HHS Public Access

Author manuscript

Obesity (Silver Spring). Author manuscript; available in PMC 2018 April 30.

Published in final edited form as:

Obesity (Silver Spring). 2017 December ; 25(12): 2149–2155. doi:10.1002/oby.22040.

Simulating the Impact of Crime on African-American Women's Physical Activity and Obesity

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Disclosure: The authors declared no conflict of interest.

Author Contributions: Tiffany M. Powell-Wiley provided expert guidance and leadership throughout the project – she was involved throughout model development, parameterizing the model, data analysis and writing the manuscript. Michelle S. Wong provided leadership and managed the study. She was involved at each stage of model development, parameterizing the model, running simulations, data analysis and writing the manuscript. Joel Adu-Brimpong focused on parameterizing the model, analyzing the output and contributing to manuscript writing. Shawn T. Brown provided expert guidance throughout the project, involved at each stage of model development, parameterizing the model, running simulations, programming the model, data analysis and writing the manuscript.

Daniel Hertenstein focused on programming the model, running simulations, analyzing output, developing figures and contributing to manuscript writing. Eli Zenkov focused on programming the model, running simulations and developing figures. Marie C. Ferguson focused on developing the model, analyzing output and writing the manuscript. Samantha Thomas focused on developing and parameterizing the model, and contributing to manuscript writing. Dana Sampson provided contextual information about physical activity among African American women and crime, contributed to model development and manuscript editing. Chaarushi Ahuja focused on parameterizing the model, analyzing output and contributing to manuscript writing. Joshua Rivers focused on parameterizing the model, analyzing output and contributing to manuscript writing. Bruce Y. Lee provided expert guidance throughout the project. He was involved throughout the project guiding model development, determining appropriate simulations and writing the manuscript.

Conflict of Interest Statement: The project described was supported by the Global Obesity Prevention Center (GOPC) and from the Eunice Kennedy Shriver National Institute of Child Health & Human Development (NICHD). The project is co-funded by the NICHD and the Office of Behavioral and Social Sciences Research (OBSSR). This project is also funded by NICHD via grant U01HD086861 and the Agency for Healthcare Research and Quality (AHRQ) via grant R01HS023317. This project is also funded by contract HHSN268201600067P through the Division of Intramural Research at the National Heart, Lung, and Blood Institute (NHLBI) of the National Institutes of Health. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NICHD, AHRQ, or OBSSR. This study was approved by the Johns Hopkins Bloomberg School of Public Health Institutional Review Board (IRB #00004203). None of the study sponsors had any role in the study design, collection, analysis, and interpretation of data, writing the report, nor the decision to submit the report for publication. The Powell-Wiley research group is funded by the Division of Intramural Research of the NHLBI at the National Institutes of Health. This research is also supported by the National Institutes of Health Undergraduate Scholarship Program via funding for Joel Adu-Brimpong and Samantha Thomas. Joshua River's participation was made possible through the National Institutes of Health (NIH) Medical Research Scholars Program, a public-private partnership supported jointly by the NIH and generous contributions to the Foundation for the NIH from the Doris Duke Charitable Foundation, the American Association for Dental Research, the Colgate-Palmolive Company, Genentech and alumni of student research programs and other individual supporters via contributions to the FNIH. For a complete list, please visit the Foundation website at: http://fnih.org/mrsp. The views expressed in this manuscript are those of the authors and do not necessarily represent the views of the NHLBI; the National Institutes of Health; or the U.S. Department of Health and Human Services.

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Abstract

Objective—The objective of this study was to quantify the impact of crime on physical activity location accessibility, leisure-time physical activity (LTPA) and obesity among African-American women.

Methods—We developed an agent-based model, in 2016, representing resource-limited Washington, DC communities and their populations to simulate the impact of crime on LTPA and obesity among African-American women under different circumstances.

Results—Data analysis conducted between 2016 and 2017 found that in the baseline scenario, African-American women have a 25% probability of exercising. Reducing crime so more physical activity locations are accessible (increasing from 10% to 50%) decreases the annual rise in obesity prevalence by 2.69%. Increasing the probability of African-American women to exercise to 37.5%, further increases the impact of reducing crime on obesity (2.91% annual decrease in obesity prevalence).

Conclusions—Our simulations show that crime may serve as a barrier to LTPA. Reducing crime and increasing propensity to exercise through multilevel interventions (i.e. economic development initiatives to increase time available for physical activity and subsidized health care) may promote greater than linear declines in obesity prevalence. Crime prevention strategies alone can help prevent obesity, but combining such efforts with other ways to encourage physical activity can yield even greater benefits.

Keywords

modeling; physical activity; obesity

Introduction

African-American women report the lowest rates of leisure-time physical activity (LTPA)[1–4] and have the highest obesity prevalence in the U.S.[5], and increased risk for cardiometabolic diseases, including diabetes and coronary artery disease. A disproportionate number of African Americans live in urban, resource-limited areas (i.e., communities with lower neighborhood-level socioeconomic status and resources for PA and healthy nutrition), where neighborhood crime has emerged as a potential correlate with out-of-home PA and obesity[6,7]. However, connecting neighborhood crime changes to health behaviors and

subsequent outcomes is difficult. Methodological limitations exist for cross sectional or variable-based studies quantifying neighborhood crime's impact on LTPA[8–10]. Moreover, existing studies do not adequately account for complex interactions between individual- and environmental-level factors in the neighborhood crime and LTPA relationship. Therefore, we developed an agent-based model (ABM) to simulate individuals' actions and their interactions with the environment, specifically African-American women's LTPA practices in low-resource settings. Given the significant resources required for public health interventions to increase LTPA, the ABM allows for testing potential interventions before implementation.

Our experiments quantified the impact of varying the effects of individual- and neighborhood-level factors (including crime) on PA location accessibility, LTPA and obesity among a population of African-American women, age 18–65, living in the three lowest median-income neighborhoods, or wards, of Washington, D.C.'s eight wards [11].

Methods

Model Structure

Our Virtual Population Obesity Prevention (VPOP) Lab, a geospatially explicit ABM developed in 2016 in Python, included virtual representations of households, PA and crime locations, and African-American women (age 18–65) living in Washington D.C. Wards 5, 7 and 8 . Each agent has various characteristics including age, height, lean/fat mass, and household location and income. Each agent also has an embedded metabolic model converting caloric intake and expenditure to corresponding lean/fat mass[12,13]. Table S1 provides additional assumed agent characteristics for the model.

Figure 1 illustrates the model structure and Table S1 also provides model assumptions and data sources. Each agent has a baseline probability to exercise. This captures the agent's current desire to exercise and includes factors like household financial and employment status, family/caregiving responsibilities, chronic health conditions, weather, social group influence, and broader social pressures including density of and relatability to exercisers in the community[14–18]. The agent decides where to engage in LTPA based on a gravity model, which considers LTPA locations within an agent's transport radius from home (0.5 miles if walking[19]; 2.5 miles if driving.) There are three location types where agents can engage in LTPA: 1)home, 2)outdoor locations (pools, parks, bike trails and lanes), or 3)municipal recreational centers. Outdoor locations and recreational centers match real geographic locations within Washington D.C. We excluded commercial gym facilities as there are none in Ward 8. If an agent is unable to select a suitable location, she does not exercise. Lastly, an agent decides on LTPA duration and intensity. The probability of PA intensity (moderate vs. vigorous) and duration differ based upon whether agent exercises at home or out-of-home(Figure 1). Caloric expenditure from exercise is determined by LTPA intensity, duration, and the agent's current body weight[20].

Crime Parameters Affecting Exercise Decisions

We assume that crime affects LTPA decisions by reducing PA location accessibility when crime occurs at or near PA locations, or on the agent's travel path to the location[21]. Crime events are represented in the model at a given time and date, by a specific type (violent vs. property), and at a given location. We calculated the crime's impact on LTPA accessibility based on three crime parameters: radius, duration, and effect (Figure 1). "Radius" represents the agent's LTPA locations within the specific radial distance from the crime origin that is affected by the crime; "Duration" represents amount of time the crime affects an agent; and "Effect" represents a decrease in the probability that agents will travel through or exercise in areas affected by the crime. Multiple crimes occurring on the agent's travel path or at the LTPA location have an additive effect (e.g., for a LTPA location where two crimes' radii overlap during the same duration, and each crime has a 20% reduction effect, there will be a combined 40% reduction that agents will use that LTPA location).

Data Sources

Residential and sociodemographic data about the study population came from a synthetic population developed by Wheaton, et al[22], and U.S. Census Bureau's Public Use Microdata files and Census aggregates data. Initializing fat and lean mass data and ranges for LTPA intensity came from the 2013–2014 National Health and Nutrition Examination Survey[23]. LTPA duration range data came from prior analyses evaluating time-use data[20]. Our model used historical 2014 Washington D.C. crime surveillance data based on the D.C. Metropolitan Police Department's crime report database[24]. Self-reported PA data from African-American women aged 18–65 living in Wards 5, 7, 8 from the Washington, D.C. Cardiovascular Health and Needs Assessment (DC-CHNA), a community-based participatory research project, established baseline probability to exercise[25].

Experimental Scenarios

We examined three experimental scenarios in 2016 and 2017, varying agents' baseline exercise probability. Baseline probabilities reflect population-level calculations of varied likelihood of exercising.

Scenario 1 (baseline scenario):Crime's impact on LTPA and Obesity prevalence at baseline probability (25%) to exercise—Our baseline scenario (scenario 1) was based on data collected from the DC-CHNA population[26], where we estimated that the baseline exercise probability is approximately 25%, and includes individual, social and environmental characteristics, such as family and employment commitments, that might influence one's decision to exercise.

Scenario 2: Crime's impact on LTPA and Obesity prevalence at increased probabilities (37.5% and 50%) to exercise—In scenario 2, we increased baseline probability to exercise from 25% to 37.5% and 50%. This allowed us to examine hypothetical, but feasible, circumstances where agents' baseline exercise probability increases from changes in non-crime related factors (e.g., decreasing financial barrier to exercise).

Scenario 3: Isolated impact of crime reduction on LTPA and Obesity prevalence—In scenario 3, we increased baseline exercise probability to 100%. While we recognize this is highly unlikely, this scenario allowed us to isolate effects of reducing crime on LTPA. We also tested experimental scenarios varying the radius, duration and effect of crime.

Validation

We validated our model by comparing the proportion of women exercising daily based on our simulation to DC-CHNA survey data[25,27], and the proportion of women with obesity in our model to Behavioral Risk Factor Surveillance System (BRFSS) data (Centers for Disease Control and Prevention-conducted survey on U.S. residents' health-related risk behaviors and chronic health conditions)[28] for Washington, DC. We also tested the validity of our model under extreme conditions. For an extended description, see Supplementary materials.

Results

Figure 2 illustrates the percent of women exercising daily for each scenario; as crime's impact diminishes, LTPA location accessibility increases. Figure 3 illustrates changes in overweight and obesity prevalence for each scenario over a year when 10%, 50%, and 90% of LTPA locations are accessible. We selected these values because they represent a set of anthropomorphic outcomes through the range of accessible LTPA locations to identify trends in the relationship between LTPA and anthropomorphic outcomes.

Scenario 1 (baseline): Crime's impact on LTPA and Obesity prevalence at baseline probability (25%) to exercise

In the baseline scenario, there was a moderate increase in the proportion of women engaging in LTPA on a given day as LTPA location accessibility increased due to reduced crime impact. Our model predicts that when only 10% of LTPA locations are accessible, on average, 13.08% (95% range:13.07, 13.09) of women exercise per day, yielding a 2.94% (95% range:2.88, 3.00) annual obesity prevalence increase. When crime reductions led to 50% of LTPA locations being accessible, 21.28% (95% range:21.27, 21.29) of women engage in LTPA on any given day resulting in a 0.25% (95% range:0.2, 0.3) annual increase in the proportion of women with obesity. Finally, when 90% of LTPA locations became accessible due to crime reductions, 24.23% (95% range:24.22, 24.25) of women engage in LTPA on any given day resulting in an annual 0.79% reduction (95% range:0.74, 0.84) in the proportion of women with obesity.

Scenario 2: Crime's impact on LTPA and Obesity prevalence at increased probabilities (37.5% and 50%) to exercise

At 37.5% baseline exercise probability, when only 10% of LTPA locations were accessible, on average, 19.62% (95% range:19.61, 19.63) of women exercised per day, yielding a 1.05% (95% range:1.01, 1.09) annual increase in the proportion of women with obesity. When 50% of LTPA locations became accessible due to reduced crime impact, 31.91% (95% range: 31.89, 31.92) of women exercised per day, yielding a 2.91% (95% range:2.88, 2.94) annual

reduction in the proportion of women with obesity. Finally, when crime reductions led to 90% LTPA location accessibility, 36.35% (95% range:36.34, 36.37) of women exercised per day, yielding an annual 4.46% (95% range:4.35, 4.58) reduction in the proportion with obesity.

At 50% baseline exercise probability, when 10% of LTPA locations were accessible, on average, 26.17% (95% range:26.15, 26.18) of women exercised per day, yielding a 0.77% (95% range:0.74, 0.79) annual reduction in the proportion of women with obesity. When crime reductions led to 50% LTPA location accessibility, 42.53% (95% range:42.52, 42.54) of women exercised per day, yielding a 6.70% (95% range:6.61, 6.78) annual reduction in the proportion of women with obesity. Finally, when 90% of LTPA locations became accessible with crime reductions, 48.48% (95% range:48.46, 48.50%) of women exercised per day, yielding an annual 9.13% (95% range:9.05, 9.21) reduction in the proportion with obesity.

Scenario 3: Isolated impact of crime reduction on LTPA and Obesity prevalence

At 100% baseline probability to exercise, with 10% LTPA location accessibility, on average 52.31% (95% range:52.30, 52.32) of women exercised per day, yielding an annual 9.04% (95% range:9.02, 9.06) reduction in the proportion of women with obesity. Subsequently, at 50% LTPA locations accessibility, 85.04% (95% range:85.03, 85.05) of women exercised per day, yielding a 20.11% (95% range:20.07, 20.14) reduction in the proportion of women with obesity. Finally, at 90% LTPA location accessibility, 96.93% (95% range:96.91, 96.95) of women exercised per day, yielding a 24.38% (95% range:24.33, 24.43) reduction in the proportion of women with obesity over a year.

Effect of crime parameters on LTPA

Our model predicts that LTPA location availability was most sensitive to changes to the radius of crime impact, while changes to crime's duration and effect produced only small changes to LTPA location availability. Figure 4 (https://aphez.github.io/vpop-dc-crime-map-2014/) is a representative map of crime and LTPA locations when the radius is 0.33 miles, the durations for violent crime and property crime are 14 and 7 days respectively, and the effect of each crime is a 20% reduction in going to a specified LTPA location. The link provides an interactive map where radius, duration, and effect of crime can be changed to visualize relationships between different combinations of crime and LTPA location accessibility.

Discussion

Our study aimed to examine the relationship between crime, LTPA, and obesity in a population of African-American women in a resource-limited, urban setting. While crime can affect obesity through various mechanisms, our study focused specifically on how crime's spatial nature can impact people's ability and willingness to access LTPA locations in an affected area, either on the travel route to or at LTPA locations. We found that when baseline exercise probability – which includes other individual, social, and environmental characteristics that might influence one's decision to exercise (e.g., family and employment

commitments) – is low, reducing crime's impact has the least influence on LTPA participation and obesity reduction. As baseline exercise probability increases, the impact of crime becomes more relevant reductions in crime and subsequent increases in LTPA location accessibility have a larger impact on LTPA participation. Our model demonstrates that the relationship between crime and LTPA is nonlinear and depends upon the baseline exercise probability. Crime has a small effect on LTPA when the baseline exercise probability is small, but crime becomes an increasingly important determinant of LTPA as the baseline exercise probability increases.

Our models may help to explain the mixed and null findings in prior epidemiologic studies related to crime's impact on exercise [8–10]. The heterogeneity of findings in prior research may exist because these studies were conducted in populations with different underlying baseline probabilities to exercise. For example, null results in previous studies may be due to the fact that these studies were conducted in populations with a low baseline probability to exercise.

Additionally, our study suggests the need for policies that simultaneously address crime and individual- or environmental-level factors limiting baseline probability to exercise. Based on our findings, the most effective policies to improve LTPA in resource-limited communities might include efforts that reduce crime indirectly as part of a broader community improvement strategy and have potential to improve the baseline likelihood of exercise among women living in communities with limited-resources for physical activity. These may include economic development initiatives, urban renewal and neighborhood development efforts and policies to provide subsidized childcare and health care[29,30]. While we were unable to explicitly examine other factors that influence the baseline exercise probability in this study, it is likely that a low baseline exercise probability arises from barriers, such as time and financial resource constraints that supersede the crime's influence on LTPA. To increase LTPA participation in resource-limited communities where the baseline exercise probability is low, it will be important to better understand these other barriers to LTPA. Future studies might explore the full range of potential barriers – environmental, social, and individual - to identify those that are the biggest impediment to baseline probability to conduct LTPA among residents of resource-limited communities.

Understanding how crime may impede LTPA in urban areas is important, given that while nationally, crime is decreasing overall, there has been an uptick in crime in urban areas similar to Washington, D.C. [31]. Our model is specific to Washington, D.C., but exploring scenarios that vary the baseline exercise probability can provide insights into the impact of crime reduction policies in other cities with different baseline probabilities to exercise. Our findings might be applicable to other cities like Chicago, Milwaukee, Detroit, and Baltimore. We also consider a scenario where the baseline probability to exercise is 100%. While we acknowledge this is a highly unlikely scenario, this allows us to isolate the effect of crime reduction on LTPA, overweight, and obesity. This scenario suggests that if no other factors affect LTPA except for crime, a near complete reduction in the impact of crime would decrease obesity prevalence by close to one-quarter. Importantly, we see that if future policy efforts can address barriers to LTPA to increase the baseline exercise probability, it would become important to more directly consider the effect of crime on LTPA.

An important and unique contribution of our modeling approach is our ability to examine the geo-specific nature of the relationship between crime and LTPA. Our findings suggest that an important policy lever may include efforts to alter people's perceptions of the proximity of a crime given that the sensitivity analysis demonstrates changing the radius of crime's impact is the most important mechanism through which crime affects LTPA. Radius as a crime parameter may represent how proximal people feel to crime (i.e., agents may alter their behavior due to a crime that occurred 0.25 miles away from a LTPA location if they feel that this is close to them, but may not be affected by a crime that occurred 0.75 miles away if they do not feel that this is proximal). Policies and interventions that change people's perceptions of crime's proximity to them, such that they feel safer, can be done in parallel with crime reduction efforts. This might include community engagement efforts, community policing to build relationships and trust between communities and police departments[32,33], increased police presence around frequently used LTPA locations such as parks and community recreational centers, and public-private partnerships for the development of safe, low-cost, commercial gyms – especially in locales, such as Washington DC's Ward 8, where no commercial gyms currently exist[34,35]. Unlike traditional epidemiologic studies that rely upon counts or density measures of crime, the agent-based model allowed us to differentiate between accessibility to LTPA locations, which accounts for the geo-spatial nature of crime, from commonly used aggregate measures of crime. For example, a community may experience large numbers of crime, but this may not necessarily deter LTPA if crimes occur far from LTPA locations, while even a small amount of crime near parks or recreational centers may impact accessibility and deter LTPA.

Limitations

All models are a simplification of reality and cannot account for all possible factors that may affect PA decision-making. Our model included a number of simplifying assumptions, such as crime having the same effect on LTPA behavior regardless of the time of day or type of crime within each category (property or violent crime), and a constant effect through the entire affected radius. We did not account for differences in the quality of LTPA locations. Our use of objective measures of crime may not accurately reflect agents' perceptions of crime. Recent studies have observed weak correlations between perceptions of crime and actual crime incidents[36,37] and have even suggested these constructs to be measuring different aspects of crime[37]. However, both objective and subjective[36] measures of crime are deemed important correlates of leisure physical activity. We also did not examine the specific factors that contribute to the baseline probability to exercise. We also considered only one potential mechanism through which crime might influence obesity, but crime also affects obesity through changes to the food environment[38] or through psychological stress and physiological changes[39]. When calculating body weight changes for each woman over the course of the year, we assumed that compensatory eating did not occur (i.e., women consumed the same amount of calories despite doing more PA in response to increased PA location accessibility). Our model simulated behavior of and used data specific to an urban, low-income population of African-American women. This may limit generalizability of our findings to other populations or to suburban/rural areas.

Conclusions

Given the pressing need to address the obesity epidemic, it is important to find ways to increase LTPA, particularly in populations at high risk for obesity and a sedentary lifestyle such as low-income African American women. In our study, we examined how reductions in crime, by changing the accessibility to LTPA locations, can affect LTPA participation and obesity prevalence. Our results suggest that the influence of crime on LTPA likely becomes more important as other psychosocial and socioeconomic factors that influence propensity to exercise are addressed. Thus, policies that aim to reduce obesity by increasing LTPA should take a multilevel approach that targets individual-level and environmental barriers, including crime. In particular, efforts that target crime through urban renewal efforts and policies to improve perceived safety in resource-limited, urban communities may be particularly effective in improving physical activity levels and cardio-metabolic health for high-risk populations.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding: No financial disclosures were reported by the authors of this paper.

References

1. Services USDoHaH. Physical Activity and Health: A Report of the Surgen General. La Revue du praticien. 1996; 60:1996.
2. Kruger J, Kohl HW III, Miles IJ. Prevalence of regular physical activity among adults-United States, 2001 and 2005. Morbidity and Mortality Weekly Report. 2007; 56:1209–1212. [PubMed: 18030281]
3. Whitt-Glover MC, Taylor WC, Heath GW, Macera CA. Self-Reported Physical Activity Among Blacks. Estimates from National Surveys. American Journal of Preventive Medicine. 2007; 33:412–417. [PubMed: 17950407]
4. Schoenborn, Ca, Adams, PE. Health behaviors of adults: United States, 2005–2007. Vital and health statistics. 2010:1–132. Series 10, Data from the National Health Survey.
5. Ogden CL, Carroll MD, Fryar CD, Flegal KM. Prevalence of Obesity Among Adults and Youth: United States, 2011–2014. NCHS data brief. 2015:1–8.
6. McGinn AP, Evenson KR, Herring AH, Huston SL, Rodriguez DA. The association of perceived and objectively measured crime with physical activity: a cross-sectional analysis. J Phys Act Health. 2008; 5:117–131. [PubMed: 18209258]
7. Loukaitou-Sideris A, Eck JE. Crime prevention and active living. Am J Health Promot. 2007; 21:380–389. iii. [PubMed: 17465184]
8. Foster S, Giles-Corti B. The built environment, neighborhood crime and constrained physical activity: An exploration of inconsistent findings. Preventive Medicine. 2008; 47:241–251. [PubMed: 18499242]
9. da Silva IC, Payne VL, Hino AA, et al. Physical Activity and Safety From Crime Among Adults: A Systematic Review. Journal of Physical Activity & Health. 2015:1–78.
10. Yu E, Lippert AM. Neighborhood Crime Rate, Weight – Related Behaviors, and Obesity: A Systematic Review of the Literature. Sociology Compass. 2016; 10(3):187–207.
11. DC State Data Center based on U.S. Census Bureau. American Community Survey. 2010–2014.

12. Hall KD, Butte NF, Swinburn BA, Chow CC. Dynamics of childhood growth and obesity: development and validation of a quantitative mathematical model. The lancet Diabetes & endocrinology. 2013; 1(2):97–105. [PubMed: 24349967]
13. Lee BY, Adam A, Zenkov E, et al. Modeling The Economic And Health Impact Of Increasing Children's Physical Activity In The United States. Health Affairs. 2017; 36(5):902–908. [PubMed: 28461358]
14. Joseph RP, Ainsworth BE, Keller C, Dodgson JE. Barriers to Physical Activity Among African American Women: An Integrative Review of the Literature. Women & health. 2015; 55(6):679–699. [PubMed: 25909603]
15. Strong LL, Reitzel LR, Wetter DW, McNeill LH. Associations of perceived neighborhood physical and social environments with physical activity and television viewing in African-American men and women. Am J Health Promot. 2013; 27(6):401–409. [PubMed: 23398134]
16. King AC, Castro C, Wilcox S, Eyler AA, Sallis JF, Brownson RC. Personal and environmental factors associated with physical inactivity among different racial-ethnic groups of U.S. middle-aged and older-aged women. Health psychology : official journal of the Division of Health Psychology, American Psychological Association. 2000; 19(4):354–364.
17. Baruth M, Sharpe PA, Parra-Medina D, Wilcox S. Perceived Barriers to Exercise and Healthy Eating Among Women from Disadvantaged Neighborhoods: Results from a Focus Groups Assessment. Women & health. 2014; 54(4):336–353. [PubMed: 24617795]
18. Prince SA, Reed JL, Martinello N, et al. Why are adult women physically active? A systematic review of prospective cohort studies to identify intrapersonal, social environmental and physical environmental determinants. Obesity Reviews. 2016; 17(10):919–944. [PubMed: 27465602]
19. Centers for Disease Control and Prevention (CDC). [Accessed 2017, Feb 15] CDC Vital Signs: More People Walk to Better Health. CDC Vital Signs. 2012. https://www.cdc.gov/vitalsigns/walking/
20. Dunton GF, Berrigan D, Ballard-Barbash R, Graubard BI, Atienza AA. Environmental influences on exercise intensity and duration in a U.S. time use study. Medicine and science in sports and exercise. 2009; 41(9):1698–1705. [PubMed: 19657302]
21. Fish JS, Ettner S, Ang A, Brown AF. Association of perceived neighborhood safety on body mass index. American journal of public health. 2010; 100(11):2296–2303. [PubMed: 20864717]
22. Wheaton, WD., Cajka, JC., Chasteen, BM., et al. Methods report. Vol. 2009. RTI Press; 2009. Synthesized population databases: A US geospatial database for agent-based models; p. 905
23. Centers for Disease Control and Prevention (CDC). National Center for Health Statistics (NHCS). U.S. Department of Health and Human Services CfDCaP. National Health and Nutrition Examination and Survey (NHANES). Hyattsville, MD: 2013–2014.
24. Department MP. DC Police Crime Mapping. http://crimemap.dc.gov/CrimeMapSearch.aspx
25. Yingling LR, Brooks AT, Wallen GR, et al. Community Engagement to Optimize the Use of Web-Based and Wearable Technology in a Cardiovascular Health and Needs Assessment Study: A Mixed Methods Approach. JMIR mHealth and uHealth. 2016; 4(2):e38. [PubMed: 27113680]
26. Thomas S, Yingling L, Mitchell V, et al. Adherence with Physical Activity Monitoring Wearable Devices in a Community-Based Population: Observations from the Washington, D.C., Cardiovascular Health and Needs Assessment. Translational Behavioral Medicine. 2017
27. Thomas S, Yingling L, Adu-Brimpong J, et al. Mobile Health Technology Can Objectively Capture Physical Activity (PA) Targets Among African-American Women Within Resource-Limited Communities-the Washington, D.C. Cardiovascular Health and Needs Assessment. J Racial Ethn Health Disparities. 2016
28. Centers for Disease Control and Prevention (CDC). Behavioral Risk Factor Surveillance System (BRFSS).
29. Brown BB, Werner CM, Tribby CP, Miller HJ, Smith KR. Transit use, physical activity, and body mass index changes: objective measures associated with complete street light-rail construction. American journal of public health. 2015; 105(7):1468–1474. [PubMed: 25973829]
30. Miller HJ, Tribby CP, Brown BB, et al. Public transit generates new physical activity: evidence from individual GPS and accelerometer data before and after light rail construction in a neighborhood of Salt Lake City, Utah, USA. Health & place. 2015; 36:8–17. [PubMed: 26340643]

31. Johnson, C. [Accessed 1 December 2016] FBI: Murders Up Nearly 11 Percent in 2015; violent Crime Rose Slightly. the two-way: Breaking News from NPR. 2016. http://www.npr.org/sections/thetwo-way/2016/09/26/495460107/fbi-violent-crime-rose-slightly-in-2015-murders-up-nearly-11-percent?sc=17&f=495460107&utm_source=iosnewsapp&utm_medium=Email&utm_campaign=app
32. Palladian Partners I. Strengthening the Relationships between Law Enforcement and Communities of Color: Developing an Agenda for Action. Washington, DC: Office of Community Oriented Policing Services; 2014. https://ric-zai-inc.com/Publications/cops-p307-pub.pdf
33. Campbell, MS. The Collaboration Toolkit for law enforcement: Effective Strategies to Partner with the Community. 2011.
34. Mayor Reiman, DJ. Borough of Carteret. Public-Private Partnerships Are Essential To Redeveloping New Jersey.
35. Kania, J., Kramer, Mark. Stanford Social Innovation Review. 2011. Collective Impact.
36. McGinn AP, Evenson KR, Herring AH, Huston SL, Rodriguez DA. The association of perceived and objectively measured crime with physical activity: a cross-sectional analysis. Journal of physical activity and health. 2008; 5(1):117–131. [PubMed: 18209258]
37. Oh AY, Zenk SN, Wilbur J, Block R, McDevitt J, Wang E. Effects of perceived and objective neighborhood crime on walking frequency among midlife African American women in a home-based walking intervention. Journal of physical activity and health. 2010; 7(4):432–441. [PubMed: 20683084]
38. Le-Scherban F, Albrecht SS, Osypuk TL, Sanchez BN, Diez Roux AV. Neighborhood ethnic composition, spatial assimilation, and change in body mass index over time among Hispanic and Chinese immigrants: Multi-Ethnic Study of Atherosclerosis. Am J Public Health. 2014; 104(11): 2138–2146. [PubMed: 25211724]
39. Pham DQ, Ommerborn MJ, Hickson DA, Taylor HA, Clark CR. Neighborhood Safety and Adipose Tissue Distribution in African Americans: The Jackson Heart Study. PLoS ONE. 2014; 9(8):e105251. [PubMed: 25166297]

Study Importance Questions

What is already known about the subject?

- African-American women have the highest rates of obesity and obesity-related cardiometabolic disease with the lowest rates of leisure-time physical activity.
- Effective lifestyle interventions to increase physical activity and reduce obesity among African American women are needed; however, little is known about the potential impact of crime reduction strategies as a part of these interventions.

What does your study add?

- Our model simulations show that crime reduction strategies as a part of a multilevel physical activity intervention can increase physical activity and reduce obesity prevalence in a simulated population of African-American women in a resource-limited, urban setting.

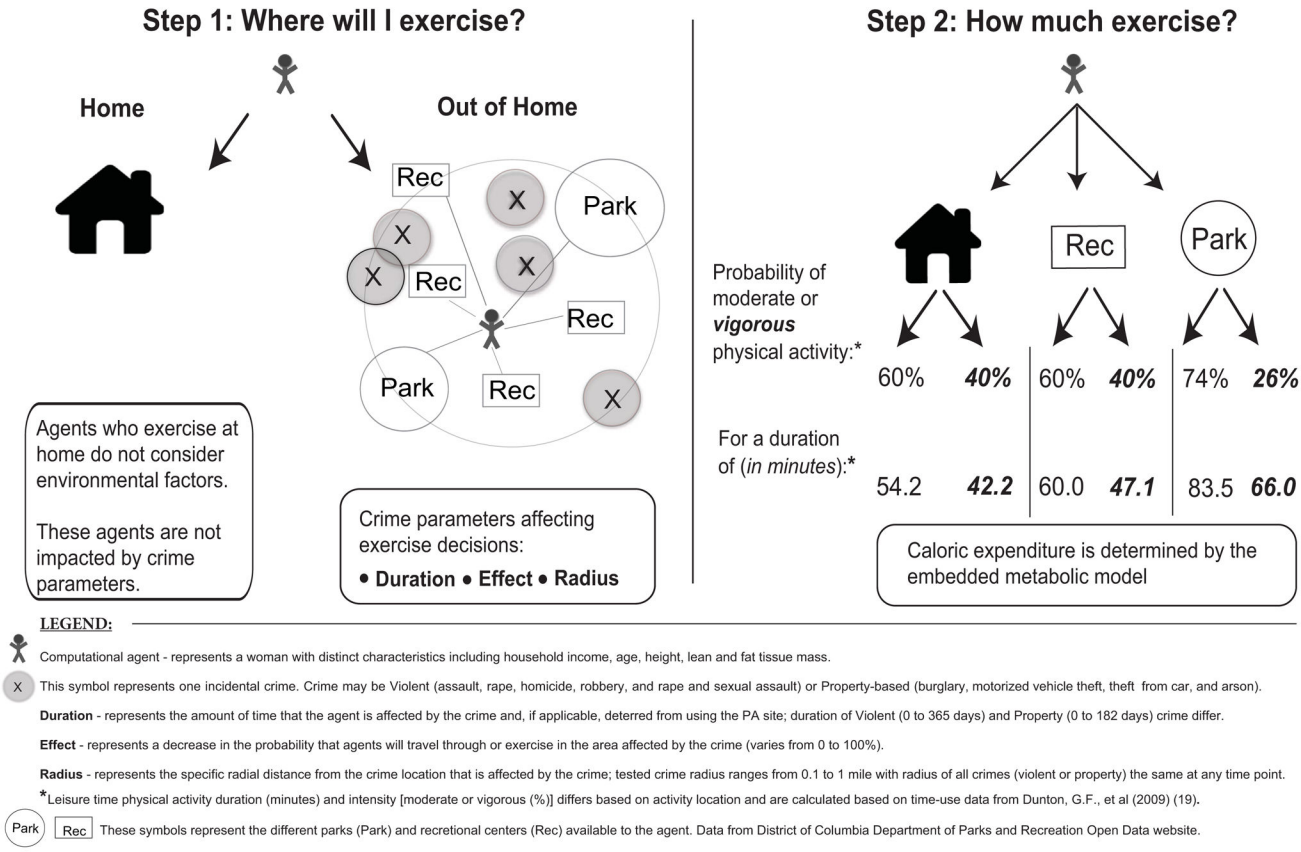

Figure 1.

Model Diagram

Computational agent - represents a woman with distinct characteristics including household income, age, height, lean and fat tissue mass.

This symbol represents one incidental crime. Crime may be Violent (assault, rape, homicide, robbery, and rape and sexual assault) or Property-based (burglary, motorized vehicle theft, theft from car, and arson).

Duration - represents the amount of time that the agent is affected by the crime and, if applicable, deterred from using the PA site; duration of Violent (0 to 365 days) and Property (0 to 182 days) crime differ.

Effect - represents a decrease in the probability that agents will travel through or exercise in the area affected by the crime (varies from 0 to 100%).

Radius - represents the specific radial distance from the crime location that is affected by the crime; tested crime radius ranges from 0.1 to 1 mile with radius of all crimes (violent or property) the same at any time point.

***** Leisure time physical activity duration (minutes) and intensity [moderate or vigorous (%)] differs based on activity location and are calculated based on time-use data from Dunton, G.F., et al (2009) (19).

These symbols represent the different parks (Park) and recretional centers (Rec) available to the agent. Data from District of Columbia Department of Parks and Recreation Open Data website.

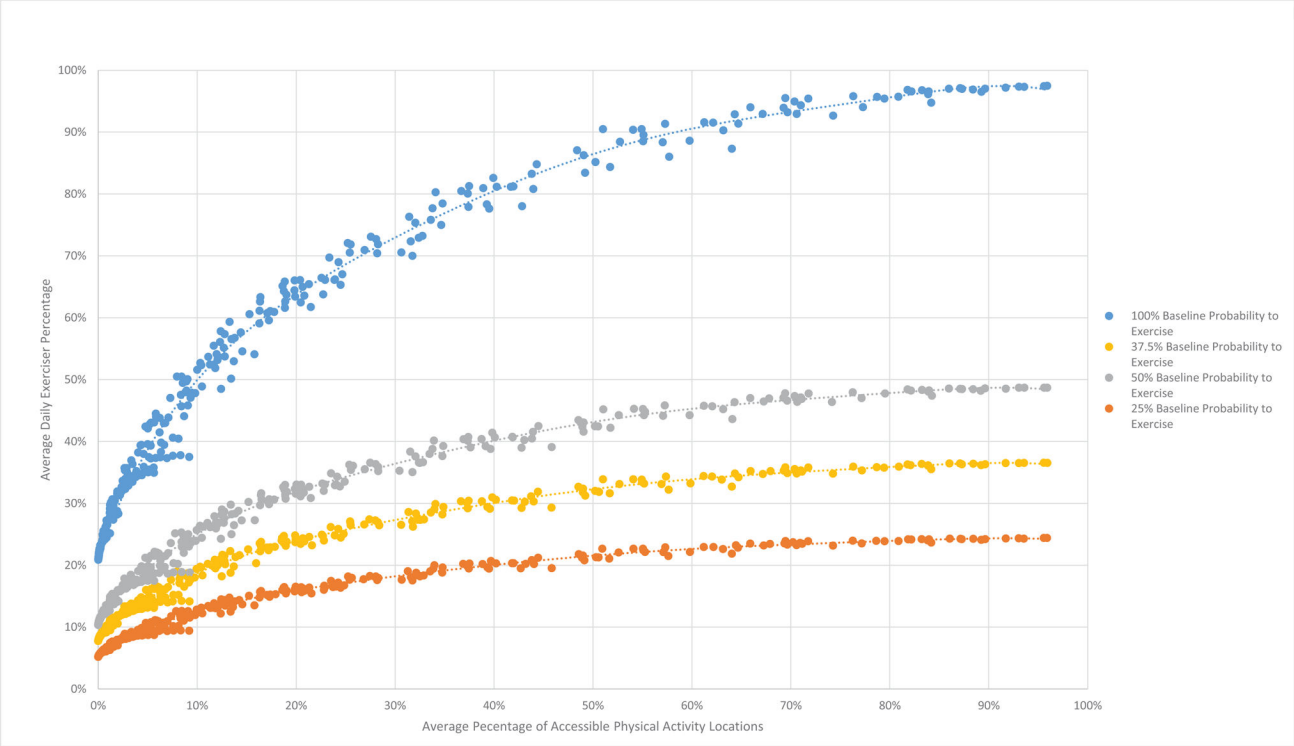

Figure 2.
Average Daily Exerciser Percentage by Average Percentage of Accessible Physical Activity Locations

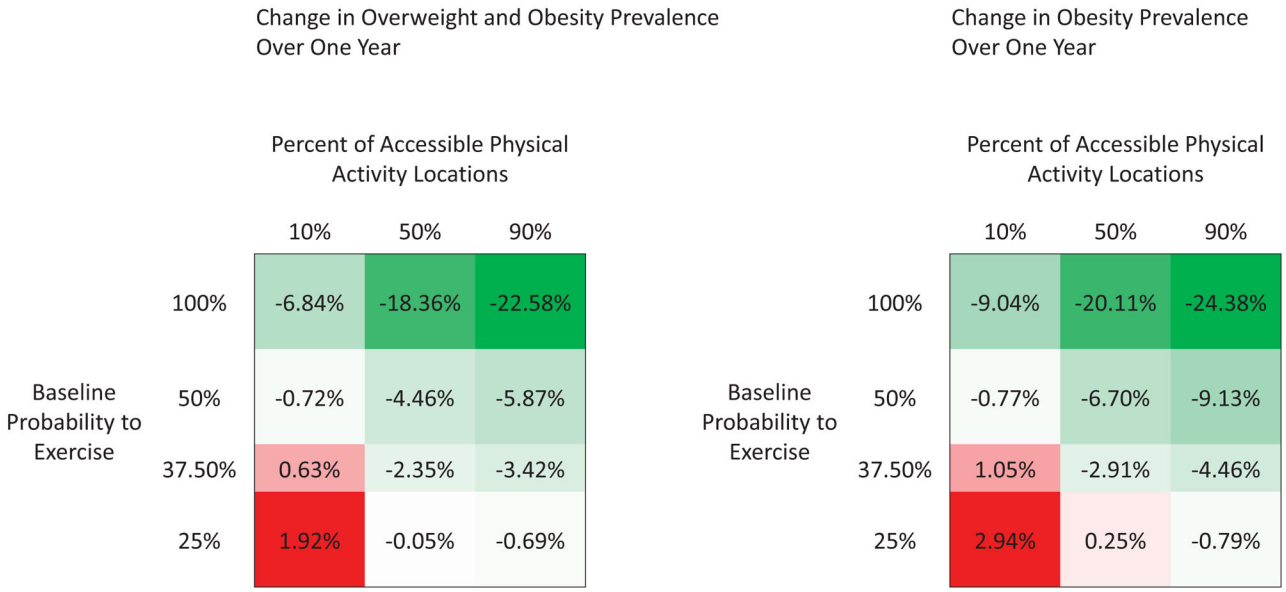

Figure 3.
Change in Overweight and Obesity Prevalence Under Different Circumstances

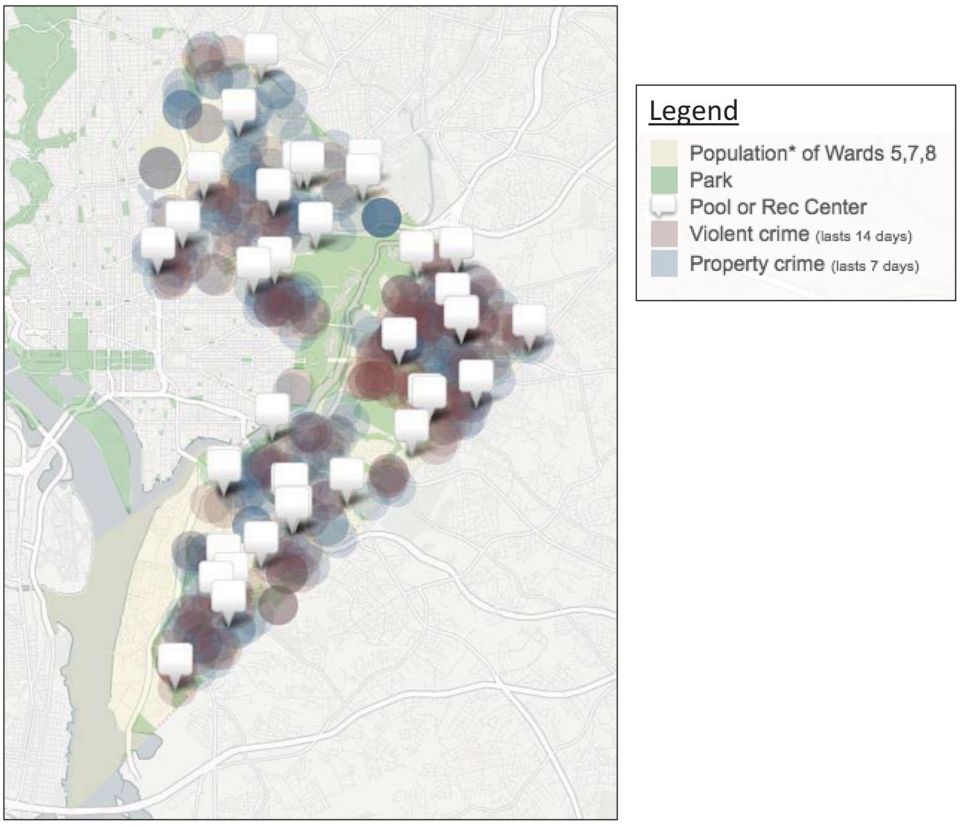

Figure 4.

Map of crime and physical activity locations in Wards 5,7 and 8 in Washington, DC

Note: crime radius = 0.3 miles; crime effect = 20%; crime duration = 14 days for violent crime and 7 days for property crime See link for interactive crime map: https://aphez.github.io/vpop-dc-crime-map-2014/