Published in final edited form as:

J Trauma Acute Care Surg. 2022 July 01; 93(1): 91–97. doi:10.1097/TA.0000000000003578.

The Association between Food Insecurity and Gun Violence in a Major Metropolitan City

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Abstract

Background: Food insecurity (FI) is an important social determinant of health that is associated with many forms of violence. We hypothesized that FI would be associated with gun violence.

Methods: Firearm injury data was collected from 2016–2020 (n=3115) at a single institution that serves as the only Level I trauma center in a major southern US city. The data was linked with Map the Meal Gap data, a publicly available dataset which estimates rates of county-level FI based on state-level FI and social determinants, including unemployment, poverty, disability, and other factors. Regression analysis was utilized to examine the relationship between FI with rates of overall gun trauma and odds of gun-related violence. FI by county of patient residence was categorized by rates less than the national average of 11.5% (Low), between the national and state

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Authorship Contribution:
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Conflicts of Interest
All other authors have no conflicts of interest or financial disclosures to report.

Presentations:
This study was presented as an oral presentation during the Cox-Templeton Injury Prevention Paper Competition at the Eastern Association for the Surgery of Trauma annual meeting in Austin, Texas on January 13th, 2022.

average (16.5%) (Moderate), and greater than the state average (High). Out of state residents were excluded from the analyses.

Results: Of the 3115 patients with firearm injuries identified, 138 (4.4%) resided in counties with low FI rates, 1048 (33.6%) in moderate FI, and 1929 (62.0%) in counties with high FI. Patients in regions of high FI were more likely to be a level 1 trauma activation, a victim of assault, and have Medicaid or be self-pay. There was no significant difference in mortality by levels of FI. FI was significantly associated with firearm injury, with each percent increase in FI being related to approximately 56 additional gun-related injuries per 100,000 people (95% confidence interval (CI): 54 – 59) and increased odds of the injury classified as assault (odds ratio: 1.13, 95% CI 1.07–1.19).

Conclusion: Violence prevention initiatives targeting food insecure communities may help alleviate the US gun violence epidemic. Further, trauma center screening for household FI and in-hospital interventions addressing FI may help reduce gun violence recidivism.

Level of Evidence: IV

Study Type: Epidemiologic

Keywords

firearm; gun; trauma; food insecurity

Background

Firearm death rates secondary to homicide, suicide, and unintentional injury are more than seven times higher in the United States (US) compared to other developed countries.(1, 2) Over the past decade, gun violence numbers have steadily increased. Annual firearm deaths in the US rose by 56% from 2014 to 2020, while firearm injuries grew by 73%.(3) The gun violence epidemic has major social and economic consequences related to healthcare costs and lost productivity.(4) In 2019, the Joint Economic Committee estimated the annual cost of firearm related injuries was be $229 billion.(5) If the worsening gun violence epidemic in the US is not addressed, the high social, economic, and physical health burden will continue to increase.

Increasingly, attention has been drawn to the impact of social determinants of health (SDOH). The World Health Organization defines SDOH as the “conditions in which people are born, grow, live, work, and age” and “the fundamental drivers of these conditions”.(6) Food insecurity (FI) is one such determinant and is defined as inadequate access or ability to acquire affordable and quality nutrition or enough food.(7) In 2010 alone, it was estimated that 48.8 million Americans were food insecure.(8) In children, FI has been associated with increased risk of developmental difficulties, anemia, cognitive problems, behavioral problems, poorer general health, and mental health issues.(9–11) In adults, consequences of FI include chronic illness (diabetes and/or hypertension), partner violence, substance abuse, poorer general health status, and lower scores on physical and mental health scales.(12–15)

Studies have shown that SDOH such as poverty, income inequality, and FI are associated with homicide and violent crime.(16, 17) Smith et al. found that FI was independently

associated with an increased risk of firearm related injury for Atlanta's urban population.(18) Despite these findings, the link between FI and gun-related trauma is still understudied, with limited studies in most U. S. cities and data generally obtained from an aggregate level. The aim of this study was to investigate the association between area-level FI and gun violence in New Orleans, Louisiana, a region with high levels of food insecurity and significant rates of gun violence. We hypothesized that rates of food insecurity would be associated with increased gun violence and overall gun-related trauma rates.

Methods

Firearm-related trauma activation data between 2016 and 2020 was acquired from the Norman E. McSwain Jr. MD, Spirit of Charity Trauma Center at University Medical Center (UMC), located in New Orleans, Louisiana. UMC registry data included all patients that met criteria for inclusion as defined by the American College of Surgeons National Trauma Data Standard data dictionary.(19) In addition, UMC is the only level 1 trauma center in southeastern Louisiana. Patients with missing parish of residence data (2.5%) were excluded from our analysis, as were patients with residence outside of Louisiana (0.8%). Transferred patients were not excluded from the analysis if they otherwise met inclusion criteria by location of residence. The resulting sample included 3,115 patients nested in 29 parishes, which are the equivalent of county in the state of Louisiana.

Outcomes of Interest

In this analysis, firearm injury was defined as any firearm-related trauma at our institutional trauma registry. Firearm violence was defined by an intent of injury classified as assault and was operationalized as a binary variable. The second outcome of interest was rate of firearm-related trauma, which was estimated by cases during the study period divided by parish population in 2018, as provided by the Map the Meal Gap (MMG) dataset.(20) For this outcome, only cases that occurred within the institutional catchment area were included. The catchment area included 9 of the 29 parishes represented in our dataset and captured 96% of the study population.(21)

Exposure of Interest

Food insecurity (FI) at the parish-level was the exposure variable of interest and was provided by the MMG dataset. The MMG dataset estimates county-level FI based on state-level rates and variables that highly associate with FI, such as disability status, income, poverty, unemployment, and homeownership rates.(20) Full methodology and details of the MMG dataset have been previously described.(20) FI estimates from 2018 were utilized for the present analysis. To examine potential demographic differences between parishes based on food insecurity, FI was classified as low, moderate, and high. Low FI was defined as a rate of FI less than the national average of 11.5% in 2018.(20) Rates between the national average of 11.5% and the state of Louisiana average, 16.1%, were classified as moderate. Parishes with high FI were defined by a FI rate greater than the Louisiana average (> 16.1%). Because FI in Louisiana is well above the national average, this categorization allowed examination of the wide range of FI between parishes in our catchment area that may not be present in other locales.

Statistical Analysis

Categorical and continuous demographic variables were examined using Pearson's chi-squared test and the Wilcoxon-Kruskal-Wallis test, respectively. Missing data were treated as missing at random, and imputation not performed, as no variable of interest had greater than 10% missing.(22)

To examine the relationship between firearm violence and overall firearm-related injury, logistic and linear regressions were utilized, respectively. In these analyses, FI rate was treated as a continuous variable. Potential model covariates considered included: age, sex, race, method of payment, FI category, psychiatric and neurologic comorbidities, and history of substance abuse. Method of payment was chosen due to its independent association with health outcomes and was stratified into Medicaid/Medicare/no cost, private/commercial, self-pay, and other.(23) Race was categorized as self-reported black, white, and other and classified as white or non-white for regression models. Race was interpreted as a marker of structural inequality and SDOH, such as consequences of residential segregation or housing and education disparities.(24, 25) Psychiatric/neurologic comorbidities were defined as a history of cerebral vascular accident with persistent dysfunction or a diagnosis of pre-injury mental/personality disorder, as described in the National Trauma Data Standard.(19) These comorbidities, along with history of substance abuse, were chosen to be considered as covariates secondary to their shown association with firearm-related injury and were encoded as binary variables in our model.(26) Initial models for each outcome were adjusted for all described covariates, with final model covariates selected based on forward and backwards stepwise AIC criterion.(27) After application of this criterion, the logistic regression examining the relationship between FI and assault was adjusted for age, race, and psychiatric/neurologic comorbidities. In the linear regression of overall rate of firearm-related trauma, final model covariates included history of substance abuse, psychiatric/neurologic comorbidities, race, and payment method.

All statistical analysis was performed using R version 3.6.3 (R Foundation for Statistical Computing, Vienna, Austria).(28) This study conforms with STROBE guidelines, and a complete checklist is provided as supplementary digital content (SCD Table 1).

Results

Population Overview

A total of 3,224 firearm-related trauma victims presented to our institution between 2016 and 2020 (Figure 1). There were 80 (2.5%) patients with missing parish of residence data and 26 (0.8%) patients who were non-Louisiana residents. After excluding these patients, 3,115 patients remained for analyses. A comparison of firearm injury cases per parish of residence, along with FI and county demographic statistics, with national and statewide averages for comparison, are shown in Supplemental Table 2 (SCD Table 2). In summary, Louisiana, compared to overall United States averages, has a higher population in poverty (19% vs. 11%), higher rates of food insecurity (16% vs. 11%), and a greater percentage of African American population (33% vs. 13%). The most represented parish, Orleans (60% of

study population), was 60% African American, with 23% of its population living in poverty and an average FI rate of 18%.

Patient Demographics

Full demographic details of our study population are shown in Table 1, stratified by low, moderate, or high FI. Most victims of firearm-related trauma lived in parishes with high FI (62% vs. 34% and 4% in moderate and low FI parishes, respectively). There was no significant difference in age or sex between groups, with an average age of approximately 26 and the majority, about 86% of patients, being male. Furthermore, there were no differences in substance use disorders, and rates of diabetes, obesity, and psychiatric and neurologic co-morbidities were similar. Patients had similar severity in injuries at baseline, with a median injury severity score (IIS) of 9 across groups and a median GCS of 15 across groups.

Race differed significantly by FI in parish of residence, with 95% of patients from high FI regions being non-white, versus 82% and 63% in moderate and low FI parishes, respectively ($p<0.001$). Most patients were recipients of Medicaid, Medicare, or other government insurance, although a significantly greater proportion of patients in low FI parishes had private insurance, and fewer were uninsured ($p=0.008$). Patients were least likely to be transfer patients if from parishes of high FI ($p<0.001$), and most likely to have arrived via private vehicle ($p <0.001$). Patients from high FI parishes were most likely to have a tier 1 activation, the highest tiered activation, and most likely to be associated with an intent of injury of assault ($p<0.001$). Approximately 41% of patients from low FI parishes were injured in a different parish of their residence, compared to 34% and 5% of patients residing in medium and high FI parishes respectively. (Figure 2)

FI and Gun Violence

There were 3,101 patients remaining in our cohort after excluding patients with undetermined intent of injury. Of these, 2,810 (90.6%) were categorized as an assault. Logistic regression analysis revealed that increasing percent of FI was significantly associated with gun violence (odds ratio (OR): 1.13, 95% confidence interval (CI): 1.07–1.19, $p<0.001$). Other variables associated with gun violence included younger age and non-white race as shown in Table 2. The presence of psychiatric or neurologic comorbidities was associated with decreased risk of assault (OR 0.42, 95% CI 0.28–0.65, $p<0.001$). Of patients with psychiatric or neurologic comorbidities, a significantly higher proportion of cases were classified as self-inflicted (16% vs. 3%, $p<0.001$).

Firearm-Related Trauma

The 3001 patients who presented with gun-related injuries during the study period are shown by parish in SDC Table 3, along with the respective estimated rate of firearm-related trauma per 100,000 residents. The most represented parish was Orleans, with 2139 cases (71.3%), which also had the highest estimated rate of gun-related trauma, with approximately 137 cases annually per 100,000 residents between 2016–2020. (Supplemental Figure E1) As shown in Table 3, on multivariable linear regression, FI was associated with firearm-related trauma (regression coefficient (RC): 56, 95% CI 54–59, $p<0.001$). Therefore, each percent increase in rate of FI at the patient's parish of residence was predictive of 56 persons per

100,000 increases in the rate of gun violence in the parish of injury between 2016 and 2020. Other variables associated with the incidence of gun-related trauma were alcohol/drug use and non-white race.

Discussion

Firearm-related trauma is a multi-faceted problem that has reached epidemic levels in the United States.(29, 30) Similarly, another public health crisis continues with an estimated 11.5% of households in the nation meeting the definition for being food insecure.(20) Social determinants of health and health disparities, such as FI, are actionable risk factors for acute trauma in the same way that diabetes is an actionable risk factor for cardiovascular pathology. In our study, we focused specifically on FI and gun-related trauma. We found that FI was an independent predictor of assault in victims of firearm injuries, and that FI was associated with an increase in the rate of overall gun-related trauma. Therefore, our findings reiterate the need for household FI screening and targeting of FI to reduce gun-related trauma.

FI was found to be independently associated with rates of violent firearm injury, which has been reported in prior studies. Using the United States Department of Agriculture's Food Access Research Atlas, Smith et al. showed that FI was associated with urban gun violence in Atlanta, Georgia.(18) Other studies have shown a similar finding. For example, community distress has been shown to be predictive of firearm violence, particularly in children.(31) Collectively, this suggests that FI may be a modifiable risk factor in preventing further gun violence in the United States. Therefore, public health measures that aim to reduce FI in communities may play a role in decreasing gun violence in urban locations.

Interestingly, patients with a psychiatric or neurologic comorbidity were less likely to be involved in firearm-related traumas classified as assault. This is consistent with previous work that has shown that mental illnesses such as depression, substance use, and psychosis are the most important risk factors associated with suicide/self-inflicted injury.(32) In our dataset, 16% of patients with psychiatric or neurologic comorbidities had self-inflicted injuries compared to 2.8% in patients without. Firearms are one of the most used methods for suicide amongst these patients and make up the second most common cause of death among patients in the second and third decade of life.(32–34)

Another important finding was that each increase in percentage of FI of the victim directly corresponded to an increase in overall gun-related trauma at the parish level. This suggests that FI is not only related to violent firearm injury, but also to self-inflicted injury, accidental shootings, and overall firearm-related trauma. Numerous studies have demonstrated links between FI and health disparity that may explain this finding.(35–37) Therefore, it is possible that reduction of FI may indirectly reduce self-inflicted firearm injury and overall firearm-related trauma, although our study is inadequately powered to show the former. In other words, it is unclear whether measures targeting FI will proportionally reduce all modalities of firearm-related trauma, or if assault, self-inflicted injury, or accidental trauma is most related to FI. Future studies that explore these relationships are needed.

Being non-white was associated with both gun violence and any firearm related injury. This finding is supported by current literature, which extensively describes the racial disparities that exist in gun violence.(29, 38, 39) For example, Beard et al. found that 82% of firearm assault victims in Philadelphia were Black.(40) Additionally, Fowler et al. found that non-Hispanic Black youth aged 15 to 24 were 19 times more likely to be victims of firearm homicide than their non-Hispanic White peers.(41) It is evident that structural racism and social determinants of health play key roles in this disparity and must be addressed.(29, 42)

Community level interventions have tried to alleviate FI, particularly in south Louisiana, where the FI is significantly worse than the national average.(43) Such organizations provide food access, advocacy, education, and disaster response to numerous community partners and programs across many parishes, aiding thousands of families struggling with FI. The most well-known of these programs is the Supplemental Nutrition Assistance Program (SNAP). Nationally, the SNAP-Education (SNAP-Ed) component of SNAP has been shown to improve food security and improve outcomes related to FI in low-income Americans and is supported by cost-effectiveness analyses and long-term projections.(44, 45) Our work suggests that coordination of SNAP and other programs that target FI may be a pipeline to reduce the incidence of gun-related trauma overall.(46) Importantly, our analysis is unable to identify whether such programs may help prevent gun-related trauma immediately or for future generations. Further studies are needed to examine the efficacy of SNAP and other programs, particularly as they may relate to gun-violence.

All verified trauma centers are required to introduce trauma related prevention measures for their community. Level I and II centers, specifically, are required to implement at least 2 programs that address major causes of injury in the community and partner with community leaders. These interventions, however, must be evidence based. With regards to firearm injury, patients hospitalized are at high risk for gun violence recidivism. A recent study by Pear et al. demonstrated that root cause interventions may have downstream impacts on the recurrence of firearm assault.(47) Therefore, our work suggests that FI interventions may be a future target of community intervention for trauma centers and partners.

Prior studies have indicated that programs aimed to improve FI are effective and well-received. For example, Aiyer et al. implemented food prescription programs for eligible patients in a recent pilot study in Harris County, Texas.(48) Based on survey results, patients appreciated the intervention, which resulted in a 94.1% decrease in prevalence of FI during the study at an average cost of only $12.20 per participant redemption, well below the cost of many medications used in the US.(48) Importantly, our results were based on parish-level FI and therefore cannot inform patient-level intervention. However, the association of FI at the parish level and gun violence found in our study in conjunction with the results of Aiyer et al. may suggest that formal, hospital-based interventions for hospitalized patients may be a mechanism to combat gun violence recidivism.

Finally, despite study strengths, limitations exist. Firstly, we assumed that patient residence at the time of their injury was their long-term residence and that the FI in the region was directly related their likelihood of involvement with gun-related injuries. We were not able to account for factors such as time lived in parish of residence. Next, when estimating rate of

overall gun-related trauma, we assumed that all cases of injury in our catchment area would be diverted to our institution, which is the general practice for Emergency Medical Services. However, for regions that may be close to other level I or II trauma centers, our estimates of gun-related trauma likely are underestimates, especially as our data is limited to patients that meet trauma activation criteria and do not die on scene. In addition, our data is specific to a single institution in southeastern Louisiana, and these findings may not be generalizable to other locales.

In conclusion, parish-level FI was independently associated with gun-violence and gun-related trauma in southeastern Louisiana. Our study supports the need to screen for FI and the plausibility of intervening for food insecure hospitalized patients as a mechanism to reduce gun-related trauma and violence. Future studies in multiple geographic locations are required to confirm our findings.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Source of Funding:

Dr. Taghavi, Dr. Theall, and Dr. Fleckman report research funding from Center for Disease Control (CDC) Center Grant (U01 CE003384-01).

Dr. Taghavi reports research funding from the Tulane Physician Scientist Pipeline Program and the Louisiana Clinical and Translational Science Center (LA CaTS) Grant (U54 GM104940)

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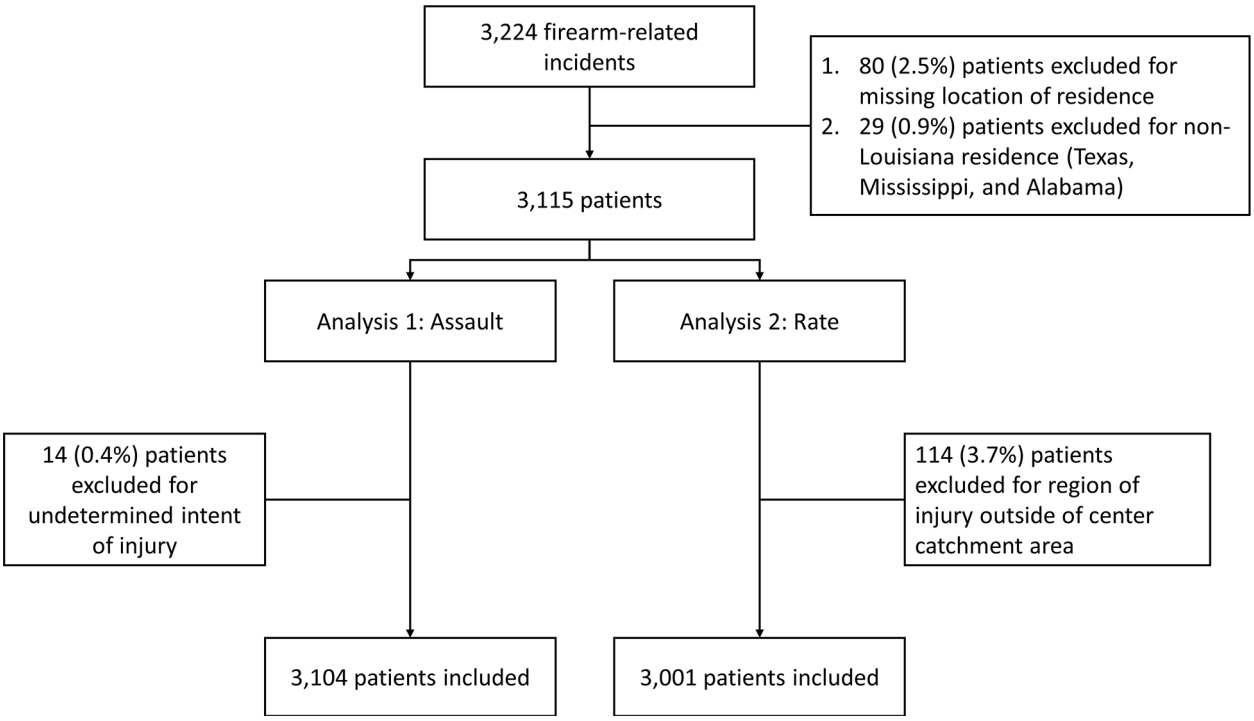

Figure 1:
Patient Selection

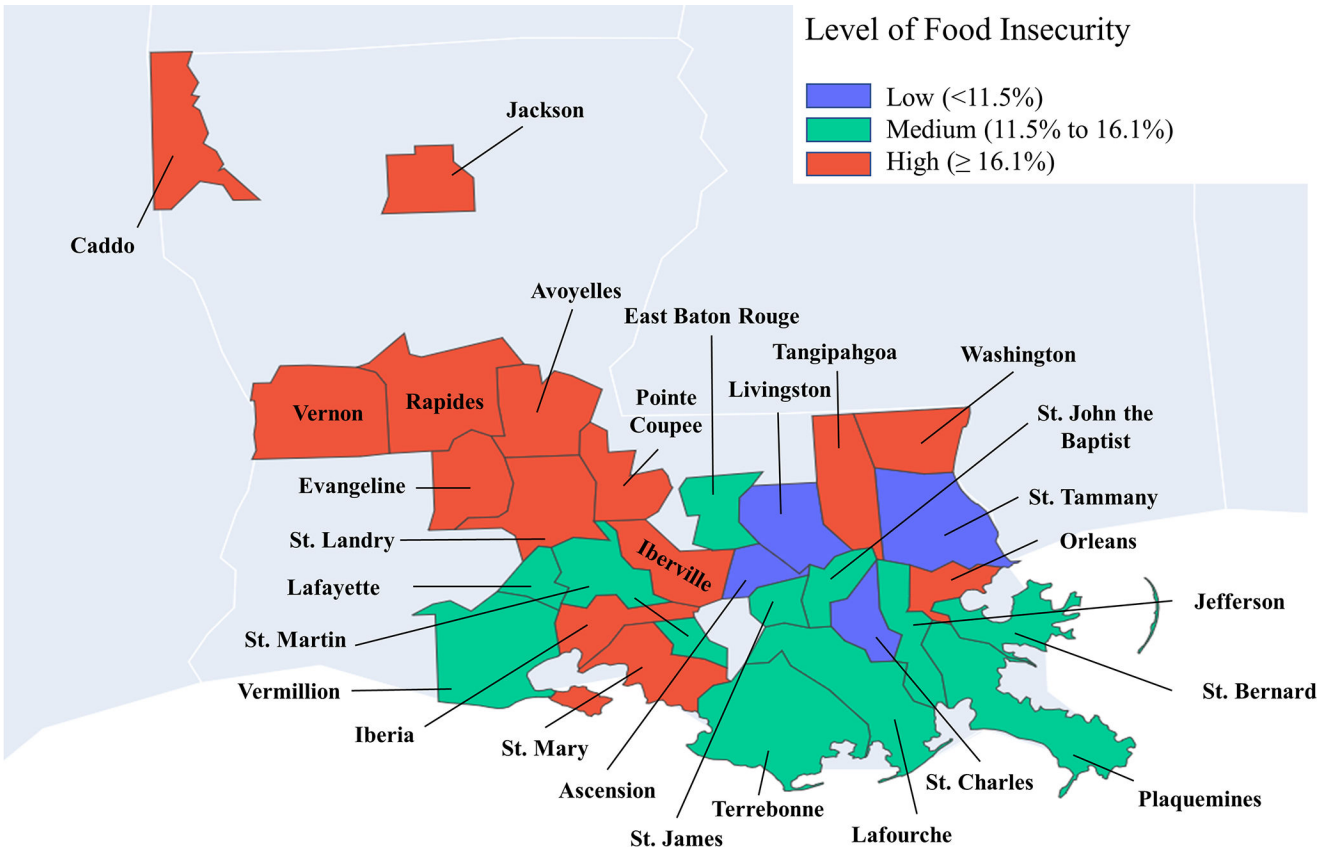

Figure 2:
Food Insecurity of Victims of Firearm Trauma at University Medical Center

Table 1:

Description of Study Population Demographics by Levels of Residence Food Insecurity

Level of Food Insecurity				
Parameter	**< 11.5%**	**11.5% – 16.1%**	**>16.1%**	**p**
Total (n, %)	138 (4.4)	1048 (33.6)	1929 (62.0)	
Age (Median, IQR)[1]	28.0 (17.0)	26.0 (14.0)	26.0 (15.0)	0.19
Male Sex (n, %)	120 (87.0)	906 (86.5)	1681 (87.1)	0.87
Non-White Race (n, %)[1, 2]	87 (63.0)	856 (81.7)	1834 (95.1)	**<0.001**
Hispanic/Latino Ethnicity (n, %)	0 (0.0)	30 (2.9)	26 (1.3)	**0.003**
Unknown Ethnicity	0 (0.0)	1 (0.1)	6 (0.3)	
Payment (n, %)[2]				**0.006**
Medicare/Medicaid/Government	83 (60.1)	703 (67.1)	1341 (69.5)	
Self-Pay	21 (15.2)	172 (16.4)	332 (17.2)	
Private/Commercial	27 (19.6)	147 (14.0)	219 (11.4)	
Other	7 (5.1)	26 (2.5)	37 (1.9)	
Transfer (n, %)	40 (29.0)	196 (18.7)	181 (9.4)	**<0.001**
Mode of Transport (n, %)				**<0.001**
Air	29 (21.0)	128 (12.2)	26 (1.3)	
Ambulance	102 (73.9)	826 (78.8)	1491 (77.3)	
Private	4 (2.9)	93 (8.9)	405 (21.0)	
Police	1 (0.7)	1 (0.1)	7 (0.4)	
Unknown	2 (1.4)	0 (0.0)	0 (0.0)	
Drug Use (n, %)				
Smoking	21 (15.2)	207 (19.8)	362 (18.8)	0.42
Alcohol/Other[2]	10 (7.2)	38 (3.6)	69 (3.6)	0.09
Comorbidities				
Hypertension	17 (12.3)	77 (7.3)	124 (6.4)	**0.03**
Diabetes	2 (1.4)	25 (2.4)	47 (2.4)	0.76
Obesity	5 (3.6)	20 (1.9)	33 (1.7)	0.27
Psychiatric/Neurologic[1, 2]	10 (7.2)	72 (6.9)	111 (5.8)	0.42
Trauma Activation				**0.011**
Tier 1	99 (71.7)	840 (80.2)	1611 (83.5)	
Tier 2	27 (19.6)	145 (13.8)	233 (12.1)	
Unknown	12 (8.7)	63 (6.0)	85 (4.4)	
Intent of Injury				**<0.001**
Assault	107 (77.5)	892 (85.1)	1811 (93.9)	
Self-Inflicted	15 (10.9)	69 (6.6)	28 (1.5)	
Unintentional	15 (10.9)	69 (6.6)	70 (3.6)	

Level of Food Insecurity				
Parameter	**< 11.5%**	**11.5% – 16.1%**	**>16.1%**	**p**
Undetermined	0 (0.0)	5 (0.5)	9 (0.5)	
Other	1 (0.7)	13 (1.2)	11 (0.6)	
Severity (median, IQR)				
Injury Severity Score	9.0 (7.8)	9.0 (13.0)	9.0 (13.0)	0.21
Glasgow Coma Score	15.0 (0.0)	15.0 (0.0)	15.0 (0.0)	0.73
Food Insecurity in Location of Injury				**<0.001**
Less than 11.5%	82 (59.4)	7 (0.7)	6 (0.3)	
Between 11.5% and 16.1%	19 (13.8)	739 (70.5)	78 (4.0)	
Greater than 16.1%	37 (26.8)	302 (28.8)	1845 (95.6)	
Injured in Parish of Non-Residence	56 (40.6%)	352 (33.6%)	94 (4.9%)	**<0.001**

[1]Variable was adjusted for in the logistic regression model examining the relationship of food insecurity and assault.

[2]Variable was adjusted for in the linear regression model examining the relationship of food insecurity and rate of gun-related trauma.

Table 2:

The Association of Food Insecurity with Firearm Violence and Assault, Results of a Logistic Regression Model

Explanatory Variable	Assault: False	Assault: True	Odds Ratio (Univariable)	Odds Ratio (multivariable)
Age (Mean Years, Standard Deviation)	35.1 (17.8)	28.9 (12.0)	0.97 (0.96–0.98, p<0.001)	0.98 (0.98–0.99, p=0.001)
Non-White Race (n, %)	153 (5.5)	2613 (94.5)	11.96 (9.12–15.71, p<0.001)	8.13 (6.02–10.98, p<0.001)
Food Insecurity of Residence (Mean Percentage, Standard Deviation)	15.2 (2.4)	16.4 (2.2)	1.25 (1.19–1.31, p<0.001)	1.13 (1.07–1.19, p<0.001)
Psychiatric/Neurologic Comorbidities (n, %)	43 (22.6)	147 (77.4)	0.32 (0.22–0.46, p<0.001)	0.42 (0.28–0.65, p<0.001)

Table 3:

The Association of Food Insecurity with Rate of Firearm Related Trauma (per 100,000 residents), Results of a Linear Regression Model

Explanatory Variable: Rate of Gun-Related Trauma per 100,000	**Coefficient (univariable)**	**Coefficient (multivariable)**
Alcohol/Drug Use	22.92 (−15.27 to 61.10, p=0.239)	34.98 (5.82 to 64.14, p=0.02)
Psychiatric/Neurologic Comorbidities	−41.44 (−71.15 to −11.73, p=0.006)	−20.96 (−43.80 to 1.88, p=0.07)
Non-White Race	166.71 (143.87 to 189.56, p<0.001)	80.15 (61.42 to 98.89, p<0.001)
Primary Payor		
Private/Commercial	-	-
Medicaid/Medicare/Free	12.54 (−9.21 to 34.30, p=0.258)	−20.66 (−37.44 to −3.87, p=0.02)
None	24.73 (−1.59 to 51.05, p=0.066)	−7.75 (−27.89 to 12.40, p=0.45)
Other	−25.55 (−78.33 to 27.23, p=0.343)	−24.68 (−64.68 to 15.32, p=0.23)
Food Insecurity Rate of Residence (%)	58.71 (56.20 to 61.22, p<0.001)	56.32 (53.78 to 58.86, p<0.001)

R^2: 0.43

F-statistic: p<2.2e-16, p<0.001