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Acceptability and Feasibility of Using a Novel Geospatial Method to Measure Neighborhood Contexts and Mobility Among Transgender Women in New York City

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Abstract

Purpose: To date, no studies utilizing global positioning system (GPS) technologies to measure mobility and environmental exposures have been conducted among a sample of transgender women despite the potential salient role neighborhood contexts may play in the health of this population. As such, the purpose of this study was to assess the acceptability and feasibility of a weeklong GPS protocol among a sample of transgender women in New York City.

Methods: A sample of 14 transgender women residing in the New York City metropolitan area were recruited through community based methods to wear and charge a GPS device for 7 days to measure daily mobility. The acceptability of these methods was assessed using a pre- and postprotocol survey and their feasibility was measured using objective data derived from the GPS device. Pre- and postprotocol survey measures were compared using McNemar's test.

Results: Participants reported high ratings of preprotocol acceptability, as well as few concerns regarding safety, appearance, and losing the device, all of which were maintained after completing the protocol. All 14 devices that were distributed were returned. In addition, all 14 participants had GPS data for at least 1 h on 1 day, and nine participants (64.3%) had at least 8 h of GPS data on all days.

Conclusion: The findings of this pilot study demonstrate that the GPS methods are both acceptable and feasible among this sample of transgender women. GPS devices may be used in research among transgender women to understand neighborhood determinants of HIV and other STIs.

Keywords: feasibility; global positioning system; neighborhoods; transgender women

Introduction

Syndemic theory has been a useful framework for understanding the determinants of disparities in HIV infection in high-risk populations,[1–3] where a syndemic refers to the concentration of multiple co-occurring epidemics interacting and reinforcing one another and ultimately giving rise to other health problems within a specific population.[1] A meta-analysis by Baral et al. found that transgender women are disproportionately impacted by HIV worldwide, with 48.8-fold increase

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in odds of HIV infection compared to all adults of reproductive age across 15 countries.[4] In 2014, 48 transgender women were newly diagnosed with HIV in New York City, representing 98.0% of all transgender people diagnosed with HIV in the city.[5] Recent research suggests that co-occurring epidemics of poor mental health, substance abuse, and violence and victimization may facilitate sexual risk behaviors and HIV transmission in this population.[6]

Neighborhood contexts can influence poor mental health, substance use, violence and victimization, and sexual risk behaviors and a growing literature has identified a number of salient neighborhood determinants related to these outcomes among other populations at high risk for HIV acquisition, such as men who have sex with men (MSM).[7–10] Neighborhoods may also be a salient determinant of health, including HIV, among transgender populations. Due to a lack of discrimination protections in housing and employment, the rates of homelessness and unemployment among transgender women are much higher than in the general population.[11,12] Given these structural barriers to formal employment and secure housing, some transgender women may engage in sex work and survival sex,[13,14] leaving many vulnerable to the psychosocial effects of living in a disadvantaged or disordered neighborhood.[15]

Some emerging work, although sparse, has begun to document geographic variations in the health of transgender populations. For example, among a national sample of transgender adults in the United States, White Hughto et al. found that the proportion of the state population who voted for the Republican candidate in the 2008 Presidential election was associated with experiences of healthcare refusal in the sample.[16] In addition, Sinnard et al. found that transgender individuals living in the United States Census Bureau division, including Arkansas, Louisiana, Oklahoma, and Texas referred to as the West South Central States, were more likely than individuals living in other regions to experience high levels of anxiety and depression.[17] A recent study among a sample of large transgender adults in the United States found that individuals living in states with few or no legal protections for lesbian, gay, bisexual, and transgender (LGBT) residents were more likely to have ever attempted suicide in their lifetime.[18] Taken together, these three studies suggest that local variations in policies and attitudes toward and resources available to transgender people have an immense impact on their overall health and well-being.

Despite the potential role neighborhood factors play in influencing health,[19] significant methodological limitations in research on neighborhoods, mental health, and substance use exist in populations at high risk for HIV infection, including the few studies conducted among transgender populations. First, all studies among transgender populations rely on crude neighborhood definitions defined by administrative boundaries (e.g., ZIP codes, census tracts, and state boundaries), which can result in spatial misclassification (i.e., incorrect characterization of a neighborhood-level exposure).[20,21] Second and perhaps most important, the vast majority of existing research has focused solely on residential neighborhoods, which is a major limitation because the concept of spatial polygamy argues that individuals are exposed to various neighborhood environments in their daily lives.[22,23] Emerging mobility research suggests that measurements relevant to the residential neighborhood only will not capture most of an individual's daily environmental exposures because most day-to-day activities are conducted outside of these areas.[22,23]

Studies are increasingly using mobility data to assess impact of multiple contextual exposures on health behaviors and outcomes in a variety of populations and have demonstrated the feasibility of global positioning system (GPS)-based approaches, including recent work among MSM.[24] However, no studies to date have focused exclusively on transgender individuals. In the aforementioned study demonstrating the feasibility of GPS methods among MSM, one participant identified as a transgender woman.[24] Because transgender individuals face stigma and discrimination in various sectors within society,[25,26] they may be less likely to participate in academic research studies, particularly in those that involve wearable monitors of daily mobility. In addition, the high rates of homelessness and housing stability among transgender women[11] may be a unique factor determining the feasibility of a GPS-based protocol that requires participants to charge a GPS device. Many of the common concerns pertaining to privacy and confidentiality while participating in studies that use GPS monitoring may be shared by transgender women and other stigmatized populations.[27] However, there may be other transgender-specific factors that influence the acceptability and feasibility of spatial methods of data capture among transgender women, such as gender transition or fear of increasing visibility and therefore exposure to stigma by carrying a GPS device.

As no GPS-based assessments of neighborhood contexts and mobility have been conducted among transgender women, the purpose of the current study was to evaluate the feasibility and acceptability of using GPS methods to understand the spatial contexts of sexual risk behaviors, substance use, violence and victimization, and mental health among a sample of transgender women in New York City.

Methods

Participants

Participants were recruited for the New York City Transgender Women's Neighborhoods and Health Study between August and November 2016, and assessments were conducted during this time frame at the New York University School of Medicine's Spatial Epidemiology Lab. To be eligible for this study, participants had to be between 18 and 40 years old, identify as a transgender woman (i.e., assigned a male sex at birth and identify as female, male-to-female [MTF], transgender female, or trans woman), live in the New York City metropolitan area, self-report no plans to leave New York City during the GPS protocol period, self-report no limitations to regular physical activity, be willing to wear a small GPS device for 1 week, and be able to provide informed consent. Participants were recruited through various community-based methods, including flyers distributed at LGBT community events (e.g., annual Latex Ball hosted by GMHC [formerly known as Gay Men's Health Crisis]) and referrals from community centers and organizations providing social services to transgender individuals in New York City (e.g., New York City's LGBT Center and the New York Transgender Advocacy Group). Participants were compensated $30 at their enrollment visit and $50 at their completion visit after returning 1 week later with the GPS device and charging materials. All research protocols were approved by the New York University School of Medicine Institutional Review Board before data collection, and written information consent was obtained from all participants before participation.

GPS protocol and data processing

The current study utilized QStarz's BT-Q1000XT GPS Travel Recorder (QStarz International Co., Ltd., Taipei, Taiwan), which has been used in multiple prior research studies.[24,27,28] Assessments of mobility using GPS devices typically require participants to wear the travel recorder for a period of 7 days.[24,27,29,30] Generally, participants wore the GPS device during 5 week days and 2 weekend days. In this study, the GPS devices were set to record locations in 10-sec intervals. Participants were instructed to place the small GPS device in their pockets or bags and to keep the device with them during the protocol. In addition, participants were instructed to charge the GPS devices nightly and to wear the GPS device at all times except when sleeping, swimming, or showering.

As a measure of self-reported protocol adherence, we asked participants to complete a travel diary consisting of questions asking, "Did you charge the GPS device today?" with two response options ("Yes" and "No") and "Did you carry the GPS device with you today?" with four response options ("Yes, for all journeys," "Yes, for some journeys," "No, but did make journeys," and "Did not travel today"). The GPS travel recorder (with a fully charged battery and unique serial number) was given to the participant in a large ziplock bag, which also contained a mini USB charging cord for the GPS device, a USB wall adapter for charging, a pamphlet containing background information on GPS technology, and a pen-and-paper travel diary. Upon completion of the 1-week GPS protocol, participants returned the GPS device, at which time participants completed the postprotocol feasibility and acceptability survey.

GPS data were then securely downloaded by research assistants using the QStarz proprietary software and stored as GPX files. These files were transformed into shapefiles and stored in an ESRI geodatabase for further analyses. Models built using ArcGIS Version 10.2 (ESRI, Redlands, CA) and the Python programming language (Python Software Foundation, Python Language Reference 2.7) were used to process the GPS data to remove duplicate or spurious data points.

GPS acceptability and feasibility

Acceptability and feasibility of the 1-week GPS protocols were measured in multiple ways. First, consistent with previous research,[24,27] acceptability and feasibility were assessed using survey-based methods. Seven similarly worded items were included in the pre- and postprotocol survey to facilitate an assessment of changes in attitudes before and after participating in the protocol. For example, at the enrollment visit, participants were asked to rate their level of agreement with statements reading, "The use of GPS *makes* it more interesting to participate in the study," while at the completion visit, the postprotocol statement read, "The use of GPS *made* it more interesting to participate in the study."[24,27] Participants were asked to use a Likert scale from 1 (strongly agree) to 5 (strongly disagree) for these items.[24,27] Similar to previous research,[24,27] the postprotocol survey included

25 items exclusive to the completion visit, including "Overall, was it easy to use the GPS?"; "Did you feel comfortable wearing the GPS?"; and "Would you participate in another GPS-based research study?" These items had two response options ("Yes" and "No"). In addition, we assessed willingness to participate in advanced GPS protocols, such as those that would require a participant to carry a GPS device for a given time period at multiple points over the course of a year and those that would require a participant to use a dedicated smartphone application on their own device to track their location.

Second, we evaluated adherence to the GPS protocol, which included returning the GPS device and objective data analyzed from the GPS devices.[24,27] GPS data may be analyzed in various ways depending upon the desire unit of analysis—the number of days of available data was assessed in this study. Valid and usable GPS data for a day were defined if a participant had at least 360 GPS data points in a single day as this would indicate 1 h of wear time with the device attempting to fix location in the aforementioned 10-sec intervals. Cutoff times of 5, 8, and 12 h were used to ascertain data quality, as done in previous research.[24,27]

Finally, a map of a participant's GPS data is presented as a final measure of feasibility. Caution should be taken in displaying maps of participant's locations given concerns regarding potential reverse identification and loss of confidentiality. Given that New York City is the most densely populated metropolitan area in the United States, it is believed that there is a low risk of identification of the participant given that all other demographic information is presented in aggregate. Nonetheless, GPS points recorded in the participant's residential ZIP code (ZCTA) are obscured in the Figure 1.

Demographic characteristics

Information on the following demographic characteristics was collected from the participants at their enrollment visit: age (in years), sex assigned at birth (male and female), current gender identity (female; MTF, transgender female, trans woman; genderqueer, neither exclusively male nor female; and additional or other gender categories), sexual orientation (lesbian, gay, or homosexual; straight or heterosexual; bisexual; queer; something else; and don't know, not sure), race/ethnicity (White; Black or African American; Hispanic or Latino; Asian or Pacific Islander; Native American or Alaskan Native; Biracial or multiracial; and Other), educational attainment (<12th grade; High school or equivalent; Some college, vocational school, or apprenticeship; and Bachelor's degree, Graduate degree, or higher), past year income (<$10,000; $10,000 to $19,999; $20,000 to $29,999; $30,000 to $39,999; $40,000 to $49,999; and $50,000 or more), and current relationship status (Yes, in a relationship with a cisgender [nontransgender] male partner; Yes, in a relationship with a cisgender [nontransgender] female partner; Yes, in a relationship with a female-to-male/transgender male partner; Yes, in a relationship with a MTF/transgender female partner; and No, I am single). To assess histories of incarceration, participants reported whether or not they had ever spent one or more nights in jail.

At the enrollment visit, participants were asked several questions regarding various aspects of their gender transition process. First, to assess social transition, participants were asked "Have you transitioned? In other words, are you living full time in your self-identified gender?" Next, to assess legal aspects of transitioning, participants were asked "Have you changed the name and/or sex listed on your original birth certificate or other legal documents (e.g., driver's license and passport)?" Four questions were used to collect information regarding different processes associated with medical transitioning. Two questions ascertained the use of hormones (e.g., estrogen) or anti-androgens (e.g., Lupron and Spironolactone) for transgender-related processes—first asking about those obtained through a prescription from a doctor and next asking about those obtained without a prescription. The third question asked "Have you had surgery to modify your chest, including breast augmentation? This is sometimes referred to as 'top surgery.'" This does not include silicone injections. The fourth question asked "Have you had surgery to modify your genitalia? This is sometimes referred to as sex reassignment surgery, gender reassignment surgery, gender confirmation surgery, or 'bottom surgery.'"

At both the enrollment and completion visits, housing status was ascertained for each participant. At both visits, participants were asked to indicate where they stayed the preceding night from a list containing 15 choices. Individuals were considered stably housed if they reported staying in a room, apartment, or house that they rent or in an apartment or house that they own. Individuals were considered to be unstably housed if they reported living in permanent supportive housing for formerly homeless persons, a psychiatric hospital, or other psychiatry facility; a substance abuse treatment facility or other detox facility; a hospital (nonpsychiatric);

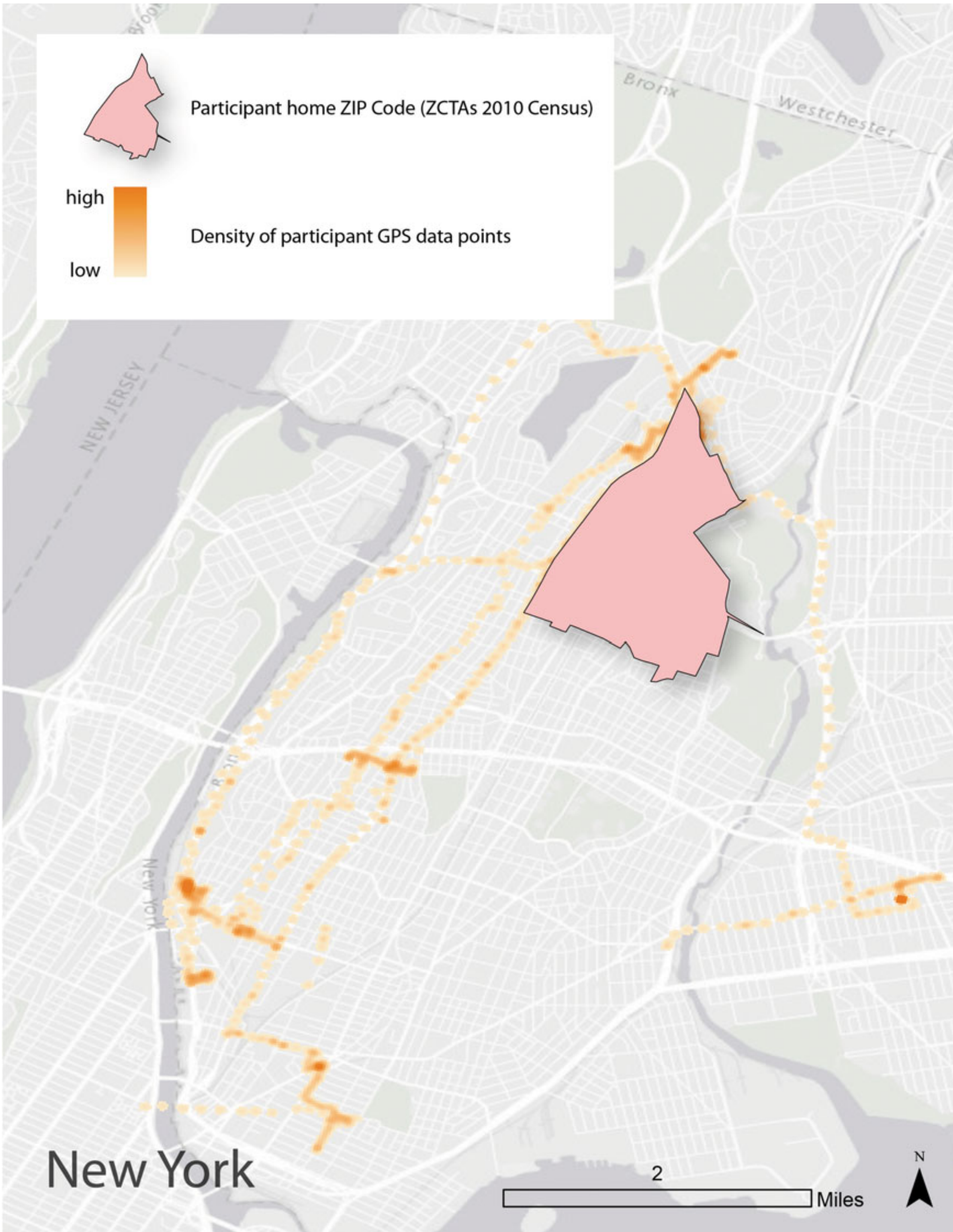

FIG. 1. Sample map of participant GPS data. GPS, global positioning system.

jail, prison, or a juvenile detention facility; a half-way or three-quarter-way home for persons with criminal offenses; in a friend or family member's room, apartment, or house; a hotel or motel paid for without emergency shelter voucher; a foster care home or foster care group home; or a group home or other supervised residential care facility. Individuals were considered homeless if they reported staying in an emergency shelter (including a hotel or motel voucher paid for by a social service organization), transitional housing for homeless persons, or in a place not meant for human habitation (e.g., street, car, park, subway).

Statistical analyses

First, descriptive statistics was computed for demographic variables. Next, the feasibility of GPS protocols among the sample was examined by computing summary statistics on the pre- and postprotocol survey measures. The analytical sample for the survey data included participants who answered the pre- and postprotocol surveys ($n=14$). Analyses of these surveys were treated as repeated measures as each participant had a set of pre- and postprotocol responses. When comparing the similar survey items asked during the enrollment visit and the completion visit, the percentages and associated p-values are presented based on chi-square statistics computed from McNemar's test for related samples.[31] Significance was determined at $p<0.05$, and all analyses were conducted in IBM SPSS 22.0 (IBM Corporation, Armonk, NY). The map of a participant's GPS data was created in ArcGIS 10.2 (ESRI).

Results

Sample demographics

The demographic characteristics of the sample ($n=14$) are displayed in Table 1. The average age in the sample was 32.2 years old (standard deviation [SD]: 4.3). All participants (100.0%) were assigned a male sex at birth; 21.4% identified their current gender identity as female, 21.4% as MTF/transgender female/trans woman; and 57.1% as both female and MTF/transgender female/trans woman. In terms of sexual orientation, 50.0% identified as straight or heterosexual. In terms of race/ethnicity, 71.4% were non-White with 42.9% reporting their race as Black or African American. Most participants reported being in a relationship (57.1%), where 21.4% were in a relationship with a cisgender male partner and 21.4% were in a relationship with a cisgender female partner. Half (50.0%) did not currently work full time or part-time. All participants completed high school and 28.6% completed a Bachelor's degree or higher. Most (85.7%) reported an estimated yearly income of less than $20,000. About one-quarter (28.6%) had ever spent one or more days in jail or prison.

Table 1. Sample Demographics (*n* = 14)

	% (*n*)
Age (years)	
20–24	7.1 (1)
25–29	28.6 (4)
30–34	21.3 (3)
35–39	42.6 (6)
Current gender identity	
Female only	21.4 (3)
MTF/transgender female/trans woman only	21.4 (3)
Both female and MTF/transgender female/trans woman	57.1 (8)
Sexual orientation	
Straight or heterosexual	50.0 (7)
Lesbian, gay, or homosexual	7.1 (1)
Bisexual	14.3 (2)
Queer	14.3 (2)
Other	14.3 (2)
Race/ethnicity	
White	28.6 (3)
Black/African American	42.9 (6)
Hispanic/Latino	7.1 (1)
Asian/Pacific Islander	14.3 (2)
Multiracial/other	14.3 (2)
Current relationship	
Yes, with cisgender male partner	21.4 (3)
Yes, with cisgender female partner	21.4 (3)
Yes, with transgender male partner	7.1 (1)
Yes, with transgender female partner	7.1 (1)
No	42.9 (6)
Educational attainment	
High school or equivalent	14.3 (2)
Some college	57.1 (8)
Bachelor's degree or higher	28.6 (4)
HIV status	
Negative	63.4 (9)
Positive	35.7 (5)
Yearly income	
Under $10,000	28.6 (4)
$10,000–$19,999	57.1 (8)
$20,000 or more	14.2 (2)
Housing status (preprotocol visit)	
Stable housing	57.1 (8)
Unstable housing	21.4 (3)
Homeless	21.3 (3)
Housing status (postprotocol visit)	
Stable housing	57.1 (8)
Unstable	28.6 (4)
Homeless	14.2 (2)

MTF, male-to-female.

Gender transition status

Most participants (92.9%) had transitioned, meaning that they were living full time in their self-identified gender. Approximately half (57.1%) had changed the name and/or sex listed on their original birth certificate or other legal documents. Most (92.9%) had taken hormones or anti-androgens that were prescribed to them, with a smaller proportion (21.4%) having taken hormones or anti-androgens that were not prescribed to them. About one-quarter (28.6%) previously had surgery to modify their chest (sometimes referred to as "top" surgery) and less than one-tenth (7.1%) previously had surgery to modify their genitalia (sometimes referred to as "bottom" surgery).

Residential location and housing stability

Most participants reported either living alone (42.9%) or with roommates or friends (42.9%). At the first visit, 57.1% were considered to be in stable housing, 21.4% were considered to be in unstable housing, and 21.4% were considered to be homeless. At the second visit, 57.1% were considered to be in stable housing, 14.3% were considered to be in unstable housing, and 28.6% were considered to be homeless. Overall, 28.6% experienced a change in housing status over the course of the weeklong protocol.

GPS protocol acceptability and feasibility

All 14 distributed GPS devices were returned (100% return rate). The results of the survey-based assessment of acceptability are displayed in Table 2. At the preprotocol visit, most participants agreed or strongly agreed that they were comfortable with the study tracking where they went with GPS technology (92.9%) and that the GPS component made participating in the study more interesting (78.6%). Before wearing the GPS device, there were low levels of concerns related to someone potentially stealing the GPS device, personal comfort while wearing the GPS device, potentially losing the GPS device, personal safety while wearing the device, and personal appearance while wearing the device. These low levels of concerns remained low after completing the 1-week protocol. Few participants (21.4%) reported issues or problems with the GPS device during the protocol.

The results of the postprotocol only survey are displayed in Table 3. Few participants (7.1%) forgot to charge the GPS device. No participants forgot where to put the GPS device during the protocol and few (14.3%) reported forgetting to wear the GPS device on a daily basis. Overall, 92.9% of participants said that it was easy to use the GPS device and that they felt comfortable wearing the GPS device. All participants reported that wearing the GPS device did not cause them to alter their behaviors. No participants reported that their daily activities were difficult to do with the GPS or that the GPS device was inconvenient to wear.

All participants (100%) expressed that they would participate in another study that used GPS devices, as well as a 2-week long GPS-based project, a longitudinal GPS-based project with two separate 1-week protocols spaced 3 months apart, and a longitudinal GPS-based project with two separate 2-week protocols spaced 3 months apart. Most participants (85.7%) expressed interest in participating in a project that utilized a smartphone application rather than a dedicated GPS device.

The results of the analyses of objective adherence to the GPS protocols are displayed in Table 4. In total, the participants generated total 560,732 data points. The number of data points per participant ranged from 2993 points (representing about 8.3 h of total wear time) to 54,482 points (representing about 151.6 h [6.3 days] of total wear time). The mean number of data points was 40,052 points (SD: 15,736), representing ~111.3 h (4.6 days) of total wear time. Overall, 78.6% of participants ($n=11$) had a total number of data points within 1 SD of the mean. The median number of data points was 47,893 points (interquartile range: 22,920),

Table 2. Comparison of Pre- and Postprotocol Survey Assessments of Acceptability

	Preprotocol, % (*n*)	Postprotocol, % (*n*)	*p*
I am comfortable with the research study tracking where I go.	92.9 (13)	75.7 (12)	0.999
GPS makes it more interesting to participate in the study	78.6 (11)	64.3 (9)	0.625
I am worried about someone trying to steal the GPS.	0.0 (0)	14.3 (2)	—
The GPS seems uncomfortable to wear.	0.0 (0)	7.1 (1)	—
I am concerned that I will lose the GPS.	7.1 (1)	21.4 (3)	0.223
I am worried about my safety wearing the GPS.	0.0 (0)	7.1 (1)	—
I am concerned about how I will look wearing the GPS.	14.3 (2)	7.1 (1)	0.344

The pre- and postprotocol columns represent the frequency of those responding "Agree" or "Somewhat Agree" to each of the items.
GPS, global positioning system.

Table 3. Postprotocol Survey Assessment of Feasibility

Item	No	Yes
Did you have problems turning the GPS device on or off?	100.0 (14)	0.0 (0)
Did you forget to charge the GPS device at night?	92.9 (13)	7.1 (1)
Did you forget where to put the GPS device?	100.0 (14)	0.0 (0)
Do you think the GPS device was too small?	85.7 (12)	14.3 (2)
Do you think the GPS device was too big?	100.0 (14)	0.0 (0)
Did the GPS device run out of battery during the day?	64.3 (9)	35.7 (5)
Overall, was it easy to use the GPS device?	7.1 (1)	92.9 (13)
Did you have any problems with charging the GPS device?	85.7 (12)	14.3 (2)
Did you have any problems with carrying or wearing the GPS device?	100.0 (14)	0.0 (0)
Were you able to solve any problems you had with the GPS?	35.7 (5)	64.3 (9)
Did you feel comfortable wearing the GPS device?	7.1 (1)	92.9 (13)
Did the GPS device get in the way of your everyday activities?	100.0 (14)	0.0 (0)
Was the battery life of the GPS device too short?	14.3 (2)	85.7 (12)
Did you forget to wear the GPS device daily?	85.7 (12)	14.3 (2)
Did using the GPS device cause you to alter your behavior?	100.0 (14)	0.0 (0)
Were there any activities that were difficult to do with the GPS device on?	100.0 (14)	0.0 (0)
Was the GPS device inconvenient to wear or carry?	100.0 (14)	0.0 (0)
Was it a chore to wear the GPS device?	78.6 (11)	21.4 (3)
Did you like the look of the GPS device?	21.4 (3)	78.6 (11)
I would participate in another GPS research study.	0.0 (0)	100.0 (14)
Would you participate in a 2-week long GPS-based research study?	0.0 (0)	100.0 (14)
Would you participate in a GPS-based research study that tracked where you went for a week and then again for a week 3 months later?	0.0 (0)	100.0 (14)
Would you participate in a GPS-based research study that tracked where you went for 2 weeks and then again for 2 weeks 3 months later?	0.0 (0)	100.0 (14)
Would you download a smartphone application that tracked where you went using GPS technology for the purposes of a research study?	14.3 (2)	85.7 (12)

representing ~133.0 h (5.5 days) of total wear time. Most participants (85.7%) had at least 1 h of data on all 7 days, and approximately one-third (35.7%) had at least 12 h of data on all 7 days. In addition, most participants (64.3%) had at least 8 h of GPS data on all 7 days of the protocol, suggesting that most participants consistently charged and wore the device. Fewer participants had at least 12 h of GPS data on all 7 days (35.7%), suggesting that strategies are needed to increase protocol compliance and data quality.

Discussion

This study represents the first to use GPS devices to measure mobility and exposure to daily neighborhood contexts among a sample of exclusively transgender women. A total of 14 transgender women in New York City were successfully recruited, where one of the eligibility criteria was being willing to wear a GPS device for 1 week. Overall, the findings suggest that GPS-based protocols are acceptable and feasible for this sample of transgender women. All distributed GPS devices were returned. Among the participants with any data points during the 1-week protocol, all participants had at least 1 h of data for 1 day, and 85.7% had data for at least 1 h on all 7 days. These data suggest that GPS methods are feasible. However, 1 h of wear time likely does represent the full scope of an individual's mobility and a greater amount of data may be required. The success rate for 1 h of wear time for 7 days was 92.9%, but this significantly decreased as the wear time thresholds increased to 5, 8, and 12 h. The fact that only five participants (35.7%) had 12 h of wear time on all 7 days may be due to a number of factors. For example, given the high percentage of participants who were unstably housed or homeless (42.8%), it is possible that not all participants had consistent access to electricity to charge the device each night and that GPS device would lose charge throughout the day.

Table 4. Number of Days with GPS Data per Participant

Days	1-H, % (*n*)	5-H, % (*n*)	8-H, % (*n*)	12-H, % (*n*)
1	100.0 (14)	100.0 (14)	92.9 (13)	92.9 (13)
2	92.9 (13)	92.9 (13)	92.9 (13)	85.7 (12)
3	92.9 (13)	92.9 (13)	92.9 (13)	85.7 (12)
4	92.9 (13)	92.9 (13)	92.9 (13)	71.4 (10)
5	92.9 (13)	92.9 (13)	78.6 (11)	64.3 (9)
6	92.9 (13)	78.6 (11)	64.3 (9)	50.0 (7)
7	85.7 (12)	78.6 (11)	64.3 (9)	35.7 (5)

Given that there are no other studies using GPS methods among transgender women, there is no other research to which these findings can be directly compared. However, studies assessing the feasibility and acceptability of these methods have been conducted among other LGBT populations. In a recent study among 75 young MSM in New York City, participants were instructed to wear a GPS device (the same QStarz BT-Q1000XT device used in this study) for 1 week.[24] Similar to our sample, participants rated these methods as acceptable before carrying the devices and these ratings were maintained over time. In addition, participants in this sample of MSM and the current sample of transgender women reported few concerns related to appearance, safety, and loss of the device, all of which were maintained after participating in the protocol. The findings of the current study are therefore comparable to this similar previous study.[24]

The acceptability and feasibility of this novel geospatial monitoring protocol are likely affected by various factors. In particular, the use of a financial incentive and the weeklong protocol period likely affected how well participants adhered to the protocols. Alternative strategies may need to be developed to increase the amount of viable GPS data collected from future samples of transgender women, including implementing protocols to send text message reminds to charge and carry the GPS device and protocols that collect mobility data using GPS-enabled smartphones rather than dedicated devices. Given the high prevalence of homelessness and housing instability,[32] future studies may need to provide mobile power sources that allow participants to charge the device regardless of whether or not they have access to an outlet for charging. In addition, because many transgender individuals early in their transition processes may fear drawing unwanted attention in public based on their appearance,[33] it may be necessary to provide alternate means of carrying the GPS device other than placing it in one's pocket so that participants can comfortably wear or carry the GPS device without increasing concerns about safety or appearance. Future studies could utilize other smaller GPS devices or research-provided or participant-owned smartphones to increase the inconspicuousness of the device.

In addition, future studies utilizing GPS methods are warranted and needed among transgender populations, including larger diverse samples that include transgender men and women and individuals with nonbinary gender identities, given the health disparities experienced by these populations.[34] These studies should include transgender and gender nonconforming individuals of different ages (e.g., adolescent and young adult individuals) and across geographies (e.g., rural areas in the Southern United States).[34] Future studies should also utilize different and more advanced protocols (e.g., those that measure mobility for single periods longer than 1 week or at multiple points over time) as these longer longitudinal measurement periods may better quantify variations in mobility patterns. Finally, future studies using GPS protocols should examine the characteristics of individuals' activity spaces and their associations with health behaviors and outcomes. These associations can be used to develop structural-level interventions[35] and also determine whether or not the efficacy of existing individual-level interventions is modified by broader contexts of daily life.[34,36]

While the study has numerous strengths, it also has some limitations. Given that survey methods were the primary measure of self-reported acceptability, participants' responses may have been affected by social desirability bias (e.g., a higher percentage of respondents may have reported these methods as acceptable or underreported any problems they have experienced). In addition, the spatial behavior measured in the single week protocol may have been affected by reactivity bias as participants knew their location was being tracked. However, this is unlikely given that all participants reported in the postprotocol survey that they did not change their behavior while wearing the GPS device. In addition, this is a small convenience sample that likely consisted of individuals who were motivated to be in the study and to complete the GPS protocol, thereby increasing the likelihood of success of these methods due to selection bias. The sample size ($n = 14$) is small for general population health research, but given that recent GPS studies have had fewer than 100 participants and that GPS studies are absent in transgender women, these findings represent a significant contribution to the literature. The study was conducted in the New York City metropolitan area and results may not be generalizable to populations of transgender women in other locations. It is also likely that the quality of these data was affected by the metropolitan environment, as large buildings may contribute to data errors with GPS devices due to multipath reflectance.[37] In addition, because individuals in New York City often travel through the subway system, the GPS devices may have been unable to obtain signals from GPS satellites, leading to additional loss of data. Although the signals may be lost for short periods of time, these data are still important in characterizing the full scope of environments and neighborhoods an individual is exposed to throughout their daily life.

Conclusion

This pilot study demonstrates the acceptability and feasibility of using GPS methods to measure mobility and environmental exposures among transgender women. GPS devices may be used in research among transgender women to understand neighborhood determinants of adverse health outcomes, including HIV and other STIs, substance use, violence and victimization, and mental health conditions. Future research with larger samples of transgender people diverse in terms of age, race, ethnicity, gender identity, and socioeconomic status is warranted and represents an exciting next step in this research area.

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Author Disclosure Statement

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Abbreviations Used

GPS = global positioning system
MSM = men who have sex with men
MTF = male-to-female
SD = standard deviation
STI = sexually transmitted infection
USB = universal serial bus

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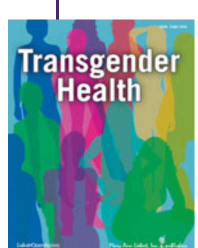

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