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Food Insufficiency and Medication Adherence Among People Living with HIV/AIDS in Urban and Peri-Urban Settings

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Abstract Food insufficiency is associated with medication non-adherence among people living with HIV/AIDS. The current study examines the relationship between hunger and medication adherence in a US urban and peri-urban sample of people living with HIV/AIDS. Men (N=133) and women (N=46) living with HIV/AIDS were recruited using snowball sampling and small media in Atlanta, Georgia. Participants completed computerized behavioral interviews that included measures of demographics, food insufficiency, social support, depression, and substance use, and provided blood specimens to determine HIV viral load. Participants also completed monthly unannounced pill counts to prospectively monitor medication adherence over 8 months. Results indicated that 45% of participants were less than 85% adherent to their medications and that food insufficiency was related to non-adherence; nearly half of non-adherent participants reported recent hunger. Geocoding of participant residences showed that 40% lived more than 5 miles from the city center. Multivariable logistic regression controlling for demographics and common factors associated with adherence showed that the interaction between distance from downtown and experiencing hunger significantly predicted non-adherence over and above all other factors. Medication adherence interventions should address access to food, particularly for people living outside of urban centers.

Keywords HIV/AIDS medications · Food security · Food insufficiency · Poverty and health

Introduction

HIV/AIDS is most concentrated in areas afflicted by poverty. Several factors associated with poverty contribute to the spread of HIV including substance abuse, co-occurring sexually transmitted infections, lack of adequate health care, unstable housing, and overlapping sexual networks (Leaver et al. 2007; Miller et al. 2010; Piot et al. 2007). Food insufficiency is a defining characteristic of poverty that is also a significant contributing factor to HIV/AIDS. In particular, lacking food is associated with bartering sex, power differences in sexual relationships, and sexual coercion (Miller et al. 2010; Vogenthaler et al. 2010; Weiser et al. 2007). In addition to contributing to risks for HIV transmission, hunger continues to plague people after contracting HIV infection.

In both developing and developed countries, food insufficiency is associated with adverse health outcomes among people living with HIV/AIDS (Anema et al. 2009). Malnutrition impairs metabolic functioning including absorption, storage, and utilization of nutrients which further compromises the immune system (Ivers et al. 2009). Food insufficiency in developed countries has the same adverse

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impacts observed in developing countries. For example, a study conducted in San Francisco showed that one in three marginally housed people living with HIV/AIDS were severely food insecure. Furthermore, those persons who were food insecure demonstrated lower T-cell (CD4) counts, poorer medication adherence, and incomplete suppression of HIV replication compared to individuals who had adequate food (Weiser et al. 2009a, c). In addition, food insufficiency is directly associated with mortality among people living HIV/AIDS. Research in British Columbia found that people living with HIV/AIDS who lacked food and were underweight were nearly twice as likely to die than their counterparts who were not food insufficient and were not underweight (Weiser et al. 2009b). These findings suggest that food insufficiency is significant in charting the course of HIV disease.

Food insufficiency also indirectly complicates HIV disease by interfering with medication adherence. Advances in antiretroviral therapy (ART) have simplified medication regimens, reduced dosing demands, and minimized toxicities. Current treatment regimens require at least 85% adherence to achieve long-term viral suppression (Parienti et al. 2008). Unfortunately, food insufficiency undermines HIV medication adherence. Among people living with HIV in urban areas of Peru, for example, food insufficiency predicts ART adherence over and above social support and adherence self-efficacy (Franke et al. 2010). We recently reported that food insufficiency among people living with HIV/AIDS in Atlanta Georgia is a more robust predictor of ART non-adherence than several other factors including years of education, employment status, income, housing, depression, social support, and substance use (Kalichman et al. 2010).

While food insufficiency is an established impediment to ART adherence among the urban poor, there are no studies of food insufficiency (hunger) in relation to HIV health outcomes in people living outside of urban centers in developed countries. People living with HIV/AIDS in peri-urban areas may lack access to AIDS-related services, some of which can offer sources of food. Proximity to urban resources may therefore moderate the adverse effects of food insufficiency by providing nutritional support (Cantrell et al. 2008; Ivers et al. 2010).

The current study examined the association between food insufficiency and ART adherence among individuals living in and around a major US city. We hypothesized that proximity to the city center would be associated with greater ART adherence observed over a prospective 8-month period. In addition, we hypothesized that the association between adherence and residence location would be moderated by hunger such that persons who live farther from basic resources and experience hunger will be less adherent than those who have not recently been hungry.

Methods

Participants and Setting

Men and women were informed about the study by placing flyers at AIDS social service providers and infectious disease clinics, and by word-of-mouth recruitment strategies. We also used a systematic approach to snowball sampling by giving each participant three study flyers to distribute to other people they know living with HIV/AIDS. The entry criteria were age 18 or older, proof of positive HIV status and currently taking HIV medications by showing a photo ID with matching ART prescription bottle.

The site of the research was Atlanta, Georgia, a city with over 23,000 reported cases of AIDS and an HIV/AIDS rate of 23 per 100,000 population, exceeding the average of 15 per 100,000 population in other major US cities (Centers for Disease Control and Prevention 2007). Of the 1,730 newly diagnosed HIV infections in Atlanta in 2007, 46% were individuals living in surrounding areas outside the city (Hall et al. 2010). The poverty rate in Atlanta is 21% compared to the state of Georgia's 13%, and 12% of Atlanta's residents have incomes below 50% of the poverty level. Joblessness in the state of Georgia consistently exceeds US national unemployment rates (Boston 2008). Like most US cities, Atlanta has a clearly discernable downtown area that is surrounded by peri-urban, suburban, and rural communities. Also like most cities, AIDS services are concentrated in Atlanta's city center.

Measures

Demographic Characteristics Participants were asked their gender, age, years of education, ethnicity, sexual orientation, monthly income and employment status. Participants also provided the street address of their current residence or where they receive mail.

Geocoding We used procedures adapted from spatial analysis in epidemiology to examine the geographical distribution of hunger and medication adherence (Elliott et al. 2002; Schleihauf et al. 2009). Participants' addresses were entered into the global positioning application of *Google Earth* for geo-coding and mapping. Coordinates were used to define participants' locations relative to Atlanta's city center and to measure their distance from basic services and resources, specifically city mass transportation stops (train or bus), nearest supermarket, nearest convenience food store, and the pharmacy from which they receive their medications. We defined city center as the main intersection that designates downtown Atlanta known as "Five Points." This location is historically the major business district that divides Atlanta into north/south and

east/west quadrants. The metropolitan rail system also intersects at this point and the State Capital is located within two blocks of this location. Distances were coded point-to-point in miles using straight lines between two locations (i.e., participant address and resource). We defined participants as residing in Atlanta's inner city if their current address was within a 5-mile radius of city center. The 5-mile radius generally defines Atlanta's downtown and peri-urban/suburban areas.

Finally, we identified human service agencies throughout the metropolitan area of Atlanta and its surrounding counties that provide housing, food, transportation, support groups, case management and other services to people living with HIV/AIDS. We located 47 AIDS service providers from directories of AIDS services in Atlanta. We contacted each agency to determine whether they were still operating when the study was completed, verifying 42 available agencies.

Housing and Transportation To assess stability of current housing, we asked participants whether they had worried about having a place to stay in the previous year. For transportation, participants indicated if they were unable to get where they needed to go and whether they were unable to get to a clinic or doctor due to lack of transportation in the previous year.

Food Insufficiency To measure food insufficiency, we used four items from the US Food Security Scale that have been validated in past research and used by the US Census Bureau (Cook and Frank 2008). We focused on the more severe forms of food insufficiency that are indicative of hunger (items are shown in the "Results" section). Participants reported whether they had experienced each hunger indicator over the previous year.

Health Characteristics We assessed HIV-related symptoms using a previously developed and validated measure of 14 common symptoms of HIV disease (Kalichman et al. 2000). We also asked whether viral load had changed since their previous test. Participants reported their most recent CD4 (T-Cell) counts. We asked participants at their final assessment to provide blood specimens to test for HIV RNA viral load. Blood samples were provided at the project offices using standard phlebotomy and couriered to the lab for processing. Whole blood specimens in EDTA tube (Becton Dickinson) were centrifuged at 500*g* for 10 min within 4 h of collection. The plasma was recovered and aliquoted into 1 ml samples and stored at −70°C. Plasma viral load was determined by Roche Amplicor HIV-1 Monitor with sensitivity for detecting down to 50 copies/ml.

Medication Adherence Participants consented to monthly unannounced telephone-based pill counts, constituting a prospective measure of adherence. Unannounced pill counts are reliable and valid in assessing medication adherence when conducted in participants' homes (Bangsberg et al. 2001) and on the telephone (Kalichman et al. 2007, 2008). Participants were provided with a cell phone that restricted service for project contacts and emergency use (e.g., 911). Following office-based training in the pill counting procedure, participants were called at unscheduled times by a phone assessor. Pill counts occurred over 21- to 35-day intervals and were conducted for each of the medications participants were taking. Pharmacy information from pill bottles was also collected to verify the number of pills dispensed between calls. Adherence was calculated as the ratio of pills counted relative to pills prescribed, taking into account the number of pills dispensed. Two consecutive pill counts were necessary for computing adherence. Adherence data reported here represents the percentage of pills taken as prescribed over eight consecutive months.

Barriers to Treatment and Adherence We used three items to index whether participants were experiencing medication-related barriers to ART adherence. Items included running out of medications prior to getting a refill, experiencing side effects, and the cost of medications. These items were responded to as either Yes or No pertaining to participants' current situation. We also assessed common barriers to care and medication adherence including depression using the 15 cognitive/affective non-somatic depression items from the Centers for Epidemiologic Studies Depression (CESD) scale, alpha=.90 (Kalichman et al. 2000; Radloff 1977). The Social Support Questionnaire was administered and included availability and validation of support responded to on 4-point scales, 1 = Definitely true, to 4 = Definitely false, alpha=.90 (Brock et al. 1996). Frequency of current alcohol use was assessed with the first item from the Alcohol Use Disorders Identification Test [AUDIT] (Conigrave et al. 1995). Participants also indicated whether they used marijuana, cocaine, methamphetamine and other drugs in the previous month. Because frequencies of drug use were low, we created an index for drug use by summing the number of different non-alcohol drugs that were used in the previous month.

Procedures

Individuals contacted our research offices to schedule an assessment appointment. Self-report measures were collected using an instructor-guided self-administration procedure in groups of 4 to 8 persons. Participants were instructed how to complete the measures, page by page using a projected facsimile of the instruments. This procedure was selected to assist participants with poor comprehension skills by clarifying instructions prior to commencing the assessment.

Participants who experienced difficulty reading the measures were interviewed (less than 10%). Data were collected between January 2008 and June 2009 and all procedures were approved by the University of Connecticut Institutional Review Board.

Data Analyses

Initial descriptive analyses compared non-adherent and adherent participants living in the inner-city and peri-urban areas separately. We defined non-adherent as taking less than 85% of medications averaged across the 8 months of unannounced pill counts (1 = adherent, 0 = non-adherent). While the demand for close adherence varies for different combinations of medications (Bangsberg et al. 2007; Parienti et al. 2008), as well as the viralogic status of patients (Rosenblum et al. 2009), a minimum of 85% adherence to ART remains necessary for optimal clinical outcomes (Parienti et al. 2008). In addition, participants were defined as living in the inner city if their reported residence was within 5 miles of Atlanta's center city. To compare adherent and non-adherent participants within geographical areas, we used independent *t*-tests for continuous measures and contingency table chi-square (X^2) tests for categorical variables. The hypothesis predicting an association between living inside and outside of downtown and ART adherence was tested in a 2 (inner-city/peri-urban) X 2 (non-adherent/adherent) contingency table. To test the hypothesis that hunger moderates the association between distance from downtown and adherence, we conducted a multivariable logistic regression entering the interaction term between geographical location and hunger status to predict adherence measured over the 8 months of observation. For all analyses, we defined statistical significance as $p<.05$.

Results

Participants were 133 men and 46 women receiving ART. More than 90% of participants were African American and over 80% were unemployed. Table 1 shows the demographic, health and psychosocial characteristics of participants living in the inner city and areas outside the city who were non-adherent and adherent to their medications. Among participants living inside and outside of the city, we found that adherence was associated with viral suppression and inversely related to running out of medications; participants who were at least 85% adherent were more likely to have undetectable viral loads and were less likely to have run out of their medications. In addition, non-adherence among persons living outside the inner city was associated with alcohol use.

Geographical Distribution of Hunger, Adherence and Basic Resources

Figure 1 shows the map of participant residences in relation to their hunger and ART adherence. One hundred and six (59%) participants resided within 5 miles of center city. Among participants who experienced hunger, more than half were non-adherent to their medications ($N=50$, 56%). However, medication adherence and geographical location were not associated; 45 (43%) participants living within 5 miles of center city demonstrated less than 85% adherence compared to 37 (52%) of persons living outside the 5-mile radius, $X^2=1.43$, $p>0.10$.

Table 2 shows the distances between participant residences and basic local resources. For participants located downtown, we found no associations between adherence and distance to basic local resources. Nearly all participants living downtown were within 1 mile of food shops and mass transit stops. In addition, individuals living downtown were on average 3.1 miles from the pharmacy that provides their medications. Individuals living outside of downtown were further from basic food and mass transit resources and were considerably farther from their primary pharmacy; on average, participants outside the city lived more than 9 miles from their pharmacy. There were again no associations between adherence and distance to basic local resources outside of downtown.

Finally, among the 42 AIDS service providers in the Metropolitan Atlanta area, the mean distance that agencies were from the city center was 5.0 miles (SD=7.1). Thus, persons who live further from downtown are also further from AIDS-related services.

Hunger and ART Adherence

Overall, half of participants reported experiencing hunger in the previous year. Table 3 shows the associations between adherence and hunger indicators for individuals living inside and outside downtown. Among participants living downtown, one in three reported not being able to afford food and more than one in five reported that they or a family member went without food for at least a day. There were no significant associations between hunger and adherence among participants living in the inner city. In contrast, adherence was associated with every indicator of hunger among persons living outside the city. Hunger was substantially more prevalent among non-adherent individuals living outside the city, with 68% reporting at least one indicator of hunger.

To test our hypothesis that the association between geographical location and adherence is moderated by

Table 1 Demographic, health, and psychosocial characteristics of non-adherent and adherent people living with HIV/AIDS inside and outside the inner city

Characteristic	Inner City					Outside of City				
	Non-Adherent (*N*=45)		Adherent (*N*=61)			Non-Adherent (*N*=37)		Adherent (*N*=36)		
	N	%	N	%	X^2	N	%	N	%	X^2
Men	35	77	46	75		27	73	25	69	
Women	10	22	15	25	0.7	10	27	11	30	0.7
African American	41	91	52	87	1.5	34	92	34	94	2.9
Gay	18	40	25	42		17	47	13	36	
Bisexual	9	20	8	13		3	8	5	13	
Heterosexual	18	40	27	45	0.8	16	44	18	50	1.1
Unemployed	39	87	56	92	1.7	31	84	4	89	2.6
Income under $1000/month	35	78	48	81	0.2	22	61	25	71	0.8
Worried about having a place to live in the past year	28	62	28	36	2.8	17	45	14	39	0.8
Has a land telephone	38	82	49	80	0.1	35	90	36	100	3.9+
Lacks transportation	24	53	28	45	0.8	21	57	12	34	4.6+
Lacks transportation to health care	19	43	22	35	0.6	12	32	8	22	1.0
Runs out of medications	19	41	8	13	11.3**	12	32	2	5	12.2**
CD4 cell count <200	9	30	6	11	4.5*	8	26	4	12	1.6
Undetectable viral load[a]	18	40	41	76	12.4**	23	66	30	88	4.9*
	M	SD	M	SD	t	M	SD	M	SD	t
Age	45	6.2	47.3	5.7	1.9+	44.3	8.2	45.5	8.0	0.6
Education	12.9	2.1	12.8	2.1	0.1	12.5	1.8	12.7	1.8	0.4
Annual income	$1207	2669	$805	1315	1.0	$1919	3392	$1552	2862	0.5
Years since testing HIV positive	13.1	7.2	14.1	6.2	0.7	13.1	6.3	13.7	6.9	0.4
HIV symptoms	4.4	3.7	3.7	3.9	0.9	4.8	4.0	3.3	2.9	1.8+
CESD-Depression	13.6	9.2	14.1	6.2	1.5	11.6	7.7	9.3	7.0	1.3
Social Support	3.0	0.7	3.1	0.8	0.7	2.9	0.7	3.2	0.8	1.9+
Alcohol use	1.4	2.1	1.0	1.9	0.9	1.6	2.6	0.4	0.5	2.7**
Drug use	0.5	0.7	0.3	0.5	1.6	0.4	0.7	0.3	0.5	0.9

+ $p<.1$, * $p<.05$, ** $p<.01$

hunger, we tested a logistic regression model predicting adherence over 8 months of observation from number of hunger indicators endorsed and controlling for multiple confounds. As shown in Table 4, only two predictors of adherence were statistically significant: alcohol use and the residence location by hunger interaction. Figure 2 illustrates the interaction between residence location and hunger in relation to adherence over time. Adherence was poorest for persons who reported hunger regardless of whether they lived in the inner-city or peri-urban areas. However, participants living outside the city who did not experience hunger demonstrated consistently better adherence than persons who experienced hunger.

Discussion

The current findings replicate past research to show that food insufficiency is associated with non-adherence among people living with HIV/AIDS; more than half of individuals who reported experiencing recent hunger were non-adherent to their medications. On average, participants who experienced recent hunger were well below the minimum level of medication adherence necessary to maintain viral suppression and avoid developing drug resistant genetic variants of HIV (Bangsberg et al. 2007). This study is among the first to examine ART adherence and food insufficiency in both urban and peri-urban areas of a US city. Overall, hunger

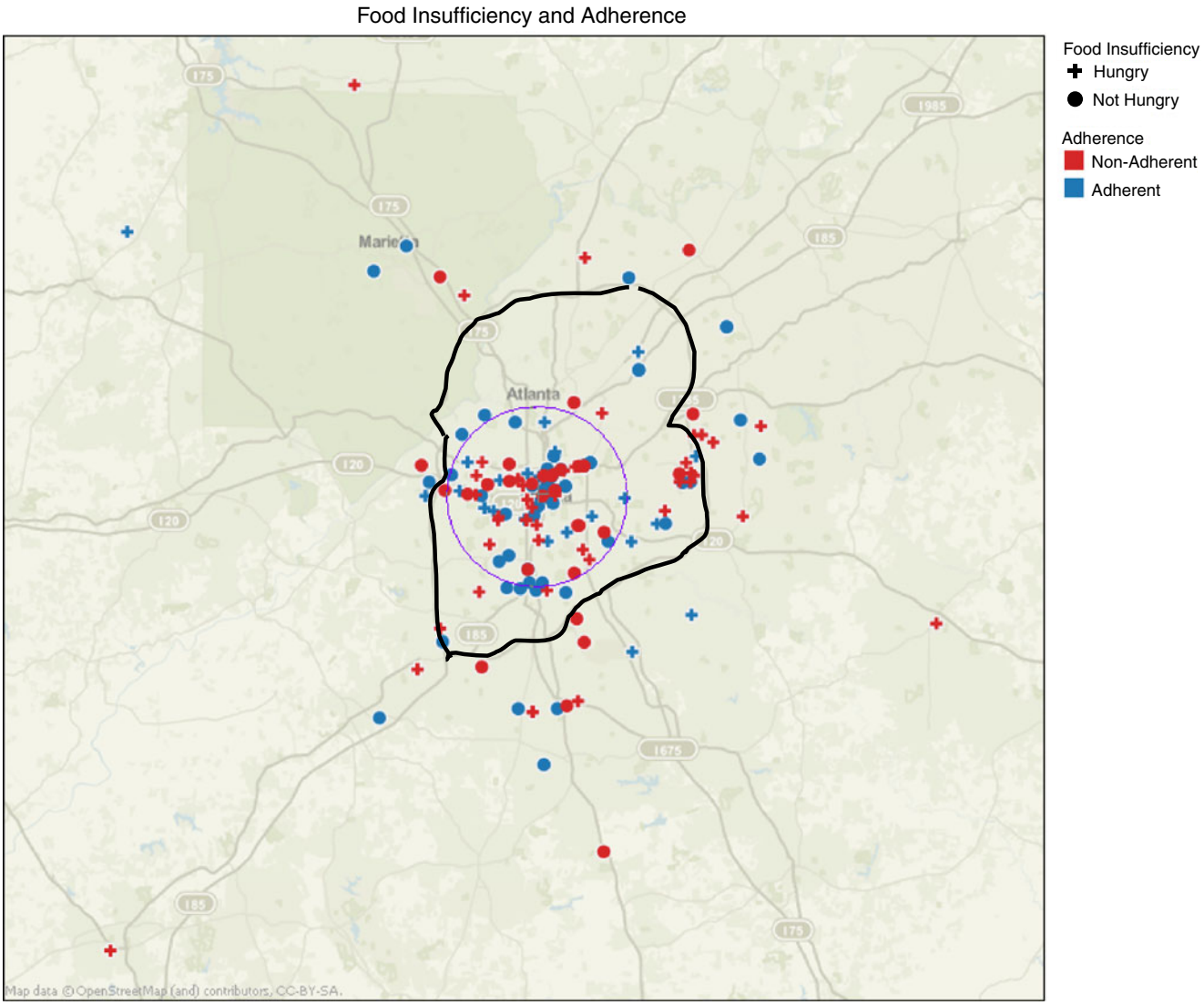

Fig. 1 Geographical locations of people living with HIV/AIDS in the Atlanta metropolitan area; + represent hunger experienced and dots represent hunger not experienced, red represents non-adherent and blue represents adherent participants. Outer black boundary represents the Interstate 285 perimeter of Atlanta; Suburban areas are located outside this perimeter. The inner circle represents a 5-mile radius around the center of downtown

Table 2 Distance from current addresses to basic local resources in metropolitan Atlanta for non-adherent and adherent people living with HIV/AIDS inside and outside the inner city

Resource	Inner City					Outside of City				
	Non-Adherent (*N*=45)		Adherent (*N*=61)			Non-Adherent (*N*=37)		Adherent (*N*=36)		
	N	%	N	%	t	N	%	N	%	t
Supermarket	0.9	0.6	0.9	0.6	0.3	1.4	0.7	1.3	0.7	0.1
Convenience store	0.2	0.1	0.1	0.1	0.3	0.2	0.1	0.3	0.2	1.4
Metropolitan bus stop	0.1	0.1	0.1	0.1	0.8	1.9	3.6	1.8	4.1	0.2
Participant's pharmacy	3.2	2.6	3.1	2.5	0.3	10.1	7.3	8.0	4.5	1.4
Center city - downtown Atlanta	2.2	1.2	1.9	1.4	1.1	11.2	6.2	9.8	4.6	0.9

Table 3 Hunger experiences among non-adherent and adherent people living with HIV/AIDS inside and outside the inner city

Hunger indicators	Inner City					Outside of City				
	Non-Adherent (*N*=45)		Adherent (*N*=61)			Non-Adherent (*N*=37)		Adherent (*N*=36)		
	N	%	N	%	X^2	N	%	N	%	X^2
Did you or other adults in the household cut the size of your meals or skip meals because there wasn't enough money for food?	19	42	21	34	0.6	19	51	8	22	6.6**
Did you eat less than you felt you needed to because there wasn't enough money for food?	21	47	27	44	0.1	22	60	8	22	10.4**
Were you hungry, but didn't eat, because you couldn't afford enough food?	17	38	20	33	0.2	15	40	4	11	8.2**
Did you or other adults in your household not eat for a whole day because there wasn't enough money for food?	9	20	15	24	0.3	9	24	3	8	3.3+
Any hunger indicators	25	56	29	47	0.6	25	68	9	25	13.2**

+ $p<.1$, ** $p<.01$

indicators were evenly distributed among adherent and non-adherent persons living in the inner city. However, the associations between hunger and adherence were substantially different for persons living outside the city; 68% of non-adherent individuals outside the city reported at least one indicator of recent hunger compared to 25% of adherent participants. The multivariate model confirmed our study hypothesis to show that distance from downtown significantly interacted with hunger in predicting adherence; individuals living outside downtown who experienced hunger had the poorest adherence, whereas those living outside the city who had not been hungry were the most adherent. Thus, while hunger is prevalent among inner-city residents, there were distinct groups differentiated by hunger and non-adherence among persons living outside the city.

Table 4 Multivariate logistic regression model predicting HIV treatment adherence over 8 months

Characteristic	Odds ratio	95%CI
Gender	0.96	0.43–2.14
Education	0.99	0.83–1.17
Employment	1.46	0.93–2.29
Years since testing HIV positive	1.01	0.95–1.06
HIV symptoms	0.98	0.89–1.08
Depression	0.97	0.92–1.02
Social support	1.07	0.67–1.71
Hunger	1.01	0.86–1.18
Alcohol use	0.81*	0.68–0.97
Drug use	0.63	0.35–1.15
Distance to nearest bus stop	1.15	0.93–1.41
Distance to city center	0.99	0.87–1.13
Hunger X Distance to inner-city	0.97*	0.94–0.99

*$p<.05$

Participants living outside the city were substantially further from supermarkets, mass transportation, and their pharmacy, compared to individuals living inside the city. However, distances to these basic resources were not associated with adherence in either urban or peri-urban settings. The current study also found that alcohol use was greatest among non-adherent participants living outside the inner city. Also among persons living outside the city, there were trends toward non-adherent persons reporting less social support, lacking transportation, and not having a telephone. Taken together, these findings suggest that some persons living outside the city may experience social isolation that can further contribute to poor adherence.

The findings from this study should be interpreted in light of their methodological limitations. With the exception of medication adherence, viral load, CD4 count, and geocoding, our study relied on self-reported health and behavior. We also

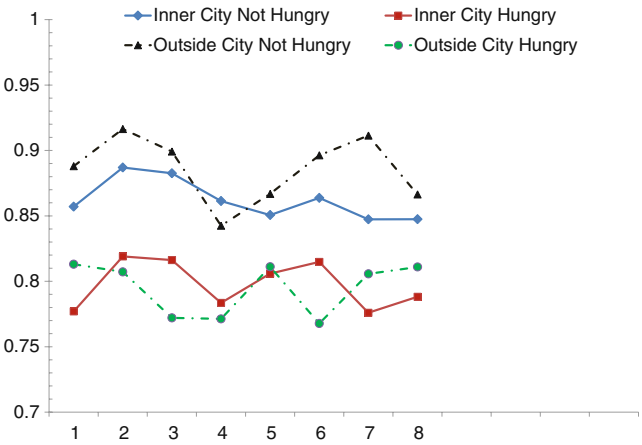

Fig. 2 Mean adherence observed over 8 months among people who had and had not recently experienced hunger in downtown and outside areas

used a 1-year time frame to define food insufficiency and are unable to link experiencing hunger to specific missed medications. We do not know the duration of hunger experiences or how close in time hunger occurred in relation to non-adherence. In addition, although we assessed multiple socioeconomic factors associated with food insufficiency, there are important factors such as nutritional status, body mass, means of finding food, and nutritional quality of food accessed that were not assessed. In addition, we defined the inner city as a 5-mile radius around the center of downtown, which is relatively proximal to downtown. To our knowledge this is the first study of its kind to use Google Earth for geocoding. Further studies are therefore needed to validate this procedure. Finally, our results are based on a convenience sample of people living with HIV/AIDS in one southern US city. Our sample may also have underestimated the role of geographical location in ART adherence because our participants were able to come to the city to participate in the study. Caution is therefore warranted before generalizing these findings to other populations of people living with HIV/AIDS. With these limitations in mind, the current research has implications for understanding the role of food insufficiency in HIV treatment and disease management.

There are few adherence interventions designed to reach people living far from their pharmacy, medical providers, and AIDS services. Lack of transportation and social isolation pose significant challenges to assisting people living with HIV/AIDS in urban and peri-urban areas of even the most resourced cities (T. G. Heckman et al. 1998). Home delivery of prescriptions, including postal delivery, may be of particular value to persons living in remote places. Telephone delivered adherence interventions have recently been tested for providing mental health services to people with HIV/AIDS living in rural areas (T. G. Heckman and Carlson 2007; T. G. Heckman et al. 2002; Stein et al. 2007), and these models are now being explored for adherence counseling (B. D. Heckman et al. 2004). Our results showed that 10% of persons living outside the city who were non-adherent to their medications did not have a telephone. The cost of providing cell phones with limited and restricted service can be offset by reducing the medical and societal expenses that come with ART non-adherence including diminished health, hospitalizations, and drug resistant virus (Bangsberg and Deeks 2010). Emerging technologies for improving medication adherence are also bringing new opportunities for people in rural areas, including real-time medication monitoring and electronic reminder systems (Haberer et al. 2010). Additional efforts to remove geographical barriers to maintaining long-term ART adherence are therefore needed to ameliorate health disparities between persons living inside and outside urban centers.

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