BMC Public Health

RESEARCH

Open Access

Does travel time matter?: predictors of transportation vulnerability and access to HIV care among people living with HIV in South Carolina

Sayward Elizabeth Harrison[1*†], Peiyin Hung[2†], Katherine Green[3], Sarah J. Miller[1], Mariajosé Paton[1], Divya Ahuja[3], Sharon Weissman[3], Caroline Rudisill[5] and Tammeka Evans[4]

Abstract

Background People living with HIV (PLHIV) in the southern United States (US) are at high risk for poor outcomes across the HIV care continuum leading to low rates of viral suppression. Understanding structural barriers to care—including transportation vulnerability—is critical to improve HIV outcomes. This study investigated relationships between travel time to HIV care, transportation vulnerability, and HIV care disruptions to inform future transportation interventions for PLHIV residing in South Carolina and other southern US states.

Methods A total of 160 PLHIV (*N* = 160) were recruited from a large immunology center in South Carolina. Participants reported on transportation experiences, transportation vulnerabilities, and residence. Differences in sociodemographic characteristics, transportation vulnerabilities, and HIV care disruptions were compared across travel time groups (< 15, 15–30, and > 30 min from residential location to the HIV clinic) using Mantel-Haenszel Chi-Square tests. Multivariable logistic regression tested our a priori hypothesis that travel time would predict HIV care disruptions.

Results A majority of participants were aged 45–64 years old (54.4%), single (77.0%), male (63.8%), and Black (77.5%). Nearly 20% of participants lived < 15 min from their HIV clinic, 59.1% lived 15–30 min, and 21.4% lived > 30 min away. PLHIV who had to travel > 30 min to HIV care were more likely than those living < 15 min away to report transportation vulnerability (73.5% vs. 51.6%, $p = 0.048$), missed HIV care appointments (64.7% vs. 41.9%, $p = 0.049$), and transportation challenges that prevented them from seeing HIV care providers (67.7% vs. 39.4%; $p = 0.014$). Adjusted odds ratios (AOR) show that PLHIV who had to travel > 30 min were more likely to experience transportation-related disruptions to HIV care, including being late to appointments (AOR 5.25, 95% CI:1.06–25.92), missing appointments (AOR 3.85, 95% CI:1.04–15.89), and being unable to see HIV providers (AOR 7.06, 95% CI:0.59–14.89).

†First authorship is shared between Sayward Harrison and Peiyin Hung.

*Correspondence:
Sayward Elizabeth Harrison
harri764@mailbox.sc.edu
Full list of author information is available at the end of the article

© The Author(s) 2025. **Open Access** This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License, which permits any non-commercial use, sharing, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if you modified the licensed material. You do not have permission under this licence to share adapted material derived from this article or parts of it. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by-nc-nd/4.0/.

Conclusions In South Carolina—a rural southern state with a disproportionate burden of HIV—long travel time (> 30 min) to HIV care is associated with care disruptions, including more missed visits. Transportation interventions, as well as other efforts to expand rural access to HIV care, are urgently needed to ensure that all PLHIV are able to engage in consistent HIV care in order to reach and maintain viral suppression.

Keywords HIV care, Transportation access, Transportation vulnerability, Care disruptions, HIV disparities

Introduction

Achieving and maintaining viral suppression is critical for people living with HIV (PLHIV), as viral suppression prevents disease progression and stops transmission of HIV to others [1]. To achieve high rates of viral suppression, a strong HIV care continuum is needed, in which PLHIV can receive a prompt HIV diagnosis, rapidly link to HIV care, be engaged and retained in care over time, and adhere to antiretroviral therapy (ART). Thus, the HIV care continuum provides a clear framework for achieving widespread viral suppression. It also features prominently in Ending the HIV Epidemic (EHE)—a federal plan designed to reduce new infections in the United States (US) by 90% by the year 2030 [2].

Despite the simplicity of the care continuum framework and efficacy of current ART regimens, rates of viral suppression in the US fall below those of many low-income nations. Data from 2021 show that only 66% of PLHIV in the US were virally suppressed [3]. Notably, no demographic groups (i.e., across gender, race, ethnicity, age) or transmission source groups (i.e., male-to-male sexual contact, injection drug use, heterosexual contact) achieved current EHE goals for viral suppression, with most groups falling > 25% points below the EHE target of 95% viral suppression by 2025 [2, 3].

Compared to other US regions, the South bears a disproportionate burden of HIV-related morbidity and mortality. The South has the nation's highest rate of new HIV diagnoses with 17.5 new diagnoses per 100,000 residents compared to a national mean of 12.7, and nearly half (48%) of all deaths among PLHIV occurred in the South despite its much smaller population share [4]. The South has more HIV diagnoses among men who have sex with men (MSM) than any other region, with a majority of these occurring among Black and/or African-American men [4]. The region also has the largest number of HIV diagnoses among people who use injection drugs (i.e., more than twice as large as any other region) and a rate of HIV diagnosis among women (i.e., 6.8 per 100,000) that is much higher than any other region (i.e., Northeast—4.2; Midwest—3.0; West—2.8) [4].

These geographic disparities in HIV outcomes are driven by social determinants of health (SDOH), such as access to and quality of healthcare and education, neighborhood and built environment characteristics, and the region's socio-cultural context [5, 6]. The southern HIV epidemic, in particular, is propelled by high levels of poverty, high unemployment, high rates of incarceration, high levels of HIV-related stigma, socio-religious norms and beliefs around gender and sexuality, cultural conservatism, and lack of adequate healthcare [7, 8]. Legal and policy-related actions further contribute to an inadequate HIV care landscape, such as the decision by some Southern states not to expand Medicaid or accept federal grants for HIV prevention, treatment, and surveillance [9, 10]. Furthermore, structural racism causes multiple, intersecting barriers for people of color, contributing to stark HIV disparities for individuals minoritized by race and ethnicity [11, 12].

Contextual challenges to a strong and effective HIV care continuum are often magnified in rural communities, and PLHIV in rural areas experience subpar outcomes across the care continuum [13–15]. Because of this, the EHE plan prioritizes seven rural states, including South Carolina, that have relatively high rates of HIV diagnosis and where more than 10% of those diagnoses occur in rural areas [2]. In 2020—immediately prior to the onset of the COVID-19 pandemic, public health officials in South Carolina convened 24 community forums across the state to inform strategic planning and resource allocation for the EHE initiative. Forums were attended by PLHIV, public health officials, HIV care providers, and community-based organization (CBO) staff. These statewide community forums identified transportation-related challenges as the top barrier to HIV prevention, testing, and care in the state [16].

However, transportation vulnerability among PLHIV remains understudied in the literature. A few nascent studies have examined impacts of transportation barriers—typically in addition to other psychosocial and social determinants of health—and have shown that transportation barriers predict poorer ART adherence, engagement in care, and retention in care among PLHIV [17–19]. One prior study has also shown that transportation barriers among recently incarcerated PLHIV predict poorer retention in care following release [20]. However, none of these studies were based in any of the seven rural Southern states targeted in the EHE plan.

Travel time to HIV care has also rarely been examined in the US. The time that PLHIV must spend to travel to access HIV services in rural Southern states is potentially a critical barrier to care. There are major rural-urban disparities in HIV clinician workforce supply in the South, with a recent study finding that 81% of Southern US counties had no HIV-experienced clinicians [21]. Additional studies are urgently needed to understand how travel-related burden and other transportation vulnerabilities contribute to existing HIV inequities in the South.

Thus, the current study aimed to examine relationships between travel time to HIV care, transportation vulnerability, and HIV care disruptions among a clinic-based sample of PLHIV in South Carolina—a rural, southern state prioritized by the federal EHE plan due to its high rural HIV burden and poor HIV outcomes.

Methods

Participants and study site

A total of 160 PLHIV were enrolled in the current study between March 2020 and June 2021, which was conducted in partnership with a comprehensive Ryan White-funded adult immunology center in Columbia, South Carolina. Recruitment, enrollment, and data collection occurred on-site at the immunology center. All participants provided informed consent prior to participation in the study, and all study procedures were approved by the [REMOVED] Institutional Review Board. One participant had an unknown residential address, yielding 159 participants in the final analysis.

Data described here were collected at baseline of a larger parent study designed to evaluate the effects of a concierge rideshare intervention. At baseline, participants completed a brief intake survey that was designed by the study team to assess participant demographics, perceived transportation barriers, and HIV care disruptions (see Supplementary File A).

All data for the current study were collected prior to implementation of any intervention components. Individuals were eligible to participate in the study if they were (1) living with HIV, (2) aged ≥ 18 years; (3) re-engaging in HIV care after being 'lost to care' (i.e., ≥ 9-months with no HIV-related medical appointments or viral load tests) and/or in care but with self-reported transportation challenges at the screening phase of the study by answering "yes" to the question "do you have any trouble getting transportation to your HIV care appointments at USC Immunology Center?"; and (4) a resident of Richland or Lexington counties in South Carolina. Transportation challenges were confirmed by participant self-report in interviews with either a 'return-to-care' specialist or an HIV case manager. All participants were eligible for a $25 participant incentive for study enrollment.

Measures

Demographic information Participants were asked to provide basic demographic information, including age, race, ethnicity, sexual identity, educational attainment, and employment status. Participants also provided their residential ZIP code.

Travel time to care To determine typical travel time (i.e., in minutes) to HIV care for each participant, we geocoded the immunology center address and each participant's residential ZIP code centroid to latitude and longitude coordinates using ArcGIS software [22]. Using a quickest driving route calculated based on the maximum official driving speed limits, we calculated one-way travel times between residential ZIP centroids and the clinic site. We then categorized the driving times into three catchment areas: <15 min, 15–30 min, and > 30 min.

Transportation barriers Participants were asked two questions to assess financial-related transportation barriers: (1) *Does the cost of gas ever prevent you from seeing your HIV care provider?* and (2) *Does the cost of transportation (e.g., taxi, bus, Lyft, Uber) ever prevent you from seeing your HIV care provider?* Participants answered yes or no for each question.

HIV care disruptions Participants were asked the following questions to assess care disruptions due to transportation challenges: (1) *Have you ever had to cancel or reschedule an HIV care appointment because of transportation problems?* (2) *Have you ever been more than 30 min late to an HIV care appointment because of transportation problems?* (3) *Have you ever missed an HIV care appointment because of transportation problems?* (4) *Does not having a ride to the doctor ever prevent you from seeing your HIV care provider?* (5) *Have you ever run out of medicines because you could not find a way to get to the pharmacy to pick up your refill?* All items had yes or no responses.

Data analysis

We first compared sociodemographic characteristics, transportation barriers, and impacts of transportation vulnerability on HIV care across residential proximity to care, measured by number of minutes needed to travel to their HIV clinic, using Mantel-Haenszel Chi-Square tests (see Table 1 and Table 2). Multivariable logistic regression models were employed (Table 3) to identify the likelihood of transportation barriers and HIV care disruptions for PLHIV living 15–30 min and more than 30 min away relative to those living within 15 min from the clinic.

To capture the differential effects on HIV care experience of residential proximity to the clinical site by the presence of transportation barriers, we then employed the models with the inclusion of interactions between residential proximity and transportation barriers. Based on this model, we calculated the average predicted probability and 95% confidence interval of each study outcome by travel time to care and the presence of transportation barriers, holding other variables at their means. All data

Table 1 Sociodemographic characteristics of participants by travel time to HIV care

	All Participants	Travel Time to Care			*P* value for diff by travel time
		< 15 min (*N* = 31)	15–30 min (*N* = 94)	> 30 min (*N* = 34)	
	N (Col %)	Proportion of Participants			
All Study Participants, Row%	160 (100%)	6 (19.5%)	56 (59.1%)	7 (21.4%)	
Age Group at Enrollment					
<25 Years Old	6 (3.8%)	2 (6.5%)	3 (3.2%)	1 (2.9%)	0.73
25–44 Years Old	61 (38.1%)	13 (41.9%)	39 (41.5%)	9 (26.5%)	0.22
45–64 Years Old	87 (54.4%)	14 (45.2%)	49 (52.1%)	24 (70.6%)	0.05
65 or Older	6 (3.8%)	2 (6.5%)	3 (3.2%)	0 (0%)	0.46
Marital					
Single (never married)	123 (76.9%)	23 (74.2%)	74 (78.7%)	26 (76.5%)	0.98
Married	11 (6.9%)	3 (9.7%)	6 (6.4%)	2 (5.9%)	0.54
Other (Widowed, Divorced, Separated)	25 (15.6%)	5 (16.1%)	14 (14.9%)	5 (14.7%)	0.95
Did not report	1 (0.6%)	0 (0%)	0 (0%)	1 (2.9%)	-
Gender					
Male	102 (63.8%)	19 (61.3%)	63 (67%)	20 (58.8%)	0.69
Female	57 (35.6%)	12 (38.7%)	31 (33%)	13 (38.2%)	0.88
Did not report	1 (0.6%)	0 (0%)	0 (0%)	1 (2.9%)	-
Sexual Identity					
Heterosexual or straight	82 (51.3%)	15 (48.4%)	47 (50%)	19 (55.9%)	0.47
Gay or lesbian	44 (27.5%)	9 (29%)	27 (28.7%)	8 (23.5%)	0.56
Bisexual	21 (13.1%)	4 (12.9%)	11 (11.7%)	6 (17.7%)	0.59
Other	5 (3.1%)	1 (3.2%)	3 (3.2%)	1 (2.9%)	0.93
Did not report	8 (5%)	2 (6.5%)	6 (6.4%)	0 (0%)	0.22
Race					
White	30 (18.8%)	2 (6.5%)	21 (22.3%)	7 (20.6%)	0.18
Black	124 (77.5%)	28 (90.3%)	70 (74.5%)	25 (73.5%)	0.13
Other	6 (3.8%)	1 (3.2%)	3 (3.2%)	2 (5.9%)	0.58
Hispanic					
Yes	10 (6.3%)	1 (3.2%)	6 (6.4%)	3 (8.8%)	0.37
No	132 (82.5%)	27 (87.1%)	76 (80.9%)	29 (85.3%)	0.37
Unknown	18 (11.3%)	3 (9.7%)	12 (12.8%)	2 (5.9%)	0.86
Insurance					
Private	17 (10.6%)	0 (0%)	15 (16%)	2 (5.9%)	0.53
Public (Medicare, Medicaid, other)	81 (50.6%)	13 (41.9%)	51 (54.3%)	16 (47.1%)	0.63
ACA	28 (17.5%)	8 (25.8%)	13 (13.8%)	7 (20.6%)	0.58
Uninsured	34 (21.3%)	10 (32.3%)	15 (16%)	9 (26.5%)	0.48
Education Attainment					
Less than high school	43 (26.9%)	9 (29%)	26 (27.7%)	7 (20.6%)	0.57
High school graduate or GED	53 (33.1%)	10 (32.3%)	29 (30.9%)	14 (41.2%)	0.49
Some College or Associate	52 (32.5%)	11 (35.5%)	32 (34%)	9 (26.5%)	0.39
Bachelor's degree or higher	12 (7.5%)	1 (3.2%)	7 (7.5%)	4 (11.8%)	0.21
Employment					
Employed full time	38 (23.8%)	1 (3.2%)	31 (33%)	6 (17.7%)	0.24
Employed part time	15 (9.4%)	1 (3.2%)	10 (10.6%)	4 (11.8%)	0.27
Unemployed	65 (40.6%)	24 (77.4%)	27 (28.7%)	14 (41.2%)	0.004
Other (student, homeworker)	6 (3.8%)	2 (6.5%)	2 (2.1%)	2 (5.9%)	0.92
Unable to work	33 (20.6%)	3 (9.7%)	21 (22.3%)	8 (23.5%)	0.12
Unknown	3 (1.9%)	0 (0%)	3 (3.2%)	0 (0%)	0.95
Household Income					
Unknown	1 (0.6%)	0 (0%)	0 (0%)	1 (2.9%)	-
Less than $10,000	89 (55.6%)	22 (71%)	45 (47.9%)	21 (61.8%)	0.039
$10,000 to $24,999	40 (25%)	6 (19.4%)	26 (27.7%)	8 (23.5%)	0.78

Table 1 (continued)

	All Participants	Travel Time to Care			*P* value for diff by travel time
		< 15 min (*N* = 31)	15–30 min (*N* = 94)	> 30 min (*N* = 34)	
	N (Col %)	Proportion of Participants			
$25,000 to $49,999	24 (15%)	3 (9.7%)	19 (20.2%)	2 (5.9%)	0.58
$50,000 or more	6 (3.8%)	0 (0%)	4 (4.3%)	2 (5.9%)	0.23

Notes: *P* values were calculated using Mantel-Haenszel Chi-Square tests to compare the differences in travel distances by each individual characteristic. – p values were unable to calculate due to small sizes

Table 2 Transportation barriers and HIV care disruptions by travel time to HIV care

	All Participants	Travel Time to Care			*P* value for diff by travel time
		< 15 min (*N* = 31)	15–30 min (*N* = 94)	> 30 min (*N* = 34)	
	N (Col %)	Proportion of Participants			
Transportation barriers	95 (59.4%)	8 (25.8%)	37 (39.4%)	15 (42.9%)	0.048
Gas Cost	60 (37.5%)	15 (48.4%)	42 (44.7%)	19 (54.3%)	0.384
Other Transportation Cost	76 (47.5%)	21 (67.7%)	66 (70.2%)	30 (85.7%)	0.074
HIV care disruptions	117 (73.1%)	15 (48.4%)	52 (55.3%)	24 (68.6%)	0.163
Cancelled/rescheduled HIV care visits	91 (56.9%)	10 (32.3%)	36 (38.3%)	17 (48.6%)	0.112
> 30-min late to HIV care visits	63 (39.4%)	13 (41.9%)	45 (47.9%)	23 (65.7%)	0.257
Missed HIV care visits	81 (50.6%)	13 (41.9%)	37 (39.4%)	24 (68.6%)	0.049
Unable to see HIV provider	74 (46.3%)	6 (19.4%)	26 (27.7%)	14 (40.0%)	0.014
Running out of medicines	46 (28.8%)	8 (25.8%)	37 (39.4%)	15 (42.9%)	0.415

Notes: *P* values were calculated using Mantel-Haenszel Chi-Square tests to compare the differences in the proportions of participants with a travel challenge and HIV care consequence by travel time to care

Table 3 Multivariable regression results on the relationships between travel time to care and HIV care disruptions

	Travel Time to Care		
	< 15 min (*N* = 31)	15–30 min (*N* = 94)	> 30 min (*N* = 34)
	Adjusted Odds Ratio (95% CI)		
HIV Care Disruptions	1.00 (1.00, 1.00)	1.04 (0.27, 3.98)	4.45 (0.76, 26.06)
Cancelled/rescheduled HIV care visits	1.00 (1.00, 1.00)	0.87 (0.23, 3.29)	3.12 (0.66, 14.68)
> 30-min late to HIV care visits	1.00 (1.00, 1.00)	1.69 (0.41, 7.04)	5.25 (1.06, 25.92)*
Missed HIV care visits	1.00 (1.00, 1.00)	1.41 (0.40, 4.97)	3.85 (1.04, 15.89)*
Unable to see HIV provider	1.00 (1.00, 1.00)	1.24 (0.33, 4.59)	7.06 (1.61, 30.99)**
Running out of medicines	1.00 (1.00, 1.00)	1.43 (0.32, 6.49)	2.96 (0.59, 14.89)

Notes: Models controlled for age, marital status, sexual identity, gender, race, ethnicity, insurance, educational attainment, employment status, and annual household income. *=<0.05; **=0.01

construction used SAS® Version 9.5 [23], and multivariate analyses were conducted using Stata Version 15.1 [24].

Results

Participants' sociodemographic data are presented in Table 1. The study sample included 160 PLHIV from central South Carolina, with the majority of the sample being middle aged (i.e., $M = 46.9$ years), male (61.9%), single (76.9%), and Black or African American (77.5%). Participants displayed a high level of vulnerability, with the majority reporting an annual household income of <$10,000. Overall, nearly one in five participants (19.5%) lived less than 15 min from their HIV clinic, 59.1% lived 15–30 min, and 21.4% lived more than 30 min from their HIV care. Participant demographics are more fully broken down by travel time to HIV care in Table 2. Travel time to HIV care was similar across demographic groups, except that participants living > 30 min to HIV clinic when compared to those living < 15 min to the clinic were less likely to be unemployed (41.2% vs. 77.4%).

Table 2 shows transportation barriers and HIV care disruptions by travel time to HIV care. In total, nearly 3 in 5 participants (59.4%) reported experiencing at least one cost-related transportation barrier, with 37.5% of participants indicating they struggled to afford gas and 47.5% indicating they had difficulty paying for other aspects of transportation (e.g., taxi costs). Participants who resided more than 30 min from their HIV clinic were significantly more likely ($p = 0.048$) to report at least one cost-related transportation barrier.

Nearly three quarter of participants indicated that their transportation challenges had caused difficulties in accessing critical HIV care, with more than one in four (28.8%) reporting running out of their medicines due to difficulties reaching their pharmacies to access life-saving antiretroviral therapy (ART). More than half of participants (50.6%) had missed HIV care visits or had to cancel and/or reschedule HIV care visits (56.9%) due to transportation challenges. Participants who resided more than 30 min from their HIV care were significantly more likely to report that they had missed HIV care visits due to transportation challenges ($p = 0.049$) and had previously been unable to see their HIV care provider when they needed to because of their transportation vulnerability ($p = 0.014$) than participants were lived closer to HIV care.

Table 3 presents findings from the multivariable regression modeling. After controlling for other sociodemographic factors, participants who had to travel > 30 min were more likely to experience transportation-related disruptions to HIV care, including being late to appointments (Adjusted Odds Ratio [AOR] = 5.25, 95% Confidence Interval [CI]:1.06–25.92), missing HIV care visits (AOR 3.85, 95% CI:1.04–15.89), and having difficulty accessing HIV providers (AOR 7.06, 95% CI:0.59–14.89).

Discussion

The current study provides evidence that longer travel time (i.e., > 30 min) to HIV care is associated with increased transportation barriers and HIV care disruptions for a clinic-based sample of PLHIV in South Carolina—a rural, southern state that bears a disproportionate burden of the HIV-related morbidity and mortality [4]. Specifically, findings show that PLHIV who resided more than 30 min from their immunology center were more likely to report transportation-related challenges related to the costs of affording gas and other transportation services (e.g., taxis, rideshare costs). Importantly, travel time to care predicted key HIV care engagement. Specifically, after controlling for a host of variables known to impact HIV care outcomes, residing more than 30 min from care predicted being late to HIV care visits, missing HIV care visits, and having difficulty seeing HIV care providers.

This has important implications for PLHIV's ability to engage effectively in care, reach and maintain viral suppression, and access a variety of other services provided by comprehensive immunology centers (e.g., case management, preventive care, timely referrals to other specialists). Prior research using a large national Medicaid claims database showed that more than one-third of rural PLHIV had to drive more than one hour to access HIV care and that rural HIV-positive Medicaid recipients had a median drive time that is nearly four time longer than urban counterparts [25]. In the current study, participation was restricted to patients living within the same county or the neighboring county in which the immunology center was located. Even within this restricted catchment area, nearly one in four PLHIV had to drive more than 30 min to access care and this travel duration was significantly associated with HIV care access.

Findings that nearly 60% of the current study participants reported facing barriers to transportation call attention to the need to prioritize transportation as a key SDOH for PLHIV and to integrate transportation interventions into local, regional, and national efforts. More importantly, we found that PLHIV living further from a clinic experienced greater disruptions in their HIV care and also reported major challenges related to the cost of gas. Overcoming these barriers is critical to support Treatment as Prevention (TasP), enable all PLHIV to achieve viral suppression, and prevent further transmission of HIV within communities [26–30]. Thus, if US policy makers are serious are meeting new goals set forth in the National HIV/AIDS Strategy to reduce new infections in the US by 90% by 2030 [2, 31], they must prioritize SDOH interventions, including transportation interventions, to ensure all PLHIV can access and remain engaged in effective care. Furthermore, due to the high rate of comorbidities among PLHIV—especially among older PLHIV—treatment for other commonly co-occurring health conditions including diabetes and hypertension is likely also stymied when transportation barriers go unaddressed [32].

Barriers related to SDOH, including lack of access to broadband internet and lack of public transportation are cited within the US National HIV/AIDS Strategy [31, 33], with the plan calling for the development and implementation of effective SDOH interventions [31]. However, to this point, development and rigorous evaluation of transportation interventions remain scarce, particularly in the southern US. A recent systematic review identified only eight transportation nonemergency medical transportation interventions across all health conditions [34]. Only one of these studies was specific to PLHIV, which found that provision of a door-to-door transportation service was associated with reductions in missed HIV care visits among women living with HIV [35]. Additionally, a study from 2007 showed that free clinic-based transportation services were often used when made available by a cohort of PLHIV in North Carolina; utilization of these services (e.g., bus vouchers, mileage reimbursements, taxi services) was associated with greater participation in treatment for mental health and substance use disorder [36].

Prior qualitative research in the mid-South region has shown that PLHIV perceived public transportation options as unreliable and remarked that they were often significantly delayed when trying to use such services to access HIV care [37, 38]. Thus, vouchers or reimbursement systems may not be sufficient to improve care outcomes. Other options for accessing transportation to HIV clinics are also needed. For instance, rideshare programs (e.g., Lyft, Uber) have rapidly expanded in recent years, and may more acceptable and convenient than traditional public transportation avenues or Medicaid transportation vouchers for accessing healthcare services. Similarly, use of telehealth increased markedly during the COVID-19 pandemic. Future studies that examine use of telehealth or mobile Health (mHealth) approaches to deliver care to PLHIV with transportation vulnerability are needed. Beyond transportation-focused interventions, other efforts to expand HIV care access to PLHIV experiencing SDOH—especially rural residents—are necessary in the Southern US. Expansion of mail order pharmacy services, multi-month dispensing of ART, and scaling up long acting injectable ART have potential to help overcome existing transportation barriers. Efforts are also needed to address rural access disparities directly, such as incentivizing rural-based providers to initiate or expand their HIV services or implementing new debt forgiveness programs for clinicians serving rural communities with high HIV rates.

The current study has some important limitations. First, the sample was geographically restricted to two counties in South Carolina. Limiting enrollment to residents of two counties (i.e., Richland and Lexington counties) was necessary due to the intervention study from which these baseline data were collected. That intervention study was designed to test the effects of a concierge rideshare intervention on key HIV outcomes. The number of rideshare drivers was so low in other surrounding counties that they had to be excluded from the intervention—reflective the broader transportation challenges in this largely rural state. Future studies are warranted to examine travel time and HIV care among PLHIV residing in very rural communities.

In terms of other limitations, all participants had also either experienced gaps in care or existing SDOH-related vulnerability. In addition, a majority of the sample had <$10,000 annual income. While this does reflect broader socio-demographic characteristics of PLHIV in South Carolina, findings should be considered within this context. Second, we constructed average travel time to HIV care using population-weighted residential ZIP centroids and latitude and longitude coordinates of the immunology center, opting to use quickest driving route for our estimates. In the real world, participants may select other routes to the clinic or may occasionally be traveling to the clinic from other sites. Relatedly, patients likely selected this comprehensive immunology center for their care for multifaceted reasons, but there might have been other HIV providers located closer to participants' homes that they did select for care due to personal preferences, privacy concerns, or other reasons. Lastly, this cross-sectional survey study does not allow us to conclude causality between travel time to care and HIV care outcomes, especially when unmeasured confounding (e.g., length of time living with HIV) cannot be ruled out. Future research is warranted to identify the specific mechanisms through which travel time and transportation barriers impact HIV care engagement and viral suppression rates.

Conclusion

Expanding access to transportation services for PLHIV in the South is critically needed, especially given the poor public transportation infrastructure that exists in many southern states. Findings from the current study highlight the need to screen for transportation vulnerability and develop strategies and programs designed to overcome transportation barriers for PLHIV. Providers should be aware that transportation barriers are not confined to rural residents or those who have to travel long distances to HIV care. In fact, in the present study, nearly one in two individuals who lived less than 15 min from their HIV clinic reported that transportation problems had negatively impacted their ability to engage in HIV care. This highlights the ubiquity of transportation barriers for many PLHIV in the southern US and the urgent need for transportation interventions and other efforts to address SDOH that impede many from accessing life-saving HIV treatment..

Abbreviations

ACA	Affordable Care Act
AOR	Adjusted odds ratio
ART	Antiretroviral therapy
CI	Confidence interval
CBO	Community-based organization
EHE	Ending the HIV Epidemic
GED	General Educational Development Test
HIV	Human Immunodeficiency Virus
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome
MSM	Men who have sex with men
PLHIV	People living with HIV
SD	Standard Deviation
SDOH	Social determinant of health
TasP	Treatment as Prevention
US	United States

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-025-22090-y.

Supplementary Material 1

Acknowledgements

The authors greatly thank Rajee Rao for her significant contributions to the management of this study.

Author contributions

PH and SH developed the research question and study idea. KG led data collection. PH led statistical analysis. PH, SH, and SM led interpretation of data. PH, SH, KG, SM, MP, DA, SH, CR, and TE contributed to drafting the manuscript, with SH leading manuscript development. DA and SW obtained funding for the project. PH and SH provided administrative, technical, and material support. PH and SH supervised students working on the project and conducted critical revision of the manuscript for important intellectual content.

Funding
This work was supported by funding from ViiV Healthcare Foundation. Dr. Harrison is supported by the NIH National Institute of Mental Health (NIMH) grants K01MH118073 and R01MH127961. Dr. Harrison is supported by the Health Resources & Services Administration (HRSA) grant D40HP45690. Drs. Hung and Harrison are supported by the NIH Eunice Kennedy Shriver National Institute of Child Health & Human Development (NICHD) grant U01HD110062 and by HRSA grant U1CRH45498. Dr Rudisill is supported by the Center for Disease Control and Prevention grants U48DP006401 and U18DP006513, the National Heart, Lung and Blood Institute (NHLBI) grant R01HL163714 and the Duke Endowment.

Data availability
The data used for this publication are restricted for the authors' use due to the need to protect patient confidentiality. De-identified data may be made available by submitting a request to Dr. Divya Ahuja at the University of South Carolina School of Medicine—Department of Internal Medicine (Divya.Ahuja@uscmed.sc.edu).

Declarations

Ethics approval and consent to participate
This research involved human participants, was performed in accordance with the Declaration of Helsinki, and was approved by the University of South Carolina Institutional Review Board (#Pro00090288). All participants provided informed consent prior to participation.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Disclaimer
This work is the responsibility of the authors and does not necessarily reflect the views of ViiV Healthcare Foundation, NIH, or HRSA.

Additional Information
The data used for this publication are restricted for the authors' use due to concerns about patient confidentiality. De-identified data may be made available upon request.

Author details
[1]Department of Psychology, South Carolina SmartState Center for Healthcare Quality, University of South Carolina, Columbia, South Carolina, USA
[2]Department of Health Services Policy and Management, Arnold School of Public Health, University of South Carolina, Columbia, SC, USA
[3]Department of Internal Medicine, University of South Carolina School of Medicine, Prisma Health–Midlands, Columbia, SC, USA
[4]ViiV Healthcare, Research Triangle Park, NC, USA
[5]Department of Health Promotion, Education and Behavior, Arnold School of Public Health, University of South Carolina, Columbia, SC, USA

Received: 27 March 2024 / Accepted: 25 February 2025
Published online: 08 March 2025

References
1. Eisinger RW, Dieffenbach CW, Fauci AS. HIV viral load and transmissibility of HIV infection: undetectable equals untransmittable. JAMA. 2019;321(5):451–2.
2. Fauci AS, Redfield RR, Sigounas G, Weahkee MD, Giroir BP. Ending the HIV epidemic: a plan for the united States. JAMA. 2019;321(9):844–5.
3. Centers for Disease Control and Prevention. Monitoring selected national HIV prevention and care objectives by using HIV surveillance data—United States and 6 dependent areas. 2021. HIV Surveillance Supplemental Report, 2023; 28(No. 4). http://www.cdc.gov/hiv/library/reports/hiv-surveillance.html
4. Center for Disease Control & Prevention (CDC), Surveillance Report HIV. 2021. Published online 2023. Accessed February 29, 2024. https://www.cdc.gov/hiv/library/reports/hiv-surveillance/vol-34/index.html
5. Centers for Disease Control and Prevention (CDC). Social determinants of health: Know what affected health. 2020; Retrieved March 18, 2023, from https://www.cdc.gov/socialdeterminants/about.html
6. United States Department of Health and Human Services (US DHHS). Healthy people 2030—Social determinants of health. US DHHS. 2020. Retrieved October 18, 2020, from https://health.gov/healthypeople/objectives-and-data/socialdeterminants- Health.
7. Abbott LS, Williams CL. Influences of social determinants of health on African Americans living with HIV in the rural Southeast: a qualitative meta-synthesis. J Assoc Nurses AIDS Care. 2015;26(4):340–56.
8. Reif SS, Whetten K, Wilson ER, McAllaster et al. 2014. HIV/AIDS in the Southern USA: a disproportionate epidemic. AIDS Care. 2014;26(3):351-9.
9. Searing A, Adimora AA. HIV and Medicaid expansion: Failure of southern states to expand Medicaid makes elimination of HIV infection in the United States much harder to achieve. Georgetown University Health Policy Institute Center for Children and Families: 2020, Nov. https://ccf.georgetown.edu/wp-content/uploads/2020/11/HIV-and-Medicaid_Nov-30.pdf
10. Tran NM, Rebeiro P, McKay T. Tennessee rejects federal HIV prevention funds: A looming public health and financial disaster. Health Affairs Forefr. 2023 Apr 8.
11. Bailey ZD, Krieger N, Agénor M, et al. Structural racism and health inequities in the USA: evidence and interventions. Lancet. 2017;389:1453–63.
12. Harrison SE, Muessig K, Poteat T, et al. Addressing Racism's role in the US HIV epidemic: qualitative findings from three ending the HIV epidemic prevention projects. JAIDS. 2022;90(1):S46–55.
13. Schafer KR, Albrecht H, Dillingham R, et al. The continuum of HIV care in rural communities in the united States and Canada: what is known and future research directions. JAIDS. 2017;75(1):35.
14. Lopes BLW, Eron JJ Jr., Mugavero MJ, Miller WC, Napravnik S. HIV care initiation delay among rural residents in the southeastern united States, 1996 to 2012. JAIDS. 2017;76:171–6.
15. Nelson JA, Kinder A, Johnson AS, et al. Differences in selected HIV care continuum outcomes among people residing in rural, urban, and metropolitan areas—28 US jurisdictions. J Rural Health. 2018;34(1):63–70.
16. South Carolina Department of Health and Environmental Control. Ending the HIV Epidemic Plan: South Carolina. 2020. Accessed December 21, 2021. https://scdhec.gov/sites/default/files/media/document/SC-Ending-HIV-Epidemic-Plan-2021-2025_FINAL.pdf
17. Cornelius T, Jones M, Merly C, Welles B, Kalichman MO, Kalichman SC. Impact of food, housing, and transportation insecurity on ART adherence: a hierarchical resources approach. AIDS Care. 2017;29(4):449–57. https://doi.org/10.1080/09540121.2016.1258451.
18. Magnus M, Schmidt N, Kirkhart K, et al. Association between ancillary services and clinical and behavioral outcomes among HIV-infected women. AIDS Patient Care STDs. 2001;15(3):137–45. https://doi.org/10.1089/108729101750123607.
19. Sherer R, Stieglitz K, Narra J, et al. HIV multidisciplinary teams work: support services improve access to and retention in HIV primary care. AIDS Care. 2002;14(SUPPL 1):31–45. https://doi.org/10.1080/09540120220149975.
20. Althoff AL, Zelenev A, Meyer JP, et al. Correlates of retention in HIV care after release from jail: results from a Multi-site study. AIDS Behav. 2013;17(02):156–70. https://doi.org/10.1007/s10461-012-0372-1.
21. Bono RS, Dahman B, Sabik LM, et al. Human immunodeficiency virus–experienced clinician workforce capacity: urban–rural disparities in the Southern united States. Clin Infect Dis. 2021;72(9):1615–22.
22. Redlands CESRI. ArcGIS Desktop: Release 10. 2011.
23. SAS® V. 9.5, Cary, NC: SAS Institute Inc.
24. Stata Version 15.1. College Station, TX: Stata Corp.
25. Bono RS, Pan Z, Dahman B, Deng Y, Kimmel AD. Urban-rural disparities in geographic accessibility to care for people living with HIV. AIDS Care. 2023;35(12):1844–51.
26. Cohen MS, Gay C, Kashuba AD, et al. Narrative review: antiretroviral therapy to prevent the sexual transmission of HIV-1. Ann Intern Med. 2007;146:591–601. https://pubmed.ncbi.nlm.nih.gov/17438318/.

27. Cohen MS, Chen YQ, McCauley M, et al. Antiretroviral therapy for the prevention of HIV- 1 transmission. N Engl J Med. 2016;375(9):830–9. https://pubmed.ncbi.nlm.nih.gov/27424812/.
28. Wood E, Milloy MJ, Montaner JS. HIV treatment as prevention among injection drug users. Curr Opin HIV AIDS. 2012;7(2):151–6.
29. Montaner JS, Hogg R, Wood E, et al. The case for expanding access to highly active antiretroviral therapy to curb the growth of the HIV epidemic. Lancet. 2006;368(9534):531–6.
30. Li Z, Purcell DW, Sansom SL, Hayes D, Hall HI. Vital signs: HIV transmission along the continuum of Care — United States, 2016. Morb Mortal Wkly Rep. 2019;68:267–72. https://doi.org/10.15585/mmwr.mm6811e1externalicon.
31. The White House. 2021. *National HIV/AIDS Strategy for the United States 2022–2025*. Washington, DC.
32. Godfrey C, Vallabhaneni S, Shah MP, Grimsrud A. Providing differentiated service delivery to the ageing population of people living with HIV. J Intl AIDS Soc. 2022;25:e26002.
33. Douthit N, Kiv S, Dwolatzky T et al. Exposing some important barriers to health care access in the rural USA. Public Health 2015(June);129(6):611–20. https://doi.org/10.1016/j.puhe.2015.04.001
34. Solomon EM, Wing H, Steiner JF, Gottlieb LM. Impact of transportation interventions on health care outcomes: A systematic review. Med Care. 2020;58(4):384–91. https://doi.org/10.1097/MLR.0000000000001292.
35. Andersen M, Hockman E, Smereck G, et al. Retaining women in HIV medical care. J Assoc Nurses AIDS Care. 2007;18(3):33–41. https://doi.org/10.1016/j.jana.2007.03.007.
36. Whetten R, Whetten K, Pence BW, Reif S, Conover C, Bouis S. Does distance affect utilization of substance abuse and mental health services in the presence of transportation services? AIDS Care. 2006;18(sup1):27–34.
37. Sagrestano LM, Clay J, Finerman R, Gooch J, Rapino M. Transportation vulnerability as a barrier to service utilization for HIV-positive individuals. AIDS Care. 2014;26(3):314–9. https://doi.org/10.1080/09540121.2013.8194037.
38. Miller SJ, Paton M, Ahuja D, Weissman S, Evans T, Gutner CA, Harrison SE. A qualitative.
39. study of transportation. -related barriers to HIV care in South Carolina. South Med J. 2024;117(10):617–22.

Publisher's note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.