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Neighborhood-level characteristics as effect modifiers on the efficacy of the MyPEEPS mobile intervention in same-sex attracted adolescent men

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ABSTRACT

To estimate the effect of neighborhood-level modification on the efficacy of the MyPEEPS Mobile intervention on the reduction of condomless anal sex acts among same-sex attracted adolescent men.

A series of generalized linear mixed model was used to examine if the effect of the MyPEEPS Mobile intervention on condomless anal sex acts was moderated by neighborhood-level factors using data from the 2019 American Community Survey US Census Bureau. "The magnitudes of intervention were significantly smaller at both 6- and 9-month follow-up among adolescents living in neighborhood with high proportions of Hispanic or Latino residents (IRR6M = 1.02, 95 % CI: 1.01, 1.02; IRR9M = 1.03, 95 % CI: 1.01, 1.05) and high proportions of families with income below the poverty level (IRR6M = 1.07, 95 % CI: 1.01, 1.12; IRR9M = 1.05, 95 % CI: 1.01, 1.10), which indicated that living in communities with a higher concentration of residents living under poverty or of Hispanic/and Latino ethnicity significantly modified the effective of program intervention on condomless sex among adolescent MSM. Understanding how neighborhood characteristics modify the effect of HIV prevention interventions may be useful in better targeting delivery and tailoring content of interventions based on neighborhood level characteristics such as the ones identified in this study.

1. Introduction

In the United States (US), HIV transmission rates disproportionally affect racial and ethnic minority gay, bisexual and other sexual minority men accounting for almost 70 % of new HIV infections each year (Giroir, 2020; Center for Disease Control and Prevention). Moreover, young men who have sex with men (MSM) are particularly vulnerable to HIV infection, with 27 % and 22 % of new HIV cases identified as Black and Hispanic/Latino men who have sex with men (MSM) 13–24 years old, respectively (Prevention CfDCa, 2018). To curb the current HIV epidemic it is critical to consider psychosocial (e.g., bullying, victimization, isolation), behavioral (e.g., number of sexual partners, condom use and testing for HIV and sexually transmitted infections) and contextual (e.g., family, peer and partner relationships) risk factors of

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HIV have been identified (Stephenson, 2006). Additionally, recent identification of social-structural factors influencing HIV susceptibility, such as neighborhood-level characteristics (alcohol outlets, neighborhood disadvantage, poverty and limited health resources) (Brawner et al., 2022; Duncan et al., 2021; Scribner et al., 2010), are of growing interest for the development of more comprehensive understanding of the risk profiles associated with HIV acquisition in young MSM (Duncan et al., 2018).

The socioecological framework posits that multilevel structures exist in which individual, interpersonal, neighborhood and social factors interact to influence health outcomes, such as HIV (Baral et al.,2013; Duncan et al., 2020; Frye et al., 2017; Halkitis et al., 2015; Obidoa et al., 2023). For this reason, understanding the complex and cross-level interaction of the multiple structures where individuals operate may be essential for the development of effective preventive strategies. For example, evidence suggests that alcohol outlets (neighborhood-level factor) and geographical clusters of sexual network members (interpersonal factor) contributors to the risk of HIV among MSM, such that higher densities of alcohol outlets are associated with alcohol consumption and are associated with high-risk sexual behavior within sexual networks (Scribner et al., 2010; Rosenberg et al., 2015). Efforts in identifying modifiable factors using a multilevel approach within the socioecological framework may help improve HIV prevention intervention by simultaneously addressing multiple causative factors. Given the increasing incidence of HIV among young MSM (Perez et al., 2022), research is needed to identify multilevel risk factors to develop effective HIV prevention invention in this population. There has been limited research on the effects of the contextual level factors of HIV with some studies examining structural factors and Past studies have examined some of the structural and others considering contextual factors, such as resilience and stigma (Banks et al., 2020; Li et al., 2022; Mehrotra et al., 2019).

By operationalizing the socioecological framework to better understand the findings from the MYPEEPS Mobile Trial, we can examine whether the efficacy of the HIV prevention intervention may be modified by upstream factors in which individuals operate, such as neighborhood factors. Therefore, the objective of our current study is to evaluate neighborhood-level modification and estimate its effect of the MyPEEPS Mobile intervention on the reduction of condomless anal sex acts among same-sex attracted adolescent men. Results of this study can be used to improve our understanding for whom the intervention did and did not demonstrate effects to achieve population level impact through the reduction of high-risk sexual behavior and inform future prevention efforts. Further, integration of American Community Survey US Census Bureau aggregate data with the individual-level data from RCT participants based on the geographical coordinates to create multilevel data, is an innovative approach for improving program evaluation with the potential for policy shift.

2. Methods

2.1. Study design and participants

This study is a secondary analysis of data collected as part of the MyPEEPS Mobile randomized controlled trial (RCT) conducted from June 2018–April 2020. The study was conducted to test the efficacy of the MyPEEPS Mobile intervention on HIV risk behaviors, specifically condomless anal sex acts, among same-sex attracted *cis*-gender adolescent men (aged 13–18 years). Randomization occurred at baseline on a 1:1 ratio (MyPEEPS Mobile (n = 382) versus a delayed intervention (n = 381)); the intervention group received access to the MyPEEPS Mobile app at the baseline visit. The primary analysis was on intervention effects at 3-, 6-, and 9-months post-baseline) The waitlist control arm crossed over to intervention at 9 months. Written or electronic informed assent (under 18 years of age) and consent (18 years of age) was obtained for participants with parental consent waived for minors. Columbia University served as the single institutional review board for all study activities (Kuhns et al., 2020), and the RCT was registered in ClinicalTrials.gov as NCT03167606.More details on the RCT are published elsewhere (Schnall et al., 2022). Study participants were recruited from the US States and its territories. Ultimately participants were enrolled from 49 States in the US and Puerto Rico.

2.2. Outcome

The primary outcome of interest was change in the number of recent condomless anal sex acts (within the past 3 months) between intervention and delayed intervention groups at baseline versus 3-, 6- and 9-month post-baseline. The number of condomless anal sex act, as either the receptive and/or insertive partner, was self-reported by the study participant during each study visit using a modified version of the AIDS Risk Behavior Assessment (Donenberg et al., 2001) through Qualtrics online survey software. Participants were asked to estimate the number of recent anal sex partners (i.e., receptive and insertive) and the number of condomless sex acts with partners, which provided the basis for the primary outcome (a count variable).

2.3. Neighborhood-level characteristics

Neighborhood-level characteristics were obtained using data from the 2019 American Community Survey US Census Bureau. Using geographical coordinates (latitude and longitude) of the participants' residence obtained at their baseline study visits, neighborhood-level characteristics were matched with geographic identifiers (GEOIDs) provided by the ACS. The geographical coordinates (latitude and longitude) were automatically collected through Qualtrics survey software. GEOIDs are numeric codes used to uniquely identify all administrative/legal and statistical geographic area tabulated by the US Census Bureau (Income, 2008). The unit of analysis for the geographical variables was census tract. The following neighborhood-level characteristics were included as potential effect modifiers: Total Population, Percent Population Non-Hispanic, Percent Population White, Percent Population Black, Percent Population Asian, Percent Population Hispanic, Percent Population with less than High School Education, Percent Population with High School Education, Percent Population with College Education, Percent Population Unemployed, Percent Population with Median Household Income, Gini Index (measure of income inequality), Percent Families with Income Below Poverty, Percent Population with No Health Insurance Coverage, Percent Population with Female Household, and Percent Population with Foreign Born (Brawner et al., 2022). All variables were included as percentage * 100, except Median Household Income, Total Population, and Gini coefficient. Median Household Income used the raw value, Total population was converted to thousands (i.e., divided by 1000), and the Gini coefficient, which was the value multiplied by 100 to be on a similar scale to the most other variables.

2.4. Individual-level characteristics

Participants completed standardized quantitative assessments of demographics (age, race/ethnicity) and outcome data at baseline, 3-, 6- and 9-month follow up visits using Qualtrics online survey software. The following covariates were assessed: Age, race, ethnicity and enrollment type (i.e., in-person or online). Participant's age was coded as ($<$16 and $\geq$ 16 years). The remaining variables were coded as the following: Race (American Indian/Alaskan Native, Asian American, Black/African American, Native Hawaiian/Asian Pacific Islander, White/Caucasian, Multiracial, or unknown/not reported), ethnicity (Hispanic/Latino/Latinx or not Hispanic/Latino/Latinx) and enrollment type (online/in person enrollment). These covariates were included in analysis of the MyPEEPs trial analysis (Schnall et al., 2022).

2.5. Statistical analysis

We used a series of generalized linear mixed model (GLMMs) with a negative binomial distribution for count variables (i.e., condomless anal sex acts) to examine if the impact of the intervention was moderated by neighborhood factors (N = 687). To examine the difference in the rate of change for the outcome variables (McCulloch and Searle, 2004), we used mixed-effects models with a participant-level random intercept to allow the baseline outcome measure (e.g., condomless sex acts) to vary across participants and account for within-participant correlation. The primary intervention efficacy of MyPEEPS Mobile in reducing condomless anal sex acts was estimated using the interaction of arm (i.e., Control vs. Intervention) and time (i.e., Baseline, 3-months, 6-months, or 9-months). Therefore, the interaction term between arm and each time point indicates a significantly different change in the experiment arm between baseline and the time point. The current analysis extends this analysis by adding in a 3-way interaction with each neighborhood-level characteristic (i.e., Arm * Time * Neighborhood Characteristic). Therefore, these models estimated if the difference in rate of change from baseline to each timepoint across arms differed by neighborhood-level characteristics, while controlling for age, race, ethnicity, study site and enrollment type. For a subset of neighborhood characteristics that showed consistent moderation of the intervention effect, we also estimated the simple slopes (i.e., marginal means of linear trends) for the interaction of Arm * Time at varying levels of the neighborhood characteristic. This estimate provides greater insight into how the difference in change across arms varies across levels of the neighborhood characteristics. In addition, we estimated the simple slope for change from baseline to 6 and 9 months for the control and intervention group at varying levels of the neighborhood characteristic (i.e., the simple slope for Time once specifying both arm and the designated level of the neighborhood characteristic). For all simple slopes, we selected values of the moderator using the mean, 1 Standard Deviation (SD) above, and 1 SD below the of the neighborhood characteristic to estimate these effects and help illustrate how the nature of the underlying continuous moderator impacts the difference between control/intervention arms and corresponding estimated change for each arm. Missing data for the primary outcome at each time point ranged from 16.7 % (3-months) to 19.2 % (9-months). Data analysis used an intention-to-treat approach, and all analyses were conducted in R.

3. Results

Table 1 provides the descriptive statistics for participants and neighborhood characteristics. In the analytic sample of 687 study participants, over 70 % were 16 years of age or older; 90 % had some high school education; 251 (37 %) were White, 136 (20 %) were Black, 38 (6 %) were American Indian/Alaskan Native, 67 (10 %) were Asian; and 288 (42 %) participants identified their ethnicity as Latino (any race). For neighborhood characteristics, the mean population size was 5840.6 (SD = 4067.76) with a mean percent of White population of 48.8 (SD = 29.9) and Non-Hispanic population of 76.1 (SD = 25.7).

At 3-month follow-up, we did not find any neighborhood-level characteristics that significantly moderated the effects of the MyPEEPS intervention on condomless anal sex acts among same-sex attracted adolescent MSM. However, the effect of the intervention was significantly moderated at both 6- and 9-month follow-up by *percent Hispanic or Latino residents* (Incidence Rate Ratio $(IRR)_{6M} = 1.02$, 95 % CI: 1.01, 1.02; $IRR_{9M} = 1.03$, 95 % CI: 1.01, 1.05) and *percent* of *families with income below the poverty level* ($IRR_{6M} = 1.07$, 95 % CI: 1.01, 1.12; $IRR_{9M} = 1.05$, 95 % CI: 1.01, 1.10), which indicated a smaller intervention effect in regions of higher poverty and higher percentage of Hispanic and Latino residents (Table 2). At 9-month follow-up, two additional neighborhood-level characteristics were found to significantly moderate the effects of the Intervention on condomless anal sex, *percent of residents with a High School education or less* ($IRR_{9M} = 1.06$, 95 % CI: 1.01, 1.07) and *percent foreign born residents* ($IRR_{9M} = 1.04$, 95 % CI: 1.01, 1.07) (Table 2).

Table 1
MyPEEPS individual-level and neighborhood characteristics at baseline.

Individual-level Characteristics	N (%)
Total	687 (100)
Arm	
Intervention	340 (49.5)
Control	347 (50.5)
Missing	0
Age	
Less than 16 years old	198 (28.8)
16 years or older	489 (71.2)
Missing	0
Race	
American Indian or Alaskan Native	38 (5.5)
Asian or Asian American	67 (9.8)
Black or African American	136 (19.8)
Native Hawaiian or Pacific Islander	10 (1.5)
White or Caucasian	251 (36.5)
Multiracial	91 (13.3)
Unknown	94 (13.7)
Missing	0
Hispanic ethnicity	
No	399 (58.1)
Yes	288 (41.9)
Missing	0
Condomless Anal Sex Acts*	1.5 (5.5)
	M (SD)
Neighborhood Characteristics	
Total Population**	5840.6 (4067.76)
Percentage of population Non-Hispanic	76.1 (25.7)
Percentage of population White	48.8 (29.9)
Percentage of population Black	16.0 (21.4)
Percentage of population Asian	7.4 (11.7)
Percentage of population Hispanic	23.9 (25.7)
Percentage of population with less than High School education	14.7 (12.1)
Percentage of population with High School	25.3 (10.5)
Percentage of population with College education	60.0 (19.0)
Percentage of population unemployed	6.1 (4.2)
Median Household Income**	69194.4 (35043.3)
GINI**	42.7 (6.5)
Percentage of population with Income Below Poverty	11.8 (10.9)
Percentage of population with No Health Insurance Coverage	9.4 (7.0)
Percentage of population with Female Household	14.6 (8.6)
Percentage of population with Foreign Born	18.5 (14.6)

Note. *Condomless anal sex acts are mean and standard deviation. **All neighborhood characteristics are percent of the population except total population, median household income, and GINI.

Looking at simple slopes for two of the neighborhood characteristics with the most consistent moderation effect (i.e., Poverty and Hispanic Population), the intervention group decreased greater than the control group at six months for neighborhoods 1 SD below the mean for Poverty (IRR = 0.29, 95 % CI: 0.12, 0.67) at 6 months, but not when poverty was mean or 1 SD above the mean (Table 3). This moderation leads to a significant decline in number of condomless sex acts at 6 months both 1 SD below the mean (IRR = 0.42, 95 % CI: 0.23, 0.77) and mean levels (IRR = 0.60, 95 % CI: 0.39, 0.91) of poverty but no significant decrease (IRR = 0.85, 95 % CI: 0.52, 1.39) in areas with 1 SD above the mean of poverty. In contrast, the control group saw no significant declines in condomless anal sex acts at any level of poverty. For *percent Hispanic or Latino residents,* the intervention decreased greater than the control group at 6 months for 1 SD below the mean (IRR = 0.35, 95 % CI: 0.16, 0.81), but not at mean or 1 SD above the mean for Hispanic or Latino residents (Table 4). This moderation leads to a significant decline in the number of condomless anal sex acts from baseline to 6 months among the intervention group at the mean level of Hispanic population (IRR = 0.64, 95 % CI: 0.42, 0.98) but no significant effect of the intervention at 1 SD above or below the mean levels of Hispanic population. In addition, despite the significant interaction term, there is no significant decline in condomless anal sex acts at nine months for the control or intervention

Table 2
Moderation analysis results of generalized linear mixed models of visit by study arm by designated neighborhood factor.

	Condomless Anal Sex Act	
	IRR	p-value
3 Month Follow-up Visit * Study Arm * Designated Characteristics		
Total Population	0.94	0.4668
Population Non-Hispanic	0.99	0.4561
Population White	0.99	0.8933
Population Black	0.99	0.8354
Population Asian	0.98	0.4551
Population Hispanic	1.01	0.4561
Population with less than High School education	1.01	0.6737
Population with High School	1.05	0.1109
Population with College education	0.98	0.2306
Population unemployed	1.01	0.8720
Population with Median Household Income	1.00	0.9294
GINI	1.02	0.5844
Families with Income Below Poverty	1.02	0.4439
Population with No Health Insurance Coverage	1.02	0.6810
Population with Female Household	1.01	0.8354
Population with Foreign Born	1.01	0.5220
6 Month Follow-up Visit * Study Arm Study Arm * Designated Characteristics		
Total Population	0.83	0.0572
Population Non-Hispanic	0.98	0.0474*
Population White	0.98	0.1247
Population Black	1.01	0.4064
Population Asian	0.96	0.1649
Population Hispanic	1.02	0.0474*
Population with less than High School education	1.04	0.1169
Population with High School	1.05	0.0950
Population with College education	0.97	0.0504
Population unemployed	1.08	0.2559
Population with Median Household Income	1.00	0.1977
GINI	1.00	0.9629
Families with Income Below Poverty	1.07	0.0147*
Population with No Health Insurance Coverage	1.06	0.1728
Population with Female Household	1.07	0.4019
Population with Foreign Born	1.03	0.1367
9 Month Follow-up Visit * Study Arm Study Arm * Designated Characteristics		
Total Population	0.97	0.7430
Population Non-Hispanic	0.97	0.0085*
Population White	0.99	0.2269
Population Black	0.98	0.1534
Population Asian	0.99	0.8526
Population Hispanic	1.03	0.0085*
Population with less than High School education	1.06	0.0185*
Population with High School	1.06	0.0392*
Population with College education	0.96	0.0053*
Population unemployed	1.08	0.1652
Population with Median Household Income	0.99	0.0621
GINI	1.06	0.1732
Families with Income Below Poverty	1.05	0.0317*
Population with No Health Insurance Coverage	1.05	0.2032
Population with Female Household	1.03	0.3487
Population with Foreign Born	1.04	0.0226*

Note. Each incidence rate ratio (IRR) coefficient represents the three-way interaction between intervention arm, timepoint, and the designated contextual variable. All models are also adjusted age, race, ethnicity, and enrollment type (i.e., online or in-person).
*Statistically significant at p-value < 0.05.

Table 3
Simple slopes analysis by intervention arm across levels of poverty.

Level of moderator	Study Arm	Condomless Anal Sex Acts	
		6 Months IRR (95 % CI)	9 Months IRR (95 % CI)
1 SD below mean poverty	Intervention v. Control difference	0.29 (0.12, 0.67)*	0.48 (0.20, 1.08)
	Intervention − change	0.42 (0.23, 0.77)*1.46	0.64 (0.35, 1.15)1.33
	Control − change	(0.80, 2.65)	(0.76, 2.34)
Mean poverty	Intervention v. Control difference	0.57 (0.31, 3.19)	0.83 (0.46, 1.50)
	Intervention − change	0.60 (0.39, 0.91)*1.04	0.94 (0.62, 1.42)1.12
	Control − change	(0.68, 1.59)	(0.74, 1.70)
1 SD above mean poverty	Intervention v. Control difference	1.14 (0.52, 2.54)	1.46 (0.70, 3.04)
	Intervention − change	0.85 (0.52, 1.39)0.74	1.38 (0.84, 2.27)0.95
	Control − change	(0.40, 1.37)	(0.55, 1.63)

Note. Control v. intervention represents the difference in change (from baseline) between the control and intervention conditions (i.e., interaction between Intervention and Time) at the given level of the moderator. Intervention and control "change" provide the estimated change (form baseline) in each arm at each time based on the value of the moderating variable. Mean poverty indicates the average percentage of population across all time points (i.e., 11.8 %) while 1 SD below (1.0 %) and above (22.6 %) the mean represents their respective variation from that mean. All models are also adjusted age, race, ethnicity, and enrollment type (i.e., online or in-person). *Statistically significant at p-value $<$ 0.05.

Table 4
Simple slopes analysis by intervention arm across levels of Hispanic population.

Level of moderator	Study Arm	Condomless Anal Sex Acts	
		6 Months IRR (95 % CI)	9 Months IRR (95 % CI)
1 SD below mean Hispanic population	Intervention v. Control difference	0.35 (0.16, 0.81)*	0.41 (0.18, 0.94)*
	Intervention − change	0.56 (0.31, 1.01)1.58	0.62 (0.34, 1.11)1.49
	Control − change	(0.89, 2.82)	(0.84, 2.63)
Mean Hispanic Population	Intervention v. Control difference	0.59 (0.32, 1.08)	0.80 (0.45, 1.45)
	Intervention − change	0.64 (0.42, 0.98)*1.08	0.93 (0.61, 1.41)1.15
	Control − change	(0.71, 1.66)	(0.76, 1.75)
1 SD above mean Hispanic population	Intervention v. Control difference	1.02 (0.47, 2.20)	1.64 (0.78, 3.45)
	Intervention − change	0.74 (0.44, 1.24)0.72	1.44 (0.86, 2.41)0.88
	Control − change	(0.41, 1.27)	(0.51, 1.50)

Note. Control v. intervention represents the intervention and given time interaction at the given level of the moderating variable. Intervention and control change provide the estimated change (form baseline) in each arm at each time based on the value of the moderating variable. Mean poverty indicates the average percentage of population across all time points (i.e., 24.1 %) while 1 SD below (0.0 %) and above (50.0 %) the mean represents their respective variation from that mean. All models are also adjusted age, race, ethnicity, and enrollment type (i.e., online or in-person). *Statistically significant at p-value $<$ 0.05.

arms at any level of the moderator.

4. Discussion

Few behavioral interventions have considered potential effect modification by neighborhood-level characteristics. Our innovative study identified two neighborhood-level characteristics, *percent Hispanic or Latino residents* and *families with income below poverty level,* which moderated the effects of the MyPEEPS Mobile intervention on condomless anal sex among same-sex attracted adolescent MSM at both 6- and 9-month follow-up visit. These findings show the potential for this intervention to be efficacious given certain neighborhood characteristics which were not evident in the findings of our RCT.

In this study we enrolled a large and diverse national sample of adolescents with ZIP Code level data/ census tract/ to examine neighborhood-level characteristics i.e., age, race, ethnicity, and income). Similar to the literature we found that addressing ethnicity and

income can play a significant role in improving the efficacy of interventions in RCTs (Johnson Lyons et al., 2022; Kraemer et al., 2008; Sims et al., 2020). Importantly, neighborhoods may operate in ways that enable the behaviors of individuals or restrict access to preventive care or health resources (Diez Roux and Mair, 2010; Akinyemiju et al., 2013), further exacerbating adverse health outcomes. For this reason, the socio-ecological framework – which posits that individuals operate within multiple domains of social influence and prevention strategies can be used to consider the continuum of these influences (Schölmerich and Kawachi, 2016), which can moderate the efficacy of behavioral interventions. By establishing significant neighborhood-level moderators, findings from this analysis can be used to better understand why the intervention may not have worked well for these groups. This can allow us to optimize the efficacy of the MyPEEPS Mobile intervention by targeting participants living in areas with specific neighborhood characteristics or can be tailored to the needs of participants with the discrete neighborhood characteristics found in our analysis (Collins et al., 2007). For instance, the MyPEEPS Mobile App is not currently available in Spanish, but, given lower efficacy of this intervention in neighborhoods with a high percentage of Latino families, this is likely a worthwhile investment to further increase the impact of MyPEEPS Mobile in Latino youth. Notably, language is a known structural barrier to accessing healthcare services (Kalich et al., 2016). On the other hand, the MyPEEPS Mobile users were English speaking and so it could be that the intervention content didn't meet their needs or that they were unable to operationalize behavioral changes based on their specific barriers. These findings are an invitation to investigate further.

Use of mHealth-based interventions is a promising and innovative way to increase reach in targeted populations at the individual level, but understanding the multi-level associations between individual- and neighborhood-level prevention strategies may also be important to understand the pathways in which social ecological context influences health outcomes (Baral et al., 2013; Barrenger and Draine, 2013). For instance, macrosocial factors such as neighborhood characteristics may constrain or promote the occurrence of individual-level behaviors associated with health risk (Minh et al., 2017). In other words, neighborhood characteristics may interact with individual-level factors, influencing risk of outcome among exposed individuals embedded in specific neighborhood contexts (Mair et al., 2008; Stockdale et al., 2007).

There are several limitations of this analysis. The geographical coordinates (latitude and longitude) were automatically collected through Qualtrics survey software, which may not have correctly identified each participant's location. In addition, we used census tract data which has the potential for spatial misclassification (Duncan et al., 2018). Further there is the potential for residual confounding which has been observed in past studies of socioeconomic background and health outcomes (Sorjonen et al., 2021). Finally the generalizability of our findings are limited given the relatively small sample size for a national-level study.

5. Conclusions

Our study examined the interaction between multiple neighborhood-level characteristics and the MyPEEPS Mobile interventions through statistical modelling of cross-level interaction in the multilevel model, revealing significant interactions between MyPEEPS Mobile interventions and the *percent Hispanic or Latino residents* and *families with income below poverty level* at 6- and 9-months. Further understanding how these neighborhood characteristics modify the effect of HIV prevention interventions may be useful in better targeting delivery of interventions and tailoring content of interventions based on neighborhood level characteristics such as the ones identified in this study. Finally, convergence of research methods and theory in future studies is needed to advance efforts in HIV prevention by addressing modifiable factors at both the individual and neighborhood level.

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CRediT authorship contribution statement

Evette Cordoba: Writing – original draft, Formal analysis, Conceptualization. **Robert Garofalo:** Writing – review & editing, Investigation, Funding acquisition, Conceptualization. **Lisa M. Kuhns:** Supervision, Project administration, Funding acquisition, Writing – review & editing. **Cynthia Pearson:** Writing – review & editing, Supervision, Investigation, Funding acquisition, Conceptualization, Writing – review & editing. **D. Scott Batey:** Writing – review & editing, Supervision, Project administration, Investigation. **Patrick Janulis:** Writing – review & editing, Validation, Supervision, Formal analysis. **Haomiao Jia:** Writing – review & editing, Formal analysis. **Josh Bruce:** Writing – review & editing, Supervision, Project administration, Funding acquisition, Writing – review & editing. **Marco A. Hidalgo:** Writing – review & editing, Investigation, Funding acquisition, Conceptualization. **Sabina Hirshfield:** Writing – review & editing, Validation, Supervision, Funding acquisition, Conceptualization. **Asa Radix:** Writing – review & editing, Supervision, Investigation. **Uri Belkind:** Writing – review & editing, Supervision, Project administration. **Dustin T. Duncan:** Writing – review & editing, Supervision, Investigation, Data curation, Conceptualization. **Byoungjun Kim:** Writing – review & editing, Formal analysis, Data curation, Conceptualization. **Rebecca Schnall:** Writing – review & editing, Supervision, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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