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► **To cite this version:**

Benjamin D. Huber, Byoungjun Kim, Basile Chaix, Seann D. Regan, Dustin T. Duncan. Objective and Subjective Neighborhood Crime Associated with Poor Sleep among Young Sexual Minority Men: A GPS Study. *Journal of Urban Health*, 2022, 10.1007/s11524-022-00674-y . hal-03889745

HAL Id: hal-03889745

<https://hal.sorbonne-universite.fr/hal-03889745v1>

Submitted on 6 Mar 2023

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Title: Objective and Subjective Neighborhood Crime Associated with Poor Sleep Among Young Sexual Minority Men: A GPS Study

Benjamin Huber¹

Byoungjun Kim¹

Basile Chaix²

Seann D. Regan^{1S}

Dustin T. Duncan¹

¹Department of Epidemiology, Columbia University Mailman School of Public Health, New York, New York, United States

²Sorbonne Université, INSERM, Institut Pierre Louis d'Epidémiologie et de Santé Publique IPLESP, Nemesis team, F75012 Paris, France

Corresponding author: Benjamin Huber, MPH, Columbia University Mailman School of Public Health, Department of Epidemiology, Columbia Spatial Epidemiology Lab, 722 West 168th Street, New York, NY 10032. Email: bh2771@cumc.columbia.edu

Keywords: Sleep; neighborhood Crime; perceived safety; exposure to crime; spatial analysis.

Running Head: Subjective and Objective Neighborhood Crime Associations with Sleep among YSMM:A GPS Study

Acknowledgements:

We thank the participants of the study and the Center for Health, Identity, Behavior and Prevention Studies(CHIBPS) research staff that contributed to the project. The P18 Neighborhood Study was funded by a grant from the National Institute on Mental Health (Grant # R21MH110190). At the time of writing, Dr. Dustin Duncan was supported in part by grants from the National Institute on Minority Health and Health Disparities (Grant Number [5R01MD013554-04](#) and [3R01MD013554-04S1](#)), the National Institute on Mental Health (Grant Number [7R01MH112406-05](#)), the National Institute on Drug Abuse (Grant Number [1R01DA054553-01](#)) and the National Heart, Lung and Blood Institute (Grant Number [1R01HL160325-01](#)).

ABSTRACT

Sleep disparities in sexual minority male (SMM) populations have received relatively little attention but they may be critical to explaining other health disparities seen among SMM, via neural or hormonal pathways. Recent research suggests that crime may be a psychosocial stressor that contributes to sleep disparities but that finding has been based on subjective measures of crime.

We conducted the P18 Neighborhood Study of 250 SMM in New York City, including 211 with adequate GPS tracking data. We used the GPS tracking data to define daily path area activity spaces and tested the associations of violent crime in those activity spaces and in the subject's residential neighborhood, perceived neighborhood safety and witnessing crime with a subjective measure of sleep.

Using quasi-Poisson regression, adjusted for individual and neighborhood socio-demographics, we found that SMM who witnessed more types of crime experienced significantly more nights of poor sleep over the course of a month (RR: 1.16, 95%CI: 1.05 – 1.27, p-value: <0.01). We did not find any associations between violent crime rates in either the activity area or residential area and sleep.

Our findings support the conclusion that personal exposure to crime is associated with sleep problems and provide further evidence for the pathway between stress and sleep. The lack of association between neighborhood crime levels and sleep suggests that there must be personal experience with crime and ambient presence is insufficient to produce an effect.

INTRODUCTION

Experiences with crime, including victimization, witnessing crime, and perceived neighborhood safety, have been shown to be associated with worse sleep in multiple urban populations¹⁻⁵. Developing an understanding of this phenomenon among sexual minority men (SMM) is essential because they have been shown to experience worse sleep than the general population. Poor sleep may be an important driver of other health disparities; as it has been associated with depressive symptoms, substance use, diabetes, obesity, and risk of HIV⁶⁻¹¹. The objective of this study is to compare associations of objective and subjective exposure to crime with sleep among SMM in New York City.

Sexual minority men are a marginalized population that consistently experience health disadvantage across a wide range of symptoms which can largely be explained by the minority stress model¹² which states that chronic psychosocial stressors such as stigma, prejudice, and discrimination experienced by marginalized populations can lead to a broad range of negative health outcomes and sleep could be an important mechanism for explaining some of those negative health outcomes. The connection between minority stress and sleep is particularly direct because stress increases activity of autonomic nervous system, which increases sleep latency, and fragments sleep¹³. This mechanism is substantiated in this context by previous research showing the associations between general stress and sleep in SMM¹⁴. Consistent disparities, in sleep duration and quality among sexual and gender minorities¹⁵⁻¹⁹ may explain other known health disparities via neural or hormonal pathways^{19,20}.

Early research on the neighborhood factors that affect sleep has found associations between both the social and built neighborhood environments and sleep²¹⁻²⁵. Crime is not SMM specific, but it is a

stressor and marginalized populations exposed to harassment and discrimination may experience crime differently. Previous research on combinations of multiple psychosocial health conditions (syndemics) has shown that multiple conditions can have additive effects²⁶. This could be because of altered experience with their environment, for example, due to previous experience with discrimination many SMM develop maladaptive cognitive styles such as perceptual vigilance, a heightened state of awareness of the social environment, to avoid future stigmatizing encounters.²⁷ It could also be that the negative effects of stress increase more quickly as the ANS is overwhelmed since different forms of discrimination may have unique physiological pathways²⁸ contributing to an additive effect.

Previous work by our group has shown that perceived neighborhood safety is associated with worse sleep health among SMM⁸. Other studies have used personal exposure to crime as their measure of perceived crime and found that being a victim of, or witnessing crime is associated with worse overall health outcomes, as well as shorter duration of sleep and more sleep interruptions among mothers²⁹.

Previous research examining the associations between crime and sleep among SMM has only examined perceived crime⁸. We further this work by using GIS methods to examine objective measures of neighborhood crime. Objective crime measures have been used to test associations with suicidality among SMM, activity levels and depression but little research has looked into objective measures of neighborhood crime and sleep among SMM¹ or overall²⁻⁴. Objective measures of crime typically use administrative boundaries for the subjects home neighborhood. Since subjects travel throughout the city, they experience multiple neighborhoods not captured by their residential neighborhood which leads to spatial misclassification³⁰ We have seen in previous research that there is significant spatial mobility in this data set which increases the risk of spatial misclassification³¹. Relatively recent research has addressed this problem by using GPS devices to track the movement of participants, then defines the activity space as the space within a certain distance from their path, which can lead to substantially different findings than residential neighborhoods³².

A commonly recognized problem is that GPS tracking also captures aspects of personal behavior that may confound the relationship between crime and sleep³³. Less well recognized is that personal choices about residential neighborhood may also confound the relationship between neighborhood crime and sleep. For example, subjects who value night life may choose to live in neighborhoods with more crime to be close to nightlife venues and may also sleep less. Controlling for residential self-selection may be critical for understanding the relationship between neighborhood exposure and health outcomes³⁴.

Using these GPS techniques to capture an objective measure of crime for each participants neighborhood context we will determine the relative importance of actual crime rates compared to subjective exposure to crime in determining sleep problems with the expectation that subjective exposure will be more closely linked to worse sleep because it is closely related to the biochemical pathways that govern sleep.

METHODS

Participants

This analysis includes 211 participants from the *Project 18 Cohort Study*, which included 665 HIV-negative or unknown status SMM in New York City. This subset is the *P18 Neighborhood Study* which was created by randomly selecting 450 participants from the original cohort study. 250 participants who were HIV-negative, had no mobility restrictions and were willing to carry a GPS device for two weeks,

were enrolled in the study, which was conducted from January 2017 to January 2018. 39 participants were dropped from the analysis because they failed to collect at least 1 hour of GPS data each day^{31,35}.

Measures

Objective Neighborhood Crime

We calculated objective neighborhood crime for residential neighborhood and GPS defined activity area. We defined residential neighborhood based on 400- and 800-meter circular buffers from the participants home address as well as zip code and census tract^{36,37}. In addition to residential neighborhood, we measured participant activity space using GPS tracking. Participants wore a small GPS device, which was programmed to log location every 10s for two weeks. Using the GPS data, we defined activity areas using daily path area (DPA) calculations to create 50-, 100-, 200-, 400-, and 800-m dissolved buffering zones^{35,38}. We eliminated daily path area outside of New York City due to limitations in crime rate data. We analyzed the effect of the 400-meter residential buffer and the 50-meter activity space buffer

For each neighborhood/activity area we calculated violent crime count using New York Police Department(NYPD) crime data where each complaint was geolocated to the mid-block point of the address where it occurred³⁹. and we limited our analysis to violent crimes, which includes: felony assault, murder and non-negligent manslaughter, robbery, and rape. Our count of crime included all violent crime complaints between 2012 and 2017. Figure 1 shows a heatmap of crime in New York City and an example activity area.

Subjective Neighborhood Crime

As in previous research^{8,40}, to assess global perceptions of safety, we asked participants 2 questions^{40,41}: “How safe do you feel walking alone in your neighborhood during the day?” And, “How safe do you feel walking alone in your neighborhood at night?” Response options were “Very Safe,” “Somewhat Safe,” “Somewhat Unsafe,” and “Very Unsafe.” Due to the low number of “Very Unsafe” responses it was combined with “Somewhat Unsafe” to create an “Unsafe” category.

To measure witnessed crime we asked the participants the following questions originally developed for the exposure to violence questionnaire⁴²⁻⁴⁴:

- In the past year, have you seen someone get chased when you thought they could really get hurt?
- In the past year, have you seen someone get hit, slapped, punched, or beaten up?
- In the past year, have you seen someone get attacked with a weapon?
- In the past year, have you seen someone get shot?
- In the past year, have you seen someone get shot at?
- Other than what you have already told us, in the past year, have you heard gunfire nearby?
- In the past year, have you seen someone get killed as a result of violence, like being shot, stabbed, or beaten to death?
- Other than what you have already told us, in the past year, have you seen someone threaten to seriously hurt another person?

We then summed the yes responses to get a count variable of the number of crime types witnessed during the past year. We also created an additional dichotomous predictor: no witnessed crime in the past year vs. witnessed any crime during the past year.

Sleep

To measure sleep, we asked participants: During the past 30 days, for about how many days have you felt you did not get enough rest or sleep? ⁴⁵

Individual and Neighborhood-level Covariates

Participant age was calculated based on their birthday. Other sociodemographic characteristics were self-reported race (White, Black, other/Native American, Asian, or two or more), ethnicity (Hispanic or Non-Hispanic), education (high school/GED or less, associate degree, college/graduate school), current student status (in school or not in school), birthplace (US born or foreign born), income (less than \$15,000, between \$15,000 and \$30,000, over \$30,000), sexuality (straight, gay, bisexual), relationship status, and housing status (family home, own home, with friends/roommates, temporarily with family or friends, dorm, SRO, shelter, hostel, other).

We measured residential preference to account for confounding in the relationship of interest caused by the participants choice of neighborhood^{34,46}. To measure residential preference, we asked participants: “How important was living in the city center to you when choosing to live in your current neighborhood?” with the response options: “Not at all important”, “Not too important”, “Somewhat important”, “Mostly important”, and “Very important.”

Neighborhood poverty was measured as percent of residents in the zip code below the poverty line from the 2017 5-year ACS survey. Racial makeup was measured as the percent of black or Hispanic residents from the 2017 5-year ACS survey⁴⁷.

Statistical Analysis:

Descriptive statistics were first calculated for all study variables. First, we operationalized witnessing crime and sleep problems as dichotomous variables and analyzed associations using a chi-square test. Next, we tested the bivariate associations between our crime variables and sleep using a simple quasi-Poisson regression to account for the over dispersed nature of the data and excess zeros. For the adjusted models we used quasi-Poisson regression accounting for age, race, ethnicity, education, current student status, birthplace, residential preference, neighborhood percent below poverty line, neighborhood percent Black, and neighborhood percent Hispanic. We calculated Wald 95% confidence intervals for relative risk in both the bivariate and adjusted models.

RESULTS

Demographics

Table 1 shows that the typical participant in our study was 25 years old (with a minimum of 23 and a maximum of 26). Thirty percent identified as Hispanic ethnicity. 32 % identified as White, 30% identified as Black, 18% identified as Other or Native American, 10% identified as Asian and 10% identified with

two or more races. Just over half of the participants had completed college or graduate school (56%), while 34% had completed just High School or less and 10% had an Associate's degree. A quarter (25%) were currently enrolled in school at the time of the study. Most participants were born in the US but 14% were foreign born.

The most popular response for residential preference was that was "somewhat important" to live near the city center (30%) followed by "Not very important" (28%).

The home neighborhood (zip code) of participants had, on average 36% Black (SD: 25%) and 36% Hispanic (SD: 20%). The average percent of the population living below the poverty line in the participants home neighborhood (zip code) was 20% (SD: 9%). The average violent crime count over 5 years in the participant 50m activity area was 4,173 (SD: 3,176). The average violent crime count in the participants 400m residential area was 370 (SD: 230).

Most participants reported feeling safe in their neighborhoods with only 2 participants reporting feeling unsafe during the daytime and 21 participants reporting feeling unsafe at night. Half of the participants never witnessed any crime (50%) while only 2 participants witnessed the maximum (8) types of crimes.

The median number of nights the participants reported getting poor sleep in the past 30 days was 5 (IQR: 0-15).

Bivariate models

Table 2 shows the bivariate association between objective and subjective neighborhood crime variables and sleep. We also tested the association between witnessing crime and poor sleep using a chi-square test and found that witnessing crime was associated with an increased risk of getting insufficient sleep (Chi-square: 5.47, df=1, p-value =0.02). The risk of sleeping poorly greater than 5 nights in the past month was 1.46 (95% CI: 1.08 – 2.01) times higher among those who witnessed at least one crime in the past month. In our bivariate quasi-Poisson models, we found that witnessing more types of crime was associated with more nights of poor sleep (RR: 1.17, 95%CI: 1.08 – 1.27 for an increase of 1 in number of crimes witnessed, p-value: <0.01). We also found that participants who reported feeling "Somewhat Safe" at night slept poorly significantly more nights than those who reported feeling "Very Safe" (RR: 1.37, 95%CI: 1.002, 1.89, p-value: 0.05), while feeling unsafe at night was not associated with the outcome. We did not find any significant associations between violent crime rates in either the activity area or residential area and sleep.

Adjusted Models

Many of the bivariate associations persisted in multivariate modeling (Table 3). There was an association between number of types of crime witnessed and sleep (RR: 1.17, 95%CI: 1.05 – 1.30, p-value: <0.01), as well as an adjusted relationship with the corresponding dichotomous variable. There was also a significant difference in expected nights of poor sleep between those who felt very safe and those who felt somewhat safe walking at night (RR: 1.53, 95%CI: 1.059 – 2.22, p-value 0.01) but there was no difference with the unsafe group. There were no sleep differences between groups in relation to the daytime perceived safety variable There was no association between objective neighborhood crime and sleep.

DISCUSSION

The primary finding of this paper is that witnessing crime increases the likelihood that SMM in New York City will experience insufficient sleep. This association persisted in bivariate and adjusted models, and whether we treated witnessing crime as a binary variable or a count variable. Our findings suggest that sleep problems continue to increase as the number of crimes witnessed increases which is consistent with other research on trauma and sleep⁴⁸. But some studies have found similar findings such as one that found associations between general health and exposure to crime but not perceptions of neighborhood crime levels²⁹. Perhaps witnessing crime causes the highest levels of crime related stress that was not captured in our perceived safety variables, had relatively small variance, indicating that each level captured a wide range of experiences. This demonstrates the inherent challenges in capturing other people's inner experience⁴⁹ which is critical for understanding this relationship. This is consistent with previous studies have found associations between witnessing crimes and Post Traumatic Stress Disorder(PTSD) symptoms but not necessarily with diagnosable PTSD^{50,51}. And research on fear of crime among sexual and gender minorities has shown that fear of future crime is also related to past victimization⁵². The strength of the association we found combined with these other findings suggests that personal exposure to crime is the most important factor for predicting sleep problems and ambient crime levels are not enough.

Additionally, the difference in time periods for witnessing crime (1 year) and sleep (30 days) suggests that there could be durable effects of witnessing even a single crime; it can be expected that the association with poor sleep would have been much stronger with crimes witnessed over a more recent period.

Despite the associations between witnessing crime and sleep we did not find any associations between objective crime and sleep. Given that crime related stress is on the theoretical causal pathway between crime and sleep we should expect weaker associations with objective crime than perceived crime, but the results suggest that objective neighborhood crime is only a small part of the explanation for perceived crime. Structural equation modeling used to test pathways between crime and depression found that there was a pathway through both exposure to crime and perceived neighborhood disorder but no direct pathway between objective neighborhood crime and depression symptoms³. One study in children linked neighborhood crime with sleep problems and cortisol levels helping to establish that stress is a likely link between sleep and crime⁵³.

The existence of relatively weak associations between objective measures of crime and witnessing crime in this study, consistent with other research, may help explain why we did not find associations between objective crime and sleep (i.e., people do not necessarily witness a crime even if there is some around). When we tested the association between witnessing crime and violent crime rates as a post-hoc analysis, we found a Spearman correlation of 0.224 (p-value:<0.01) with residential area violent crimes and no correlation with activity area violent crime count. There was no association between nighttime perceived safety and violent crimes. Previous research has found that the associations between perceptions of neighborhood crime and objective neighborhood crime are inconsistent and there may be different sensitivities to the actual crime rate among different populations⁵⁴. Perceived crime may be more influenced by general feelings of vulnerability and helplessness perhaps influenced by communication suggesting the risk of victimization⁵⁵. Other work has proposed that perceived safety is influenced by both the perceived physical and social environment as well as individual attitudes⁵⁶.

Another reason for a lack of correlation between objective and subjective measures may be error in objective crime measurements. We addressed spatial misclassification by using GPS tracking to determine which neighborhoods the participants were exposed to. Figure 2 demonstrates the difference in neighborhood contexts measured by activity areas vs residential areas. But even GPS tracking has some flaws for measuring exposures. For example, participants may intentionally avoid areas they know have high crime and experience stress related to the avoidance, but, the crime in that avoided area would not be captured in the activity space. Finally, there could be an association between objective measures of crime and sleep that is specific to particular types of crime. For example, objective measures of sexual and gender minority specific hate crimes are associated with suicidality among sexual and gender minority populations¹

Study limitations

The first limitations of the study are related to sampling design. This study consisted of a cross-sectional convenience sample of young SMM in New York City and is not necessarily generalizable to the whole population of young SMM. The unique density of New York City may also affect the relative spatial context of crime. The subway system may also affect spatial mobility and adds the challenge of tracking underground movement using a GPS system.

We did our best to control for both individual and neighborhood level confounders, including area socioeconomic status and residential self-selection, but there may still be residual confounding.

Additionally, the use of GPS defined activity space does not take temporal factors into account. For example, nighttime and daytime path areas were treated equally even though the time of day is relevant to perceived crime and potentially actual crime. And there was temporal inconsistency between exposure and outcome. Perceived safety was for past year, crime was sum of 5 years, activity space was for 2 weeks, and sleep was for the last month.

Finally, we measured sleep using a single survey item which limits our ability to understand the potential impacts of the sleep differences and the impacts on sleep quality. Some research has shown that stress can have differential effects between subjective and objective measures of sleep⁵⁷. Our subjective measures of crime were also based on the survey results and as a result considering subjective measures of both crime and sleep can result in same-source bias.

Future Research

Given the deleterious effects of sleep deprivation and its association with numerous health disparities experienced by sexual and gender minorities, sleep should be a priority for future research among sexual and gender minority populations and a focus for providers⁵⁸. Continuing research on neighborhood crime and sleep should employ longitudinal data and study a wider range of geographic locations. In this paper we only examined violent crime, but we have reason to believe that sexual and gender minority-specific crime can have a stronger effect on sexual and gender minorities than general crime statistics¹. If the response to a stressor like crime depends on exposure to other stressors that are not experienced by all SMM equally, then we should also use an intersectional approach, including multi-level modelling, to quantitatively capture power structures and marginalization that determine those stressors⁵⁹. This type of research is already well suited to quantifying intersectionality because many of the power-based mechanisms of marginalization occur geographically, and respondent driven sampling is well suited to quantitative research in marginalized populations. For example, future

research can study neighborhood police violence and sleep among Black SMM, given sleep disparities that this group experiences.¹⁻⁵

Technological advancements will also make it easier to capture accurate objective sleep and neighborhood exposure data. The best measures of sleep are done in the lab but wrist actigraphy has been used to measure associations between neighborhood context and sleep²⁴ complementing actigraphy such as light sensors, heart rate and body temperature measurements can help increase the accuracy and the use of smart watches to measure this data unobtrusively is improving rapidly⁶⁰.

Using ecological momentary assessment (EMA) to collect live data on participant activity will help with interpreting GPS data and increasing the accuracy of exposure assessment, including social environment. Collecting responses on sleep quality every morning while the participant has the GPS will allow us to link exposure more accurately to outcome. And adding a temporal dimension to the GPS data analysis will further improve exposure assessment.

Witnessing crime is not the only type of exposure to crime that could have an impact on sleep. In fact, direct victimization, and police harassment are also both known to erode sleep^{5,61,62}. It is likely that in many cases all three of these experiences with crime affect sleep simultaneously but most of the literature examines each separately. Using an EMA approach will allow us to capture different types of exposure to violence at a very fine temporal scale and parse the differences in effect these exposures have on sleep.

The increasing prevalence of smartphones and affordability of smartwatches offers some exciting possibilities for the future of sleep and neighborhood research by offering the possibility of relatively easily combining objective measures of sleep and other health outcomes, such as heart rate and blood pressure, with ecological momentary assessment.

Conclusion

We found associations between witnessing crime and sleep among SMM consistent with what we would expect to see based on the minority stress model. Given the importance of sleep to good health future, research should seek to better understand the relationship between objective sleep and objective neighborhood characteristics.

TABLE 1, Covariate Descriptive Summary, P18 Neighborhood Study

Variable	N = 211
Age	25.37 (0.85); 25.36 (24.68, 26.11)
Hispanic Ethnicity	
Non-Hispanic	148 (70%)
Hispanic/Latino	63 (30%)
Race	
White	67 (32%)
Black	64 (31%)
Other/Native American	35 (17%)
Asian	21 (10%)
Two or more	21 (10%)
Unknown	3
Education	
High School/GED or less	71 (34%)
Associate Degrees	23 (11%)
College/Graduate School	116 (55%)
Unknown	1
Current Schooling	
Not currently in School	158 (75%)
Currently in School	52 (25%)
Unknown	1
Birthplace	
Foreign Born	30 (14%)
U.S. Born	181 (86%)
Preference for living near city center	
Not at all important	25 (13%)
Not too important	55 (28%)
Somewhat important	59 (30%)
Mostly important	33 (17%)
Very important	27 (14%)
Unknown	12
Percent Living Below Poverty, Home Zip Code	20 (9); 21 (13, 27)
Unknown	1
Percent Black, Home Zip Code	36 (25); 32 (12, 53)
Unknown	1
Percent Hispanic, Home Zip Code	34 (20); 30 (17, 48)
Unknown	1
Number of Days Slept Poorly, past 30 days	5 (0, 15)

TABLE 2, Descriptive Statistics on Neighborhood Crime in the P18 Neighborhood Study

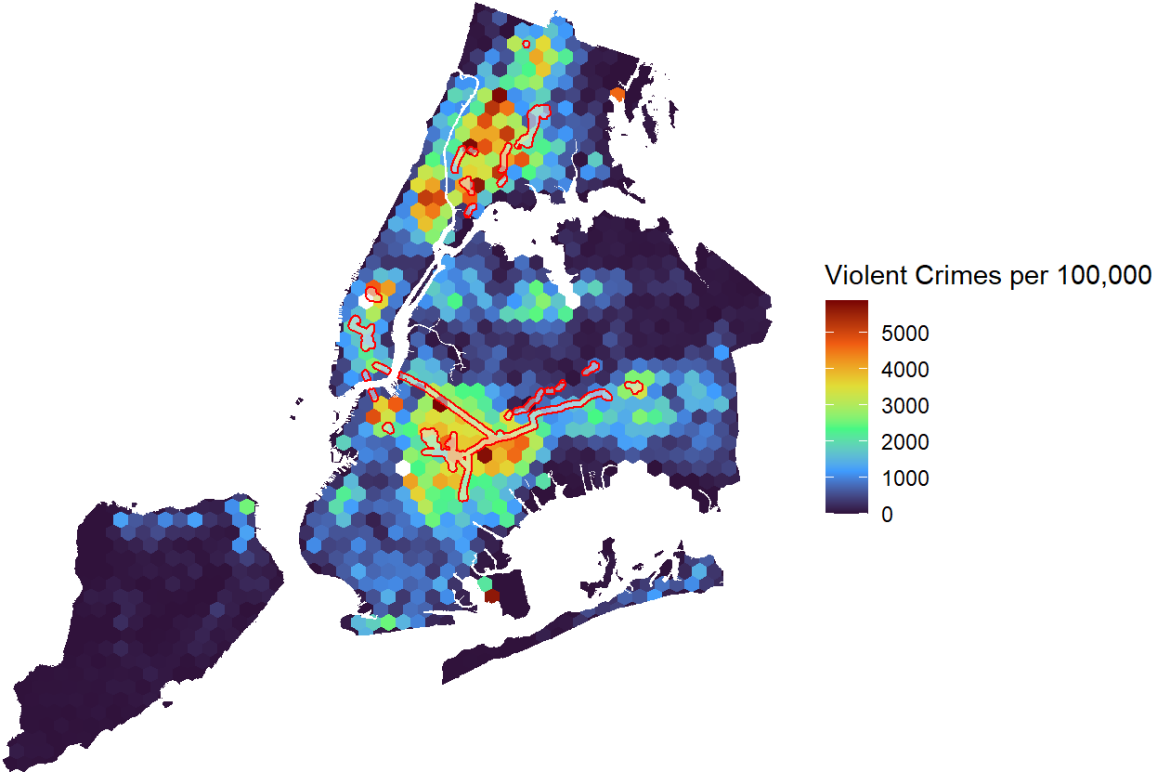
Variable	N = 211
Violent Crime Rate per 100,000, 50m activity area buffer	699 (266); 651 (552, 824)
Violent Crime Rate per 100,000, 400m residential area buffer	634 (366); 602 (364, 837)
Perceived Neighborhood Safety, Daytime	
Very Safe	159 (76%)
Somewhat Safe	48 (23%)
Somewhat Unsafe	2 (1.0%)
Unknown	2
Perceived Neighborhood Safety, Nighttime	
Very Safe	104 (50%)
Somewhat Safe	84 (40%)
Somewhat Unsafe	19 (9.1%)
Very Unsafe	2 (1.0%)
Unknown	2
Witnessed Crime, Number of Types	
0	100 (48%)
1	40 (19%)
2	37 (18%)
3	16 (7.7%)
4	7 (3.3%)
5	3 (1.4%)
6	3 (1.4%)
8	1 (0.5%)
9	2 (1.0%)
Unknown	2
Witnessed Crime, Dichotomous	109 (52%)
Unknown	2

Table 3: Bivariate and Adjusted Associations between Neighborhood Crime and Sleep Among Young Sexual Minority Men

Variable	Risk Ratio, Bivariate Model	P-Value	Risk Ratio, Adjusted Model	P-Value
Violent Crime Rate per 100,000, 50m activity area buffer	1.0001	0.719	1.000025	0.95
Violent Crime Rate per 100,000, 400m residential area buffer	-0.0002	0.371	0.9996	0.23
Perceived Neighborhood Safety, Daytime				
Very Safe	Referent	Referent	Referent	Referent
Somewhat Safe	0.9882	0.95	1.0106	0.96
Unsafe	1.9764	0.23	1.5983	0.44
Perceived Neighborhood Safety, Nighttime				
Very Safe	Referent	Referent	Referent	Referent
Somewhat Safe	1.3739	0.05	1.5585	0.01
Unsafe	0.9096	0.75	1.0448	0.89
Witnessed Crime, Number of Types	1.1437	<0.01	1.1281	<0.01
Witnessed Crime, Dichotomous	1.4210	0.03	1.4100	0.03

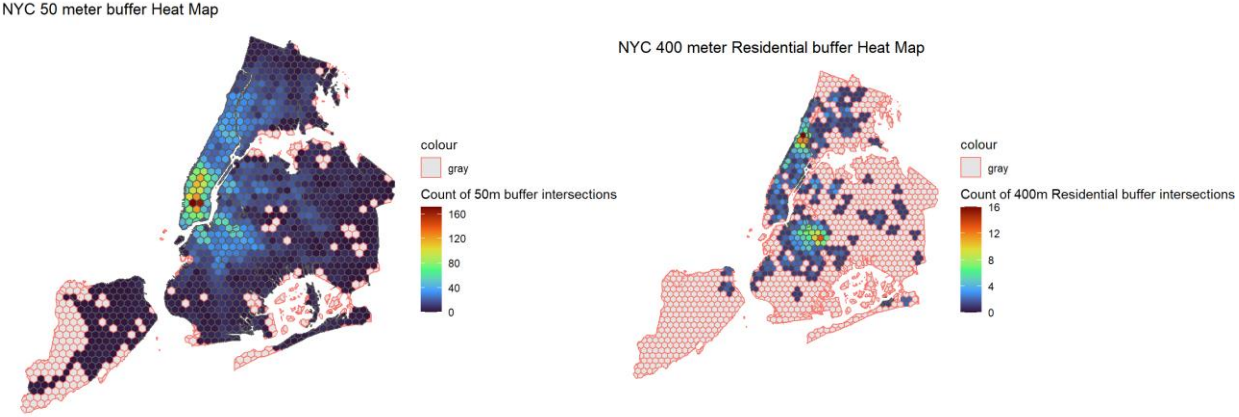
Adjusted Model controls for individual-level age, race, Hispanic ethnicity, education, current school status, birthplace, residential preference, zip code percent living below poverty, zip code percent Black, and zip code percent Hispanic.

Figure 1: Neighborhood Violent Crime Rate Heat Map with an example participant activity area buffer overlay



Heat map shows the neighborhood violent crime rate and red outline shows an activity area buffer for a sample participant. In this case we used the 200 meter buffer for visual clarity. The activity area violent crime rate would be the violent crimes per 100,000 people within the red line.

Figure 2: Composite maps of participant 50-meter activity space buffer and 400-meter residential area buffer



Heat maps show geographic distribution of residential home neighborhoods compared to 50-meter activity areas. The activity area covers a much larger area of the city and demonstrates a lot of overlap in lower Manhattan and Midtown, whereas the residential areas have more overlap in Brooklyn and Upper Manhattan.

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