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Food Insecurity Predicts Urban Gun Violence

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Abstract

Introduction: Food insecurity (FI), defined as inadequate access to affordable and quality nutrition, has negative health consequences. FI and violence share similar root causes. The aim of this study was to determine the association of FI with gunshot injury (GSI) incidence.

Methods: We performed a retrospective review of all patients from 2012 to 2018 who sustained a GSI. Food access data was abstracted from the US Department of Agriculture. We analyzed the impact of FI, low food access (LA), and low food access with no vehicle (LANV) on the incidence of GSI using Poisson regression. We also compared high-risk zip codes for GSI, FI, LA, and LANV using geospatial analysis.

Results: There were 1700 patients in our cohort from 33 different zip codes. The median incidence of GSI per zip code was 142 (85-164); 5 zip codes comprised 50% of all GSI events. FI (incidence rate ratio [IRR] 4.05, 95% CI 3.98-4.13, $P < .0001$), LA (IRR 2.97, 95% CI 2.92-3.03. $P < .0001$), and LANV (IRR 2.58, 95% CI 2.55-2.62, $P < .0001$) were significant predictors of GSI incidence. The FI model was superior to the LA and LANV models. Geospatial analysis demonstrated that both FI ($P < .0001$) and LANV ($P < .0001$) were significantly associated with GSI, while LA was not ($P > .05$).

Conclusion: FI is an independent risk factor for GSI incidence. Additionally, a majority of GSI events occur in a minority of communities. These data provide a novel opportunity for social services to guide future violence prevention strategies.

Keywords
food insecurity, gunshot injury, urban population

Introduction

In 2019, the United Nations estimated that more than 840 million people worldwide lacked the essential resources to attain reliable, affordable, and quality nutrition.[1] By definition, these individuals were food insecure. In the United States, at least 18 million households experience severe food insecurity (FI),[2] which can be exacerbated by financial instability, inadequate housing, and other material hardships (eg, limited transportation).[3,4] Furthermore, in major American cities, such as Atlanta, GA, rapid urbanization has intensified this issue as low quality, fast food is readily available and is relatively inexpensive.[4,5]

The adverse effects of FI are far-reaching. Reports from a nationally representative sample of students in the Early Childhood Longitudinal Study reveal FI results in developmental, social, and behavioral difficulties.[6] In adults, serious negative health consequences have also been linked to FI, including chronic illnesses, mental health issues, and substance abuse.[7-11] Interestingly, FI and interpersonal violence share similar root causes, such as poverty, yet, limited data exist on the relationship between FI and gunshot injury (GSI).[12] Both of these public health issues affect all individuals across the lifespan but have been shown to disproportionately afflict urban areas.[13,14]

Understanding the relationship between GSI and poor food access may help to tailor service provisions and provide targets for injury prevention. Therefore, the aim of this study was to determine the relationship between

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impaired food access and urban firearm injury. We hypothesized that areas with a high prevalence of low food access, evidenced by a combination of long distance, low income, and lack of transportation, would geographically correlate with areas of high rates of GSI incidence.

Methods

We performed a retrospective review of our Level 1 trauma center registry for patients who sustained GSI between 2012 and 2018. Zip code of home address was collected for each patient. Anyone whose address was not within the city of Atlanta, GA, was excluded. We also excluded patients lacking a documented home zip code, patients with missing data points, and patients with a self-inflicted mechanism, history of suicidality, or major psychiatric disorder. Our institutional review board approved this study.

We collected information on patient demographics, comorbidities, injury details, and hospital admission disposition (operating room, intensive care unit, floor, discharged, expired). For each patient's zip code, we determined the level of food access by using publicly available data from the US Department of Agriculture's Food Access Research Atlas.[15] The atlas is based on census tract polygons, so we crosswalked all census tract data to the zip code level using the Department of Housing and Urban Development (HUD) US Postal Service ZIP Code Crosswalk File. We standardized the resulting data for each census tract's residential ratio contribution to the zip code.[16] We specifically investigated the impact of the following 3 food access variables on GSI incidence.

1. Low access (LA): the share of an urban census tract population living more than half a mile from a supermarket.
2. Low access, no vehicle (LANV): the portion of an urban census tract population with low access and no vehicle at their housing unit for transportation.
3. Low access with low income (FI): the portion of an urban population living more than half a mile from a supermarket who also have low income.

Our primary aim was to identify an association between the 3 food access variables at the zip code level and GSI incidence. If a food access variable was significantly correlative on univariable Poisson regression, it was entered into a multivariable Poisson regression, which adjusted for patient age, Glasgow Coma Scale (GCS) score, Injury Severity Score (ISS), and gender. The multivariable regression models were then compared to discern which statistically correlated best with GSI incidence.

Our secondary aim was to visually compare high-risk zip codes for GSI, FI, LA, and LANV using geospatial analysis. Because food access variables are percentages and GSI events are integers, we standardized all data points by taking each value and subtracting from it the mean of all values in a category divided by the SD. The respective zip code coordinates for each data point were then imported into a geographic information system to generate density contours (smooth bivariate nonparametric density surfaces that reflect the density of individual data points). We chose 4 contour levels to be plotted for each metric, which represented the 100%, 75%, 50%, and 25% density contours. To assess for geospatial correlation, we then performed a mixed model regression using a spatial anisotropic power structure. This approach enables distance to be a power function of spatial correlation and spatial correlations to differ in different directions.

Continuous variables were compared using Student's *t*-tests (parametric data) and Wilcoxon rank-sum tests (nonparametric data). The chi-squared tests compared categorical data. Of note, Poisson regression was used to determine associations with GSI because we analyzed numerical count data (ie, GSI events). As a result, incidence rate ratios (IRR) were generated instead of odds ratios. Food access models were compared using R^2 statistics, the square root of the mean squared prediction error (RASE), and average absolute error (AAE). A stronger correlation is noted with a larger R^2 and a smaller RASE and AAE. A P value <.05 was considered statistically significant. Data analyses were performed with JMP Pro software, Version 13 of the SAS System for Windows (Copyright 2016 SAS Institute Inc., SAS Campus Drive, Cary, NC, 27 513, USA).

Results

Patients and Food Access

There were 21 722 trauma registry patients from 2012 to 2018, of which 1700 (7.8%) met inclusion criteria. Most patients were male (90.8%, n = 1543) with a median age of 27.2 years (21.9-35.9), median GCS of 14 (14-15), and median ISS of 10 (5-18). For the cohort, 11.5% (n = 196) died in the emergency department, 43.5% (n = 740) went directly to the operating room, 9.8% (n = 167) were admitted to the intensive care unit, and 33.6% (n = 571) were admitted to the floor. Median FI was 21% (15.4%-26.8%), median low food access was 38.8% (29.9%-43%), and median low access with no vehicle was 6.5% (5.5%-11.1%). We noted that as FI, LA, and LANV increased, ISS significantly decreased (all $P < .001$) and GCS increased (all $P < .0001$); age demonstrated no trend (all $P > .05$) (Figure 1).

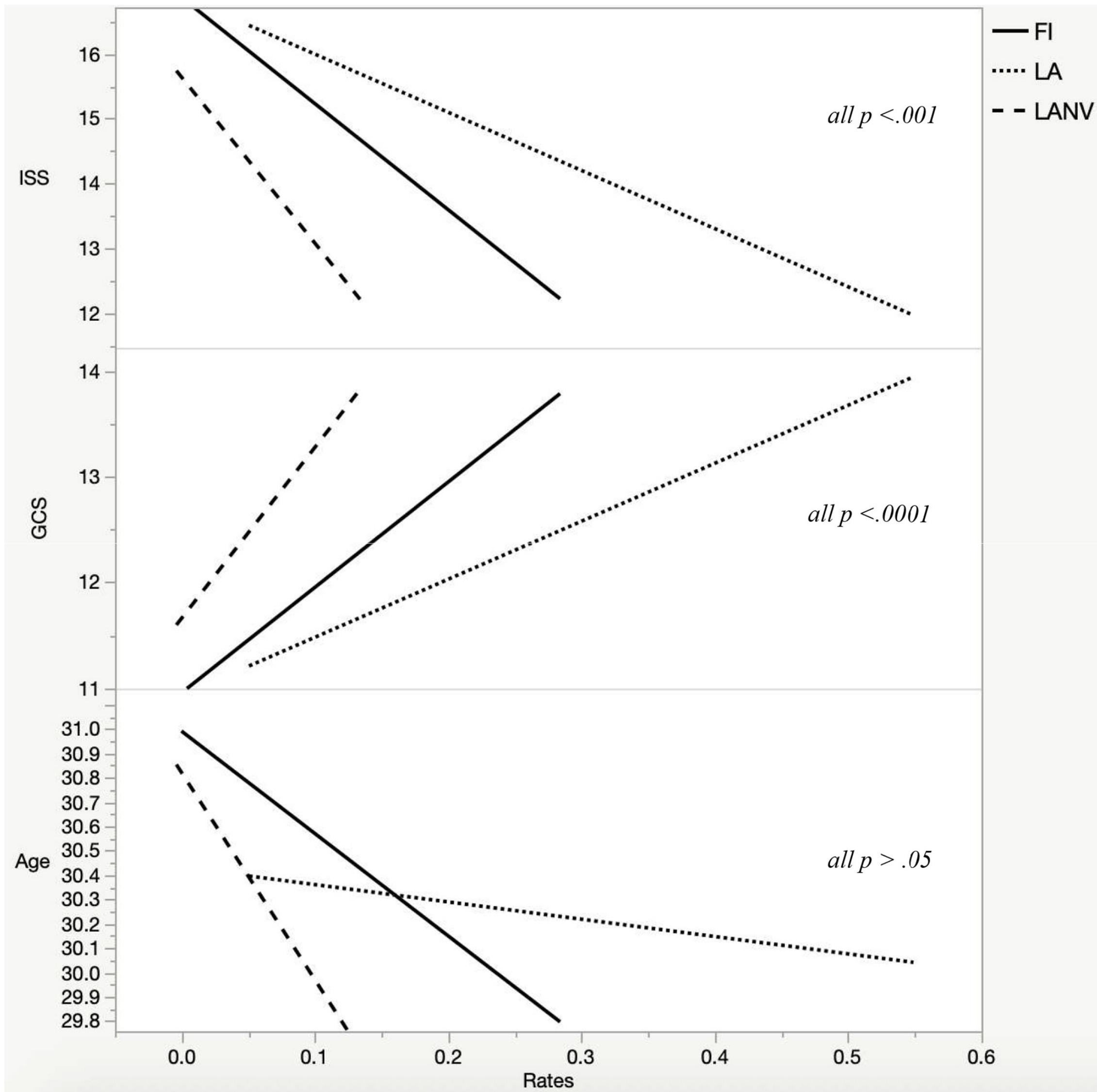

Figure 1. Relationship between food access variables and age, GCS, and ISS. FI, food insecurity; GCS, Glasgow Coma Scale; ISS, Injury Severity Score; LA, low food access; LANV, low food access with no vehicle.

Determining GSI With Food Access Variables

The median number of GSI events per zip code over the study was 142 (85-164), which yielded a median rate of 20.3 (12.1-23.4) GSI events per year. All 3 food access variables were significantly associated with GSI incidence on univariable Poisson regression. On multivariable regression, FI (IRR 4.05, 95% CI 3.98-4.13, $P < .0001$), LA (IRR 2.97, 95% CI 2.92-3.03, $P < .0001$), and LANV (IRR 2.58, 95% CI 2.55-2.62, $P < .0001$) were statistically significant in predicting GSI incidence (Table 1). When comparing the 3 models, the FI multivariable model was superior to the LA and LANV models in forecasting GSI events as demonstrated by the highest R^2 (0.57) and lowest RASE (37.7) and AAE (31.7) (Table 1).

Zip Code Patterns of GSI

Thirty-three zip codes (35.9%) of Atlanta, GA were represented by the home zip codes of the patients in our cohort. Fifty percent of GSI events occurred in only 5 of all the zip codes. Three of these 5 zip codes also had the highest FI rates, and 2 of these 5 zip codes also had the highest LANV rates. Figure 2 depicts the geospatial

Table 1. Predicting GSI With Multivariable Regression Using 3 Food Access Models.

Predictor	IRR (95% CI)[a]	*P* value	R^2	RASE	AAE
Food insecurity	4.05 (3.98-4.13)	<.0001	0.57	37.7	31.7
Low access	2.97 (2.92-3.03)	<.0001	0.33	47.0	39.9
Low food access, no vehicle	2.58 (2.55-2.62)	<.0001	0.36	45.8	36.5

Abbreviations: AAE, average absolute error; GSI, gunshot injury; IRR, incidence rate ratio; RASE, root of the mean squared prediction error.
[a]Per change in regressor over entire range.

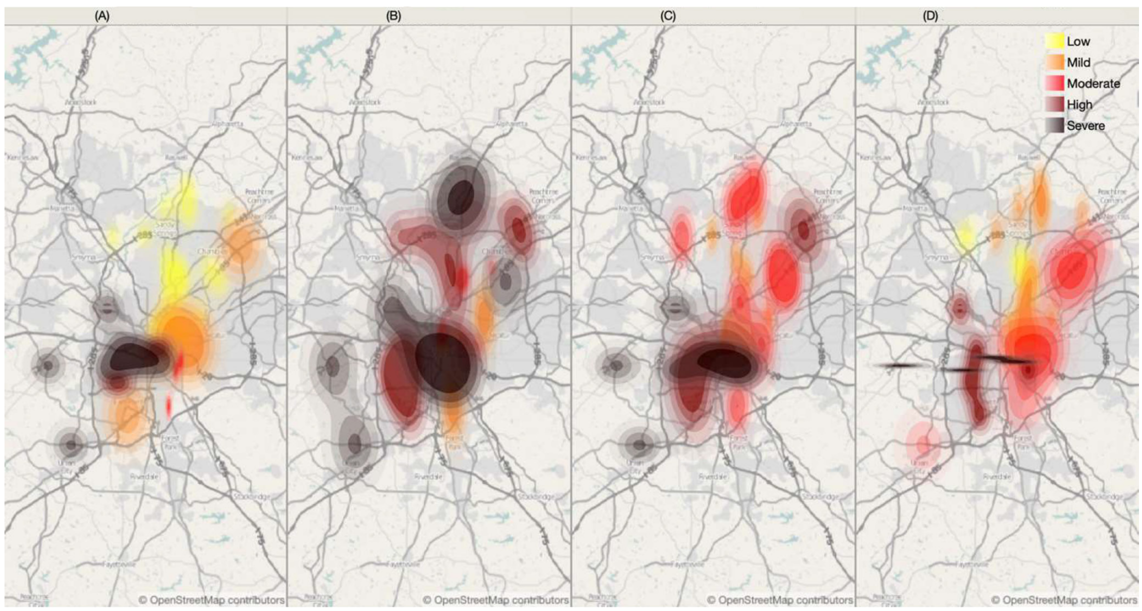

Figure 2. Visual cluster analysis of (A) GSI, (B) low access, (C) FI, and (D) low access, no vehicle in Atlanta, GA, USA.

mapping of GSI, FI, LA, and LANV in Atlanta. Geospatial regression analysis demonstrated that both FI (coefficient 49.9, $P < .0001$) and LANV (coefficient 50.8, $P < .0001$) were significantly associated with GSI, while LA was not (coefficient 9.0, $P > .05$).

Discussion

While there is a growing body of literature regarding FI and violence, we believe that our research is the first to examine the relationship between FI and GSI. We found that FI was an independent and significant risk factor for GSI incidence in our urban population. While the publicly reported FI rate for the state of Georgia approached the national average at 11.3%, areas in metropolitan Atlanta, such as Clayton, Fulton, and Dekalb counties, have FI rates that are twice the state mean with some exceeding 25%.[17] Similarly, our study median FI was 21%, which corroborates these statistics.

It is notable that other urban cities with high GSI rates similar to Atlanta also have elevated FI rates like Baltimore, MD (21.3%), St. Louis, MO (23.7%), and Chicago, IL (22%).[18] However, we found that the median ISS of our GSI cohort was 10, indicating a relatively low injury burden. Furthermore, we demonstrated that as food access metrics increased, ISS significantly decreased. This inverse correlation could suggest that FI is a marker of nonfatal gun violence in urban cities. For example, Felson et al suggest that the social factors that lead to mortality following GSI are likely different from the social factors that lead to more minor and nonfatal forms of GSI.[19]

Even after adjusting for injury severity, we noted that all 3 food access variables predicted GSI incidence; however, only FI rates and LANV rates geospatially correlated. These discoveries support our hypothesis that hot spots for FI and GSI overlap and also indicate that geographic distance from food sources is not the strongest harbinger of GSI incidence. Instead, we believe that low income or limited mobility coupled with greater distances from food access is what truly drives the increased risk of GSI. Understanding this complex relationship between GSI incidence and FI entails a discussion of structural violence, which refers to certain social structures that perpetuate health disparities. Throughout the world and much of history, FI has been extensively linked to increased risks of protests, rioting, and community violence. These conflicts can further perpetuate FI but are often assuaged in developed worlds through social assistance programs. However, the grocery industry in the United States uses “supermarket redlining” and decisions to erect food outlets are based on stereotypes, race, and reputation of a neighborhood. As a result, food stores tend to avoid habitation in urban cities and preferentially establish in suburban neighborhoods, making access for inner-city individuals a challenge.[20]

Nevertheless, FI becomes a chronic source of stress, particularly for the economically and socially disadvantaged.[20] Regions with these deteriorating economic conditions and vast inequalities between groups of people are also home to the highest rates of violent conflicts and crime.[21] Thus, FI begets violence, which begets FI. The effects of FI have also been shown to endure through generations, which supports the need to screen for low food access.[22] However, screening for FI by health care professionals occurs infrequently. In a recent nationwide physician survey with 2333 respondents, only 29.6% of physicians reported screening for FI.[23] Still, FI screening is of great public health importance, and targeting FI to reduce gun violence provides an innovative concept. Particularly for Atlanta, focusing only on 5 zip codes would theoretically address 50% of the GSI occurrence and enable outreach to the areas with the highest rates of FI and LANV.

There are several limitations that should be considered when interpreting this study. The study was retrospective in design, so we are inherently unable to demonstrate causality between food access metrics and GSI. Additionally, because the research was registry-based, intent associated with the firearm injury (ie, unintentional vs assault) was not always clearly documented. Attempts were made to mitigate this limitation by excluding patients with previous suicide attempts or major psychiatric disorders. Furthermore, we excluded patients not residing within the city of Atlanta, which consequently limits broad extrapolation of our findings to the rest of the United States. Fortunately, the study was comprised of a well-powered urban cohort, so the application of our results to other major urban cities may be conceivable. Moreover, we studied community-level food access metrics, not household or individual, which hampers personalized gun violence intervention strategies.

A final and important limitation is that we not only used zip code-specific GSI incidences but also employed census tract-specific food access data. Although we adapted census tract data to zip code appropriate information, the use of zip codes for any analytical purpose is imperfect. Zip codes were designed to efficiently deliver mail and not to perform geographic analysis. By using zip codes that have varying sizes and shapes, contrary to census tracts with relatively stable and predictable boundaries, we introduced a bias known as the modifiable areal unit problem. This common issue arises in many geospatial analyses using zip codes because while there is indeed overlap with many geographical units, zip codes are not perfectly interchangeable with, for example, census tract polygons.

FI is independently associated with an increased risk of GSI in our urban population in Atlanta. Additionally, geography imparts a significant effect as a majority of the GSIs occurred in patients residing in only a few of the city’s zip codes. These data highlight the need for addressing structural causes of GSI, such as limited food access, and provides a novel opportunity for local social services to enhance existing firearm prevention strategies.

Author's Note

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Declaration of Conflicting Interests

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