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ORIGINAL PAPER

Potentially Avertable Premature Deaths Associated with Jail Incarceration in New York City

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Abstract

This study assessed neighborhood-level association between jail incarceration and premature mortality and estimated the number of potentially avertable premature deaths associated with jail incarceration in NYC. The study outcome was premature mortality rate and the main predictor of interest was jail incarceration rate. Variables associated with premature mortality in bivariate analysis were considered for inclusion in the multivariable ordinary least squares model and in the multivariable linear mixed effects model accounting for spatial correlation. Numbers of potentially avertable premature deaths were calculated by substituting the citywide incarceration rate for the neighborhoods with incarceration rates higher than the citywide rate in the final regression model. There were large disparities in both jail incarceration and premature mortality rates. Incarceration was strongly associated with premature mortality. The number of potentially avertable premature deaths associated with jail incarceration from 2011 to 2015 was approximately 6000, representing 10% of all predicted premature deaths in NYC. This study indicates that incarceration is closely correlated with premature mortality rates, which may contribute to health inequities among low-income NYC neighborhoods with predominantly black and Latino residents.

Keywords Spatial analysis · Avoidable deaths · Inequalities · Neighborhood/place · Public health

Introduction

From 1980 to 2015, the U.S. incarnation rate has approximately tripled, reaching the highest in the world, with a rate approximately five times the average of the Organisation for Economic Co-operation and Development (OECD) countries [1, 2]. It has been estimated that approximately 40% of incarcerated people in the U.S. are incarcerated for low level offenses not related to public safety [3]. This phenomenon of mass incarceration presents challenges to public health. Those who are incarcerated are disproportionately affected by both infectious and chronic diseases [4]. Previous research has also found elevated prevalence of mental illness and substance abuse among incarcerated populations [5, 6]. In a longitudinal study of formerly incarcerated persons in Washington State, their risk of death 2 weeks after release was 13 times greater than other state residents [7].

Beyond the incarcerated individual, incarceration has a spillover effect on family members. Women with an incarcerated family member have poorer health including increased odds of cardiovascular disease [8]. Romantic partners of those who are incarcerated experience deleterious health outcomes including substance use and depression [9–11]. Children of incarcerated individuals are more likely to experience learning disabilities, behavioral problems, and developmental delays; less likely to engage in community activities; and more likely to perceive discrimination [12, 13]. Parental incarceration may also affect childhood mortality [14].

In the U.S., incarceration disproportionately affects blacks and Latinos who tend to live in segregated neighborhoods [15]. While a large number of studies have assessed the impact of incarceration on the health of incarcerated individuals and their families, relatively few have examined

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the potential impact on community health and how this may exacerbate racial and ethnic disparities. Previous research has found associations between neighborhood incarceration and health including depression and anxiety [16] and sexually transmitted infections [17]. Instead of focusing on specific disease burdens, the current study assessed the ecological association between jail incarceration and premature mortality, an overall measure of health and health equity. Incarceration was measured at the neighborhood level while controlling for other neighborhood factors, including demographics and violent felony complaint rates, which served as a proxy for the extent of the most serious crimes committed in a neighborhood. Based on the ascertained association between jail incarceration in excess of serious crime levels and premature mortality, this study then determined the number of premature deaths that could have been averted if the incarceration rate was lower in the neighborhoods with incarceration rates higher than the citywide rate.

Materials and Methods

Neighborhood Definition

This analysis defined a neighborhood as the Neighborhood Tabulation Area (NTA), a statistical area developed by the NYC Department of City Planning (DCP) for the purpose of population analysis and projections. There are 188 residential NTAs in NYC. Each NTA consists of census tracts that lie strictly within a Public Use Microdata Area (PUMA). NTAs have assigned names and boundaries corresponding to historical neighborhoods that people can easily identify. With a median population of 36,600, NTAs provide improved granularity compared with PUMAs, while having more reliable estimates than census tracts. With these advantages, NTAs represent an appropriate geography to examine neighborhood health and its determinants in NYC [18].

Measures and Data

The premature mortality rate was defined as the number of deaths < 65 years of age per 100,000 population < 65 years of age and derived from the NYC Department of Health and Mental Hygiene (DOHMH) Office of Vital Statistics data (2011–2015). The incarceration rate was defined as the number of adult (ages ≥ 18 years) admissions to a NYC Department of Correction (DOC) facility (2011–2015) per 1000 population ages ≥ 18 years. Address prior to incarceration was geocoded to the NTA using an algorithm that primarily utilizes NYC Geosupport Desktop Edition software developed by the NYC DCP. Geocoded incarceration data were deduplicated by unique person ID and NTA. The violent felony complaint rate and demographic variables were used as co-factors in the analysis. The violent felony complaint rate was defined as the number of violent felony complaints (murder and non-negligent manslaughter, robbery, and assault; rape was excluded due to censoring of location information for these complaints) reported by the New York City Police Department (NYPD) (2011–2015) per 1000 total population. X and Y coordinates from the crime data were spatially joined to the NTA shapefile to determine the NTA of the complaint, and counts were aggregated by NTA. Demographic variables were derived from aggregating census tract-level American Community Survey (ACS) (2011–2015) data to NTAs. These variables include percentage race/ethnicity (non-Hispanic white, non-Hispanic black, non-Hispanic Asian, non-Hispanic other, Hispanic) [total population], percentage age group [< 65 years of age], percentage sex [< 65 years of age], percentage below the federal poverty line [< 65 years of age], percentage foreign born [< 65 years of age], percentage unemployed of the civilian labor force [16–64 years of age], percentage less than high school education [25–64 years of age], and percentage with health insurance [18–64 years of age]. The 2011–2015 rate data were annualized by dividing by 5.

Statistical Analyses

Variables with a theoretical basis and significantly associated with premature mortality in bivariate analysis were considered for inclusion in the multivariable ordinary least squares (OLS) model. Models were weighted using the inverse of the NTA population count < 65 years of age. Variables were excluded from the multivariable model using backwards selection for variables with $p > 0.1$. Collinearity was assessed and variables with a Variance Inflation Factor > 5 were excluded from the model. Moran's I was calculated to assess spatial correlation for the outcome (premature mortality) and main predictor of interest (incarceration). A multivariable linear mixed effects model was created to account for spatial correlation using the variables included in the multivariable OLS model. The spatial correlation structure was determined by fitting a variogram of the null model with premature mortality as the outcome. A likelihood ratio (LR) test was used to determine improvement of the linear mixed effect model incorporating spatial correlation over the multivariable OLS model. Using a similar approach to previous studies, [19] we determined the numbers of potentially avertable premature deaths for the NTAs with incarceration rates above the citywide rate by substituting the citywide incarceration rate for the actual incarceration rates in the multivariable linear mixed effects model. Regression models were estimated using the gstat, sp, spdep, rgdal, and nlme packages in R 3.4.3 (Vienna, Austria).

Ethics

This study was reviewed by the NYC Department of Health and Mental Hygiene (DOHMH) Institutional Review Board, which deemed that these analyses did not constitute human subjects research.

Results

Of 393,374 instances of jail incarceration, 277,336 (70.5%) were successfully geocoded to a valid NYC address. Table 1 shows the median and range of the variables included in this analysis. The median premature mortality rate was 179.3 per 100,000 < 65 years of age (range 69.1–405.3) and the median incarceration rate was 3.8 per 1000 population ≥ 18 years of age (range 0.5–20.5). Maps of the premature mortality rates and incarceration rates are displayed in Figs. 1 and 2, respectively. There were large disparities in both premature mortality and incarceration rates among NYC neighborhoods. Residents in neighborhoods with high rates of premature mortality and incarceration are predominantly black and Latino with low household income. Significant geographic clustering was detected for both premature mortality (Moran's I = 0.61, p < 0.0001) and incarceration (Moran's I = 0.69, p < 0.0001). The spherical correlation structure best fit the data.

Table 2 shows the results of the bivariate OLS and linear mixed effects multivariable models. Incarceration, violent felony complaints, poverty, unemployment, less than high school education, race/ethnicity, native born, and female sex were associated with premature mortality in bivariate analyses. Incarceration, unemployment, and race/ethnicity were retained in the multivariable OLS model and were included in the multivariable linear mixed effects model. Incarceration, unemployment, and Asian race were statistically significant in the linear mixed effects model incorporating spatial correlation. The linear mixed effects model was a better fit than the multivariable OLS model (LR = 46.9, p < 0.0001).

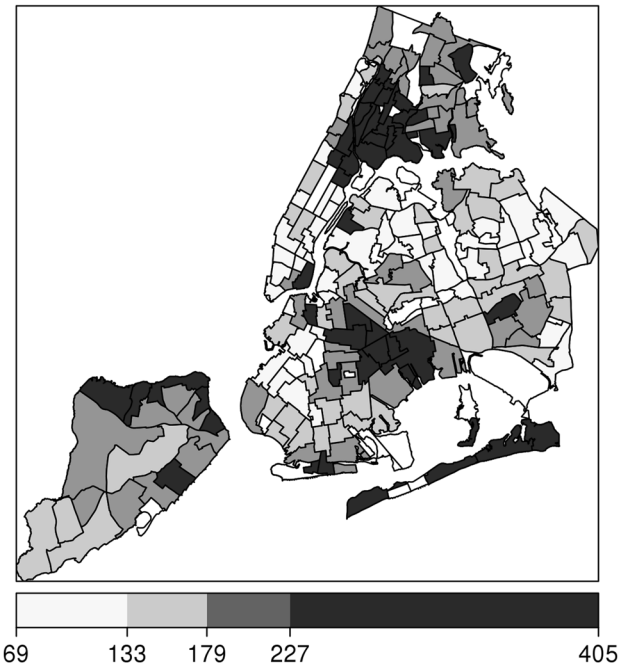

Fig. 1 NYC premature mortality (2011–2015) per 100,000 population < 65 years of age

Among the 188 residential NTAs in NYC, 67 had incarceration rates above the citywide rate (5.0 per 1000 population 18 years of age and older). The number of potentially avertable premature deaths using the hypothetical value of

Table 1 Median and range of included NYC neighborhood tabulation area study variables (2011–2015)

Variable	Median	Range
Premature mortality per 100,000 (ages < 65)	179.3	(69.1, 405.3)
Incarceration per 1000 (ages ≥ 18)	3.8	(0.5, 20.5)
Violent felony complaints per 1000 (all ages)	3.6	(0.4, 14.0)
Percentage below the poverty line (ages < 65)	17.1%	(3.8%, 57.1%)
Percentage unemployed (ages 16–64)	8.8%	(3.4%, 23.8%)
Percentage less than high school education (ages 25–64)	14.1%	(0.8%, 53.6%)
Percentage with health insurance (ages 18–64)	84.0%	(79.2%, 88.7%)
Percentage ages 45–64 (ages < 65)	28.5%	(15.8%, 48.3%)
Percentage non-Hispanic black (all ages)	9.3%	(0.1%, 90.2%)
Percentage non-Hispanic Asian (all ages)	8.0%	(0.1%, 70.5%)
Percentage non-Hispanic other race (all ages)	2.3%	(0.4%, 25.0%)
Percentage Hispanic (all ages)	20.1%	(2.7%, 88.0%)
Percentage non-Hispanic white (all ages)	25.8%	(0.5%, 95.5%)
Percentage foreign born (ages < 65)	34.2%	(7.4%, 71.0%)
Percentage female (ages < 65)	51.3%	(43.1%, 58.9%)

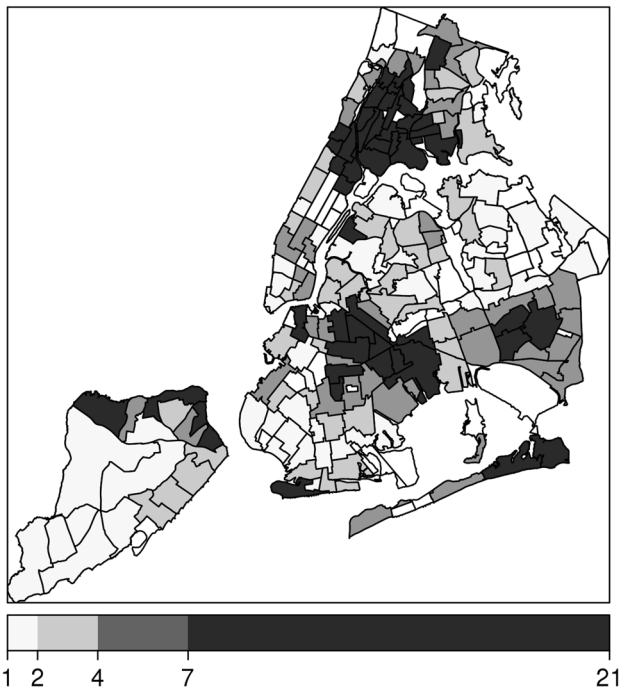

Fig. 2 Number of incarcerated adults (2011–2015) per 1000 total population ≥ 18 years of age

the citywide rate in place of the actual rates was 6363, representing 9.7% of the number of predicted premature deaths in NYC (n = 65,675) and 19.8% of the number of predicted premature deaths in the neighborhoods with incarceration rates higher than the citywide rate (n = 32,217) for this period (2011–2015). The number of potentially avertable premature deaths ranged from 4 to 334 and 1.0%–42.1% of the predicted number of premature deaths in the above-the-citywide rate neighborhoods.

Discussion

To the authors' knowledge, this is the first study to examine the relationship between neighborhood incarceration and premature mortality, as well as to quantify the potential number of avertable premature deaths associated with jail incarceration in NYC. Neighborhood incarceration, along with unemployment and Asian race, were significantly associated with premature mortality when accounting for spatial correlation. The results from this study indicate that incarceration may have impacts beyond the individual, influencing the health and well-being of the community as a whole. As much as 10% of predicted premature deaths in NYC could have been averted if incarceration rates in neighborhoods with high levels of incarceration were equal to the citywide rate.

Neighborhood crime has been hypothesized to impact health. In Chicago, poor perceived neighborhood safety was associated with limited access to health-promoting facilities (large grocery stores, pharmacies, and fitness centers) [20]. In a study of crime from a large, representative sample in England and Wales, fear of crime was correlated with poorer self-rated health even after adjusting for health behaviors and socio-economic status [21]. Likewise, among a sample of African Americans in Pittsburgh, poor perceived neighborhood safety was independently associated with higher body mass index even after adjusting for physical activity and distress [22]. However, none of these studies examined

Table 2 Coefficients and standard errors for bivariate ordinary least squares and multivariable linear mixed effects models for the outcome of neighborhood tabulation area premature mortality (2011–2015)

Variable	Bivariate ordinary least squares Coeff (SE)	Multivariable linear mixed effects Coeff (SE)
Incarceration per 1000 (ages ≥ 18)	10.7 (0.9)**	9.6 (1.1)**
Violent felony complaints per 1000 (all ages)	12.6 (1.4)**	N/A
Percentage below the poverty line (ages < 65)	3.1 (0.4)**	N/A
Percentage unemployed (ages 16–64)	11.4 (1.0)**	4.2 (1.0)**
Percentage less than high school education (ages 25–64)	2.8 (0.4)**	N/A
Percentage with health insurance (ages 18–64)	−0.8 (0.6)	N/A
Percentage ages 45–64 (ages < 65)	−0.1 (0.9)	N/A
Percentage non-Hispanic black (all ages)	1.0 (0.2)**	0.4 (0.2)
Percentage non-Hispanic Asian (all ages)	−1.9 (0.3)**	0.5 (0.2)*
Percentage non-Hispanic other race (all ages)	1.2 (0.3)**	−0.6 (0.9)
Percentage Hispanic (all ages)	1.1 (0.2)**	−0.2 (0.2)
Percentage non-Hispanic white (all ages)	Ref.	Ref.
Percentage foreign born (ages < 65)	−0.8 (0.4)*	N/A
Percentage female (ages < 65)	8.8 (1.8)**	N/A

*p < 0.05; **p < 0.01

how incarceration interacts with crime and health. The current study found that while crime was associated with premature mortality in the bivariate analysis, incarceration may have a greater influence on neighborhood health. After controlling for violent felony complaints, incarceration was still strongly associated with premature mortality, suggesting that incarceration in excess of the commensurate levels to the extent of serious crimes in a neighborhood may have deleterious effects on neighborhood health.

Incarceration has previously been proposed as a factor for increasing community health inequity [23]. Those who have been incarcerated have increased risk for premature mortality [7, 24]. If those who were formerly incarcerated return to their neighborhood of residence prior to incarceration, then their individual risk would contribute to the community risk for premature death. The heightened community risk associated with incarceration may also have resulted from premature deaths among incarcerated individuals' family members who are at greater risk for poor health outcomes [8–11, 14]. Incarceration may affect the broader community through repercussions on the social capital (e.g., by disrupting social networks and distorting social norms for desired community outcomes), collective efficacy (ex. by diminishing the capacity of residents to make decisions about their communities), and residential stability of communities (ex. by diverting political and economic capital away from the neighborhoods) [25]. The disruption of social networks from incarceration may reduce household income, increase stigma and fatalism, and impact mental health (e.g., depression and anxiety), which may have distal effects on physical health outcomes [9, 13, 16, 26]. Additional research is needed to understand how incarceration can have reverberating effects throughout the community.

It is striking that as much as 10% of all premature deaths in NYC could have been avoided if the incarceration rate in high burdened neighborhoods was as low as the citywide rate, even after accounting for other neighborhood factors. The reduction in predicted premature mortality could be as large as 40% in some neighborhoods. In a city with decreasing crime, the current administration has focused efforts to further reduce the jail population by reserving jail for serious offenses, allowing supervised release as an alternative to bail, increasing supportive housing for those with serious mental illness and substance use disorders, and creating and expanding services to prevent offenses. As of December 2017, the NYC jail population was the lowest it has been in over three decades [27]. If the NYC jail population continues to decrease, the results from the current study indicate that neighborhood health may also improve. Given the large proportion of those who are incarcerated for minor offenses in the U.S., [3] if the association between incarceration and premature mortality persists at the national level, then lowering incarceration rates has the potential to improve premature mortality rates in areas with high levels of incarceration. Given the U.S.'s high incarceration rate, this could result in the reduction of a large number of premature deaths.

Another compelling finding from the current study is that the relationship between race/ethnicity and premature mortality diminished in significance in the linear mixed effects model that included incarceration and unemployment while accounting for spatial correlation. In the spatial model, black race, other race, and Hispanic ethnicity were no longer significantly associated with premature mortality, whereas the association for Asian race remained significant. However, caution should be taken in interpreting the significance of Asian race given that the sign of the coefficient changed from negative in the multivariable OLS model to positive in the multivariable linear mixed effects model. Massoglia similarly found that incarceration considerably attenuated the effect of racial differences in physical and mental health functioning among a nationally representative sample of U.S. men and women [28]. Blacks and Latinos have high incarceration rates, which may play a role in magnifying health disparities among these populations [23]. NYC neighborhoods are racially segregated and the relationship between incarceration and premature mortality may be moderated by the disproportionate number of arrests for low-level offenses among blacks and Latinos, as has been found to be the case for marijuana arrests [29].

Neighborhood unemployment was also independently associated with premature mortality. Neighborhoods with high unemployment may have lower utilization rates of preventive health resources, which may affect premature mortality rates [30]. In neighborhoods with large numbers of blacks and Latinos, institutional racism may impact neighborhood employment through discrimination in labor markets and systemic underinvestment in marketable skills [31]. Incarceration history may impact economic opportunities as employers may be reluctant to hire those who were formerly incarcerated and unemployment may be a factor leading to recidivism [32]. It is likely that neighborhoods have maintained similar incarceration rates over time, in which case neighborhood unemployment could be a proxy for history of past incarceration, which is a likely driver of poor health outcomes [28, 33]. The association between neighborhood unemployment and premature mortality warrants further exploration.

Limitations

This study was subject to several limitations. This study utilized aggregate data and may be subject to ecological fallacy; conclusions should not necessarily be drawn based on individual characteristics. The ability to geocode was limited by the data quality; records which were incomplete,

inaccurate, outside NYC, and/or had a homeless designation could not be geocoded and neighborhood incarceration rates may be underestimated. However, if the extent of underestimation is larger in neighborhoods with high premature mortality, then the effect of incarceration would be attenuated compared to the results of this study. DOC admission data were deduplicated by individual, which does not capture the frequency of incarceration by neighborhood, nor did this study consider lengths of stays nor account for incarceration at state and federal prisons. In 2011, the average length of stay in DOC facilities was 54 days, 36% of the population was detained for less than 5 days, and 75% were discharged directly to the community [34]. However, the relationship between incarceration and premature mortality may be stronger for those neighborhoods where individuals are frequently incarcerated, have longer stays, and have been incarcerated in state and federal prison facilities. However, other studies indicate that mere exposure to the criminal justice system may have a greater impact on health at the individual-level than the length of time incarcerated [4, 24]. Census tract-level ACS data for race and ethnicity were not available by age, it is possible that these percentages may vary by age within NTAs given differences in fertility, immigration status, and premature mortality rates. The crime data included in this analysis were based on complaints to the NYPD; no additional information was available on arrests, charges, or convictions. The violent felony complaint rate was also calculated using the total population since the age structure of the population is not relevant for this measure. Similarly, the incarceration rate for those ≥ 65 years of age was not immediately available, but the proportion of those incarcerated who are ≥ 65 years of age is relatively small. Correlation does not imply causation and the relationship between incarceration and premature mortality is likely part of a complex web of social factors that manifest over a prolonged period of time; the current study included contemporaneous covariates which were found to be significantly correlated with premature mortality, but it is possible that there were factors, both concurrent and historic, that were not accounted for in this analysis. For example, it is possible that racism is driving these disparities, as Chae et al. have found area racism was associated with the prevalence of poor birth outcomes in the U.S [35]. The omission of such factors could have biased the regression estimates, leading to a possibly inflated estimate for the number of potentially avertable premature deaths. Furthermore, this analysis was based on NYC data and may or may not be generalizeable to other jurisdictions.

This study provides evidence that incarceration may contribute to neighborhood health inequities. In particular, incarceration may be driving premature mortality rates among low-income neighborhoods with predominantly black and Latino residents. Neighborhoods with high rates of incarceration may be a consequence of differential implementation of criminal justice policies and practices rather than the actions of those living in these communities. Neighborhoods that are highly burdened by incarceration and unemployment may experience disproportionate "weathering," whereby health deterioration stems from the cumulative impact of social and economic stressors [36]. Future research should consider using qualitative methods and/or hierarchical modeling nesting individual-level data within neighborhoods to gain an in-depth understanding of neighborhoods' exposure to the criminal justice system and how this may impact community health, along with examining if the association between neighborhood incarceration and premature mortality exists in other jurisdictions and at the national level. Policies and programs focused on improving neighborhood health and reducing health inequities should acknowledge the potential effect of incarceration on health outcomes.

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Compliance with Ethical Standards

Conflict of interest The authors do not have any competing interests to declare.

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