialty HIV care in underserved populations, there is a paucity of studies examining the effectiveness of TM in improving HIV clinical end points in rural US populations.

Telemedicine has been defined as remote clinical services administered using a technological medium. This included face-to-face video chat (physician-to-physician or physician-to-patient), voice chat after review of electronic health records, and electronic health record documentation after remote chart review without direct voice or video contact with the physician or patient [24]. In this study, we examine effectiveness of a real-time "videoconferencing with the patient" telemedicine intervention in delivery of direct long-term HIV care in rural Georgia. We conduct a head-to-head comparison with a parallel group of patients seen in person by the same group of Infectious Diseases (ID) physicians at a nearby tertiary institution using various parameters such as HIV polymerase chain reaction viral load (VL) and CD4 count. Services provided in both centers are similar apart from the mode of consultation with the ID physician.

METHODS

Study Population

The target population for this study comprises patients with HIV in rural communities in the Southeast United States. The study population was drawn from 2 patient groups. The telemedicine (TM) group comprised all patients in the Dublin Department of Health HIV clinic database, and the traditional group was drawn from the Augusta University (AU) (face-to-face [F2F]) HIV clinic patient database. All patients were seen by the same group of Infectious Diseases providers. The Dublin clinic is situated ~3 hours from Augusta University, in Augusta, Georgia, and patients enrolled at Dublin clinic commuted from varying distances to the clinic and were triaged and examined by the clinic nurse before video conference with an ID physician located in Augusta. Laboratory and necessary paperwork was transmitted securely to the AU ID physician before the visit. Documentation was done in the AU electronic health record (EHR) and then transmitted to the Dublin clinic by fax. Patients in the catchment area of the Dublin clinic (telemedicine group) would have needed to travel an additional 3 or more hours to have a consultation with an Infectious Diseases specialist without the telemedicine video-conferencing service.

Study Design

We conducted a retrospective data review for patients with HIV enrolled and seen between May 2017 and April 2018 for both groups. Based on the preliminary TM pool data using unpaired simple effects analysis, 250 subjects are needed to detect statistical significance at $P = .05$, 2-tailed and 80% power of detection.

Inclusion criteria were age ≥18 years and enrollment in care ≥6 months. Exclusion criteria included pregnant patients, patients newly enrolled 6 months or less before May 2017. Charts with incomplete data were excluded. Data extracted included demographics, number of visits, dates of clinic attendance, CD4 cell count, VL, HIV resistance mutations, and major comorbidities.

The F2F sample pool had 1391 cases; these were stratified by gender, then race, then by age. After a systematic sampling using a 1:5 to 1:7 sampling interval from each stratified group to give 263 cases, 31 were excluded for being enrolled <6 months. Two hundred thirty-two remained as the study population, and 32 had incomplete data, leaving 200 included in the final

study sample. The TM cases were drawn from a sample pool of 236. Twenty-six cases were excluded for being enrolled for <6 months; of the remaining 210, 25 had incomplete data, leaving 185 as the TM study population.

Definitions of Variables

VLs of <40 copies/mL were categorized as undetectable. Comorbidities were extracted by *International Classification of Diseases*, Tenth Revision, codes (ICD-10). New resistance was extracted from laboratory data in EHRs and physician chart documentation of resistance mutations. Medication changes included any change in medication class or formulation within the review period as noted in the physician's notes, prescriptions, and medication list. This was categorized in to 5 groups, coded as: 0 = no change; 1 = newer medication/physician preference; 2 = failure of therapy/new resistance; 3 = adverse effect; 4 = consolidate pill burden.

Data extraction and coding were carried out by an investigator familiar with the electronic health system of the institutions.

Outcomes

The main outcome was rates of viral suppression and maintenance of suppression during the review period.

Statistical Analysis

R statistical software, version 3.6.0, was used in the data analysis. The average CD4 count for each patient was calculated as the mean of the measurements from all visits recorded in the 12-month period for the patient. The average CD4 count for each group was computed as the mean of the average count for all patients in the group. *T* tests were conducted to test differences in average CD4 count between the 2 groups (TM and F2F).

The difference between the first and last visit measurements was used to calculate the change in CD4 counts for the patient. Based on the direction of change, patients were categorized into subgroups of those with increasing CD4 counts and those without increasing CD4 counts. The proportion of patients with increasing CD4 counts was calculated as the number of patients with an increase in CD4 count divided by the total number of patients in the group. Using the chi-square test statistic, we performed a test of proportions to determine if there was a significant difference in the proportion of patients who showed an increase in CD4 counts in the F2F and TM populations. The *t* test was used to compare the mean increase in CD4 counts between the 2 groups (TM and F2F) for the subgroup of patients with increasing CD4 counts. The *t* test was also used to compare the mean decrease in CD4 counts between the 2 groups (TM and F2F) for the subgroup without increasing CD4 counts.

The average VL for each patient was calculated as the mean of the measurements from all visits recorded in the 12-month period for the patient. The average VL for each group was computed as the mean of the average count for all patients in the group. *T* tests were conducted to test differences in average VL between the 2 groups (TM and F2F).

The proportion of patients with decreasing VL was calculated as the number of patients with a decrease in VL divided by the total number of patients in the group. Using the chi-square test statistic, we performed a test of proportions to determine if there was a significant difference in the proportion of patients who showed a decrease in VL in the F2F and TM populations.

The difference between the first and last visit measurements was used to calculate the change in VL for the patient. Based on the direction of change, patients were categorized into subgroups of those with decreasing CD4 and VL and those without decreasing VL. The Mann-Whitney *U* test [25, 26] was used to compare the mean decrease in VL between the 2 groups (TM and F2F) for the subgroup with decreasing VLs. The Mann-Whitney *U* test was also used to compare the mean increase in VL between the 2 groups (TM and F2F) for the subgroup without decreasing VLs.

For all tests, differences were considered statistically significant when the *P* value was <.05 or the 95% CI excluded the null value.

Ethical Approval

The study was approved by the Institutional Review Board at Augusta University and the Georgia Department of Public Health. A waiver of informed consent was granted by the Institutional Review Board as no direct patient contact was planned and data gathered were coded and linked for reference; however, no personal identifiers were disclosed.

RESULTS

In this study, a total of 385 cases were included (82.1% Black; 50.9% females; F2F = 200; TM = 185). The distribution of comorbidities was similar between both groups, with cardiovascular, renal, neuropsychiatric, and diabetes being the most common comorbidities, as seen in Table 1.

Through the study period of 12 months, the mean observation period was 151.33 and 131.65 days for the F2F and TM groups, respectively (*t* test, $P = .34$). We found that the mean CD4 count in the TM group, as shown in Table 2, was statistically higher (643.9 cells/mm^3) than that of the F2F group (596.3 cells/mm^3; $P < .001$). The mean change in CD4 count was 19.26 cells/mm^3 in the TM group and 8.84 cells/mm^3 in the F2F group ($P = .53$). Among those with increased CD4 counts, the mean change in CD4 count was 120.76 cells/mm^3 and 134.52 cells/mm^3 ($P = .45$) for the subgroups in the TM and F2F groups, respectively. The difference in mean change for the whole group and the subgroups with increased CD4 counts was not statistically significant.

There was a higher mean VL in the TM group (713.4 cp/mL) compared with the F2F group (416.8 cp/mL), but it was not

Table 1. Key Characteristics of Face-to-Face and Telemedicine HIV Patients

	F2F	TM
Gender	No. (%)	No. (%)
Females	106 (53.0)	90 (48.6)
Males	89 (44.5)	95 (51.4)
Transgender	5 (2.5)	0 (0)
	200 (100)	185 (100)
Race		
Black	164 (82.0)	152 (82.2)
White	30 (15.0)	32 (17.3)
Others	6 (3.0)	1 (0.5)
	200 (100)	185 (100)
Age		
18–30 y	21 (10.5)	18 (9.7)
31–50 y	77 (38.5)	68 (36.8)
51+ y	102 (51.0)	99 (53.5)
	200 (100)	185 (100)
Medication change code		
0 = no change	162 (81)	158 (85.4)
1 = new therapy/physician preference	19 (9.5)	5 (2.7)
2 = failure of therapy	8 (4)	4 (2.2)
3 = adverse effect	10 (5)	10 (5.4)
4 = consolidation for pill burden	1 (0.5)	8 (4.3)
Resistance code		
No new resistance	192 (96)	183 (98.9)
New resistance	8 (4)	2 (1.1)
Comorbidities		
Cardiac	117 (58.5)	55 (29.7)
Respiratory	17 (8.5)	3 (1.6)
Diabetes	26 (13)	20 (10.8)
Chronic kidney disease (stage 3–5)	63 (31.5)	33 (17.8)
Neuropsychiatry	75 (37.5)	32 (17.3)
Liver disease	17 (8.5)	12 (6.5)
Dental	11 (5.5)	4 (2.2)
Alcoholism	7 (3.5)	5 (2.7)
Drug abuse	16 (8)	7 (3.8)
Cancer	1 (0.5)	4 (2.2)
Autoimmune diseases	2 (1)	3 (1.6)

Abbreviations: F2F, face-to-face; TM, telemedicine.

statistically significant ($P = .30$), as shown in Table 2. The year-round rate of viral suppression during the study period was similar between both groups (TM = 154/185, 77%; F2F = 146/200, 73%). There was no significant difference between the 2 populations regarding viral suppression. The mean change in VL was -8.16×10^2 for the TM group and -3.51×10^3 for the F2F group ($P = .26$). Among patients who were not virally suppressed at the beginning of the study period with detectable VL, 38 of 85 achieved viral suppression before the end of the study period (TM = 14/31; F2F = 24/54), as shown in Table 2 (with $P = 1$ after conducting a test of proportions with chi-square statistics). Among the 38 who achieved viral suppression, the mean decline in VL was -1.24×10^4 for the TM group and -3.34×10^4 for the F2F subgroup. The difference in mean decline in both subgroups was not statistically significant by the Mann-Whitney *U* test, with $P = 1$.

Table 2. Clinical Outcomes in Face-to-Face and Telemedicine Patients With HIV

	TM	F2F	*P* Value
Mean CD4	643.9	569.3	<.001[a]
Mean VL	713.4	416.8	.31[a]
Mean ΔCD4	19.26	8.84	.53[a]
Mean ΔCD4 for increased CD4	120.76	134.52	.45[a]
Mean ΔVL	-8.16×10^2	-3.51×10^3	.26[b]
Mean ΔVL for decreased VL	-1.24×10^4	-3.34×10^4	1.00[b]
% with decreased VL	45	44	1.00[c]
% with increased CD4	43	41	.98[c]
VL UD, %	77	73	1.00[c]

Abbreviations: F2F, face-to-face; TM, telemedicine; U, undetectable; VL, viral load; VL UD, undetectable VL through study period.

[a]T-statistics.

[b]Mann-Whitney *U* statistics.

[c]Chi-square statistic.

DISCUSSION

In this study, we found HIV clinical indicators to be comparable between patients receiving specialty care through TM in rural Georgia and those receiving F2F care in a tertiary care center. Moreover, the mean CD4 count was statistically higher in the TM group. The changes in VL and viral suppression rates were not statistically different in the study groups.

The results of this study are consistent with previous studies that have examined HIV outcomes when care is delivered through telemedicine by HIV-trained physicians as compared with the F2F clinic [8, 23]. The mean CD4 count was statistically higher in the TM group, but the mean changes in CD4 count were similar in both groups. The changes in VL were not statistically different in the study groups.

In both clinics included in this study, some patients traveled 2–3 hours to attend the clinic. A significant proportion of low-income patients are dependent on grant-funded services for HIV care coverage in rural US communities. Many residents of rural areas find primary care more accessible in their locality than specialist care. Thus, they would otherwise have significant challenges accessing HIV care from Infectious Diseases physicians such as what the Augusta University HIV program provides through this collaboration [15]. The incidence rates of HIV in the Southern US states have been increasing despite a nationwide decline [1]. Previous studies have shown that poor access to care in remote and rural areas impacts the overall epidemiology of many "chronic" diseases. Patients with HIV in rural areas are more likely to be diagnosed with advanced disease and to have higher mortality rates [27]. In addition, these same patients have more difficulty in finding access to care and have lower retention rates during care [13, 14, 28, 29]. Transportation constraints and the distance to the nearest available services have been consistently documented as significant barriers to care in people with HIV (PWH) [10, 11, 16, 30]. The

shortage of physicians, especially the shortage of HIV-trained specialists, also contributes to this disparity in access to health care in rural areas [11, 31]. The unique telemedicine model makes it easier for physicians and other HIV-trained providers to deliver the same quality of care without the restrictions of geography, travel, or time. Previous studies have also demonstrated effectiveness and high patient satisfaction with telemedicine in Veteran Affairs patients and PWH. This is especially important as prior studies have demonstrated higher rates of HIV control in cohorts managed by HIV-trained specialist providers [8, 11, 22, 32].

The use of telemedicine for long-term care of many chronic diseases including HIV can be a particularly useful resource in these physician-deprived areas. Expansion of telemedicine services to rural areas particularly in the Southern United States will provide access to specialty HIV care with associated optimal viral suppression rates and a greater reduction in transmission rates, thus reducing the incidence of new cases.

An important strength of our analysis is that it was based on data obtained from routine care delivery in a rural population and is therefore more likely to have a higher level of external validity in the Southeastern United States than the few studies that have examined this topic in similar settings. Our findings should, however, be interpreted in the context of key constraints. First, the observational design of our study implies that the role of residual confounding and selection bias as an explanation for our findings cannot be completely ruled out. We applied stratification and matching techniques to limit the impact of these constraints; however, more rigorous research through randomized clinical trials is warranted. Second, the telemedicine service in this study was supported with a highly functioning existing clinic infrastructure. Through the Georgia Department of Public Health, our telemedicine site is a collaboration with a county health department clinic that offers primary care services and on-site, interdisciplinary team–based HIV care. The Infectious Diseases physicians on this team are from Augusta University, providing the only telemedicine component. Third, the patient population in both clinic sites was stable from an HIV standpoint, without new resistance or complications warranting changes in medication.

CONCLUSIONS

Telemedicine (videoconferencing directly with patients) is as effective as a face-to-face outpatient model for specialist delivery of HIV care in rural Georgia in the context of a well-functioning existing clinic infrastructure and a stable patient population. Further studies should investigate the relative effectiveness and acceptability of different modalities of delivering telemedicine care using rigorous prospective study designs.

To achieve eradication of HIV and control worldwide, we need to consider increasing the use of telemedicine outreach programs in locations where specialist care is scarce or absent. This type of program can help us improve the diagnosis, management, and prevention of HIV, especially in rural areas.

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Patient consent. The patient's written consent was waived, as the research involved no more than minimal risk to participants. The design of this research work has been approved by the institutional review board committee of the Medical College of Georgia at Augusta University, Georgia, USA.

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