J Urban Health (2024) 101:508–521
https://doi.org/10.1007/s11524-024-00865-9

ORIGINAL ARTICLE

Relationship between Civilian Injuries Caused during Contact with Law Enforcement and Community-Level Sociodemographic Characteristics

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Accepted: 27 March 2024 / Published online: 28 May 2024

Abstract Civilian injuries caused during contact with law enforcement personnel erode community trust in policing, impact individual well-being, and exacerbate existing health inequities. We assessed the relationship between ZIP code-level rates of civilian injuries caused during legal interventions and community-level sociodemographic characteristics using Illinois hospital data from 2016 to 2022. We developed multivariable Poisson regression models to examine whether legal intervention injury rates differed by race-ethnicity and community economic disadvantage across three geographic regions of Illinois representing different levels of urbanization. Over the study period, 4976 civilian injuries were treated in Illinois hospitals (rate of 5.6 per 100,000 residents). Compared to non-Hispanic white residents, non-Hispanic Black residents demonstrated 5.5–10.5 times higher injury rates across the three geographic regions, and Hispanic-Latino residents demonstrated higher rates in Chicago and suburban Cook County, but lower rates in the rest of the state. In most regions, models showed that as the percent of minority residents in a ZIP code increased, injury rates among non-Hispanic Black and Hispanic-Latino residents decreased. As community economic disadvantage increased at the ZIP code level, civilian injury rates increased. Communities with the highest injury rates involving non-Hispanic white residents were significantly more economically unequal and disadvantaged. While the injury rates were consistently and substantially higher among non-Hispanic Black residents throughout the state, the findings illustrate that the association between overall civilian injuries caused during contact with law enforcement and community sociodemographic characteristics varied across regions. Data on local law enforcement agency policies and procedures are needed to better identify appropriate interventions.

Keywords Legal intervention · Law enforcement · Police · Socioeconomic status · Urbanization · Racial-ethnic disparities

Introduction

Law enforcement-involved injuries are defined as non-fatal or fatal injuries to community members due to encounters with law enforcement personnel (also referred to as "legal intervention" cases by the ICD-10) [1]. In the USA in 2020, 780 civilians died and 83,549 required hospital care for injuries sustained

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11524-024-00865-9.

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by law enforcement [2] with consequences impacting an individuals' mental well-being, eroding community trust in policing and exacerbating existing health inequities in communities [3, 4]. Various public health surveillance systems are used to monitor legal intervention injuries [1] with many researchers relying on open-source data because traditional data systems substantially undercount civilian injuries [5, 6]. Across surveillance systems, higher incidences of fatal and non-fatal legal intervention injuries are demonstrated among racial and ethnic minorities [6–12], men [9, 13], persons 15 to 44 years old [9, 13, 14], individuals with lower socio-economic status [15, 16], and individuals with mental illness and substance use disorders [9, 10, 16, 17]. Minority individuals have higher fatality rates even in situations in which they pose lower levels of threat to officers [18, 19].

At the community level, research demonstrates that fatal injury rates are higher in communities with more economically disadvantaged persons and racial minorities [5, 6, 20, 21]. In addition, structural racism [7], racial-ethnic representation of law enforcement officers [22], high levels of household gun ownership [20], and higher crime rates in lower income neighborhoods [20, 22] are associated with legal intervention injuries.

Police to population ratio and law enforcement agency characteristics vary widely, which directly impacts policing activities and associated civilian injuries [15, 23]. Increased law enforcement activity results in more frequent contact with community members, which increases the risk of violent interactions [20, 24, 25]. In addition, police use of force varies across communities covered by the same municipal police department [26]. Across broader spatial regions, fatal injury rates vary substantially by census tracts, metro and non-metro areas, metropolitan statistical areas, and states [15, 20, 21].

Researchers have proposed theoretical frameworks to explain the intersection of urbanization, racial-ethnic composition, and economic disadvantage such as the group-position model relating to intergroup competition along racial (e.g., minority threat model addresses segregation) and economic lines (e.g., income inequality model) as well as the police competing with the community; additionally, the social disorganization theory explains increased risk of both civilian-police conflict and police oversight [24, 25, 27]. However, nearly all of the current research used to support these theoretical frameworks have relied on fatal injury data. The fundamental problem with fatality data is that the number of fatalities per year limits granular spatial analyses because of unstable rates or too many zeros when including broad regional data. Many analyses address this issue by aggregating counts to the county and state levels, but this ends up combining communities served by multiple law enforcement agencies with potentially different staffing capacities, training, cultures, and oversight, which can obscure important variability across communities [23].

Public health data shows that for every civilian death there are over 100 non-fatal injuries requiring hospital care [2]. Hospitalized injuries are captured in standardized data systems which provide detailed clinical information and data on mechanism of injury. While there have been studies using hospital data to characterize non-fatal injuries, most of these prior studies have been descriptive in nature and do not evaluate the role of urbanization, community racial-ethnic composition, and economic disadvantage on rates of injuries [8, 12–14, 17, 28]. To the best of our knowledge, only one study of California residents examined the association of community-level sociodemographic factors using non-fatal injury data, but at the county level [23].

Our study evaluates the hypothesis that civilian injury rates from law enforcement encounters at the community level (as defined by ZIP codes) are associated with the racial-ethnic composition of a community and economic factors, in particular economic disadvantage, and that these relationships will vary by level of urbanization of the respective communities. Therefore, the objectives of the present study were to (1) describe racial-ethnic disparities in legal intervention injuries by level of urbanization across regions in Illinois and (2) assess whether rates of legal intervention injuries were associated with community-level racial-ethnic composition and economic disadvantage of the injured person across regions with different levels of urbanization.

Material and Methods

Emergency Department Visits and Admissions Data

We used Illinois hospital data from January 1, 2016, through December 31, 2022 to assess civilian injuries

caused during law enforcement encounters. The outpatient or emergency department (ED) visits database includes all patients treated in the ED for less than 24 h who were not admitted as an inpatient to the hospital. The inpatient database includes all admitted patients treated for 24 h or more for any medical reason. Both databases include patient demographics (age, race-ethnicity, sex), clinical outcomes (diagnoses, hospital procedures, length of stay, facility type, and discharge status), and economic outcomes (hospital charges and payer source). Based on the annual state audit of hospitals, 96.5% of all inpatient admissions statewide are captured by the participating hospitals included in the dataset [29].

Inclusion Criteria

We identified legal intervention injuries using the International Classification of Diseases 10th revision Y35 codes that include "any injury sustained by a suspect or bystander as a result of an encounter with any law enforcement official, serving in any capacity at the time of the encounter, whether on-duty or off-duty." Only patients who were residents of Illinois based on available residential ZIP codes (available for 99.94% of patients in the dataset) were included in the analysis. We also excluded cases where the sixth digit was 1 (Y35.XX1) because these represent injuries suffered by law enforcement officers and security guards.

Urbanization Categories

The hospital dataset includes information on patient residential ZIP codes but does not provide information on location of injury. However, there is a high degree of correlation between where people live and where they are treated. The median distance from residential to hospital ZIP (based on centroid) was 3.8 miles (IQR 1.3, 8.0). For the descriptive statistics, we utilized the 2013 U.S. Department of Agriculture Rural–Urban Continuum Codes (RUCC; 1 to 9) to evaluate degree of urbanization based on population density and proximity to major metropolitan areas [30]. We evaluated three distinct regions in the state: (1) Chicago—the largest municipality in the state of Illinois accounting for 21.3% of the states' population (ACS, 2022); (2) suburban Cook County excluding the city of Chicago (19.4% of Illinois population); (3) and the rest of Illinois constituting RUCC codes 2–9.

Statistical Analysis

We conducted descriptive analyses to examine demographic and clinical characteristics of civilian injuries caused during law enforcement encounters across regions of urbanization in Illinois. We aggregated injuries by residential ZIP code and calculated average annual hospital utilization rates per 100,000 residents using 2020 census population and divided by 7 years representing the study period from 2016 to 2022 [31]. Rates were stratified by race-ethnicity and region. Categories for race-ethnicity included non-Hispanic Black (Black), Hispanic or Latino/x (Hispanic-Latino), non-Hispanic White (White), and all other racial-ethnic categories combined (all other). Based on a priori data, the following 2020 ZIP Code Tabulation Area (ZCTA) level socioeconomic data were obtained: percent not Hispanic Black or African American alone (Black), percent Hispanic or Latino of any race (Hispanic-Latino), percent not Hispanic White alone (White), percent of population living below the federal poverty line, percent unemployed, percent of population with public insurance or without health insurance, percent vacant housing, percent of population with disabilities, percent of population 15 to 44 years old, percent of population that were foreign born, and percent of population with a high school diploma or less than a high school diploma [31].

We conducted principal components analysis (PCA) to address multicollinearity between the socioeconomic census variables and created aggregated constructs. Briefly, PCA is a data reduction method used for studying multiple variables by identifying underlying linear dependencies among the variables. We performed varimax rotation which produced a simplified structure by redistributing the explained variance for the principal components. The percent of population living below the federal poverty line, unemployed, vacant housing, and persons with public or no health insurance represented a single construct which we defined as a measure of "community-level economic disadvantage." A second construct representing high-risk groups at increased risk of law enforcement encounters and injuries comprised the percent of population with disabilities, 15 to 44 years

old, foreign born, and with high school or less education [13, 14, 16, 17].

We developed multivariable regression models to examine the association of legal intervention injuries with community-level sociodemographic characteristics across the three regional urbanization categories. We used Poisson regression models to assess injury rates among residents within the city of Chicago and suburban Cook County (urbanization categories 1 and 2). We conducted a test for overdispersion and compared the model fit of Poisson and negative binomial models using Akaike information criterion (AIC) and Bayesian information criterion (BIC) statistics, and found that the Poisson specification was a better fit for the data. After initial modeling, the very low number of injuries involving minorities in the lowest population density communities (RUCC 5–9) resulted in unstable parameter estimates. For this reason, we combined semi-urban metropolitan communities (RUCC 2–4) with RUCC 5–9 communities in the same model. Because a large number of zero counts occurred in these models (RUCC 2–9), we used zero-inflated Poisson models. When analyzing the entire state of Illinois in a single model, we also used zero-inflated Poisson models to account for the large number of rural ZIP codes with zero injuries.

In the final models evaluating rates of injury among non-Hispanic Black and Hispanic-Latino residents, we included percent non-Hispanic Black, percent Hispanic-Latino, community economic disadvantage construct, and high-risk groups construct. In models evaluating injury rates among non-Hispanic White residents, we included percent non-Hispanic White, community economic disadvantage construct, and high-risk groups construct. We also included polynomial terms for the percent of racial-ethnic composition when statistical evaluation of curvilinearity indicated inclusion of the polynomial term.

Because prior research has shown a strong association between income inequality using the Index of Concentration at the Extremes (ICE) [15], we also evaluated this measure instead of the construct for community economic disadvantage. We did not include ICE and the economic disadvantage construct in the same models because they were highly collinear. We compared the models using either the community economic disadvantage construct or ICE, and all the models using the community economic disadvantage construct had substantially lower AIC and BIC statistics indicating better model fit; so, the final models did not include the ICE metric. A two-sided p-value less than 0.05 was considered statistically significant. We used SAS software (v 9.4; Cary, NC) for all statistical analyses.

Finally, we trimmed ZIP codes with extremely high injury rates from all of the multivariable models because these outliers exerted a strong influence on the parameter estimates. The following numbers of ZIP code-level rates with extreme outliers were removed from the models (out of $n=1385$): total injury rates, $n=10$; rates of injury among non-Hispanic Blacks, $n=25$; rates of injury among Hispanics/Latinos, $n=14$; and rates of injury among non-Hispanic Whites, $n=18$. ZIP codes with outlier injury rates were compared to communities without outliers by the following sociodemographic variables: percent minority populations, Index of Concentration at the Extreme, community economic disadvantage and high-risk groups.

Results

Demographic and Clinical Outcomes of Civilians Injured during Law Enforcement Encounters

Over the 7-year period, there were 4976 legal intervention civilian injuries in Illinois with over half ($n=2919$; 58.7%) occurring in residents living outside of Chicago and suburban Cook County. In Chicago and suburban Cook County, the majority of injuries involved Black residents—70.2% and 50.8%, respectively, while the largest proportion of injuries involved White residents (55.6%) in the rest of Illinois (Table 1). Across the three regions of urbanization, injuries occurred disproportionately in males (83.0%), in 15- to 44-year-olds (80.3%), and in individuals that were uninsured or covered by Medicaid insurance (75.5%). While most persons were discharged home (routine discharge), 24.3% were discharged to a court or law enforcement (Table 1).

Crude Rate Ratios: Disparities by Race-Ethnicity

The crude average annual hospital utilization rate for legal intervention injuries was 5.6 per 100,000 Illinois residents (Table 2). The highest injury rates were observed among Black residents and ranged

Table 1 Demographics and clinical outcomes of civilian injuries caused during law enforcement encounters and treated in Illinois hospitals, 2016–2022

	Chicago (*N* = 1210)	Suburban Cook County w/o Chicago (*N* = 847)	Rest of Illinois (*N* = 2919)	All of Illinois (*N* = 4976)
2020 Census data				
Race-ethnicity				
Percent Hispanic or Latino	28.6%	21.7%	11.5%	17.1%
Percent non-Hispanic Black	29.2%	16.7%	7.4%	13.8%
Percent non-Hispanic White	33.3%	51.4%	74.6%	61.4%
Mean ZIP code–level community economic disadvantage (SD)[a]	73.3 (37.2)	61.2 (22.1)	69.4 (25.1)	68.9 (25.5)
Mean ZIP code–level high-risk groups (SD)[b]	110.4 (19.8)	99.2 (25.8)	96.1 (17.2)	96.9 (18.4)
Hospital patient-level data				
Year				
2016	177 (14.6%)	143 (16.9%)	364 (12.5%)	684 (13.8%)
2017	207 (17.1%)	139 (16.4%)	376 (12.9%)	722 (14.5%)
2018	192 (15.9%)	171 (20.2%)	463 (15.9%)	826 (16.6%)
2019	205 (16.9%)	134 (15.8%)	505 (17.3%)	844 (17.0%)
2020	185 (15.3%)	96 (11.3%)	408 (14.0%)	689 (13.9%)
2021	133 (11.0%)	70 (8.3%)	381 (13.1%)	584 (11.7%)
2022	111 (9.2%)	94 (11.1%)	422 (14.5%)	627 (12.6%)
Race-ethnicity				
American Indian or Alaska Native	1 (0.1%)	1 (0.1%)	3 (0.1%)	5 (0.1%)
Asian	1 (0.1%)	5 (0.6%)	11 (0.4%)	17 (0.3%)
Hispanic-Latino	135 (11.2%)	165 (19.5%)	182 (6.2%)	482 (9.7%)
Multiracial	1 (0.1%)	4 (0.5%)	19 (0.7%)	24 (0.5%)
Native Hawaiian/Pacific Islanders	0 (0.0%)	1 (0.1%)	3 (0.1%)	4 (0.1%)
Non-Hispanic Black	849 (70.2%)	430 (50.8%)	944 (32.3%)	2223 (44.7%)
Non-Hispanic White	93 (7.7%)	189 (22.3%)	1623 (55.6%)	1905 (38.3%)
Other/unspecified	130 (10.7%)	52 (6.1%)	134 (4.6%)	316 (6.4%)
Sex				
Male	1026 (84.8%)	712 (84.1%)	2390 (81.9%)	4128 (83.0%)
Female	184 (15.2%)	135 (15.9%)	529 (18.1%)	848 (17.0%)
Mean age (SD)	32.45 (12.65)	33.01 (12.68)	34.05 (12.11)	33.48 (12.36)
0 to 14 years	11 (0.9%)	7 (0.8%)	35 (1.2%)	53 (1.1%)
15 to 24 years	347 (28.7%)	221 (26.1%)	631 (21.6%)	1199 (24.1%)
25 to 34 years	421 (34.8%)	301 (35.5%)	1005 (34.4%)	1727 (34.7%)
35 to 44 years	240 (19.8%)	167 (19.7%)	664 (22.8%)	1071 (21.5%)
45 to 54 years	111 (9.2%)	89 (10.5%)	385 (13.2%)	585 (11.8%)
55 to 64 years	59 (4.9%)	46 (5.4%)	160 (5.5%)	265 (5.3%)
65 years and above	21 (1.7%)	16 (1.9%)	39 (1.3%)	76 (1.5%)
Payer type				
Uninsured	328 (27.1%)	211 (24.9%)	568 (19.5%)	1125 (22.3%)
Medicaid	609 (50.3%)	429 (50.7%)	1608 (55.1%)	2646 (53.2%)
Private insurance	194 (16.0%)	138 (16.3%)	411 (14.1%)	743 (14.9%)
Medicare	45 (3.7%)	46 (5.4%)	219 (7.5%)	310 (6.2%)
Other	34 (2.8%)	23 (2.7%)	113 (3.9%)	170 (3.4%)

Table 1 (continued)

	Chicago (*N* = 1210)	Suburban Cook County w/o Chicago (*N* = 847)	Rest of Illinois (*N* = 2919)	All of Illinois (*N* = 4976)
Inpatient cases (> 24 h)	50 (4.1%)	43 (5.1%)	98 (3.4%)	191 (3.8%)
Mean (SD) hospital charges in USD	$5246 ($12,650)	$8572 ($33,475)	$5885 ($15,652)	$6188 ($19,317)
Discharge status				
Routine discharge	909 (75.1%)	568 (67.1%)	1986 (68.2%)	3463 (69.6%)
Court or law enforcement	252 (20.8%)	217 (25.6%)	737 (25.3%)	1206 (24.3%)
Psychiatric facility	13 (1.1%)	29 (3.4%)	59 (2.0%)	101 (2.0%)
Left against medical advice	18 (1.5%)	11 (1.3%)	63 (2.2%)	92 (1.9%)
Died or hospice	4 (0.3%)	6 (0.7%)	10 (0.3%)	20 (0.4%)
Other	14 (1.2%)	16 (1.9%)	57 (2.0%)	87 (1.7%)

[a]Community economic disadvantage—Developed using principal components analysis and is a construct composed of the percent of population living below the federal poverty line, unemployed, vacant housing, and persons with public or no health insurance based on 2020 US Census data. A higher value corresponds with greater economic disadvantage in a community

[b]High-risk groups—Developed using principal components analysis and is a construct representing "high-risk groups at increased risk of law enforcement encounters and injuries" and is composed of the percent of population with disabilities, 15 to 44 years old, foreign born, and with high school or less education based on 2020 US Census data. A higher value corresponds with greater proportion of residents who are high-risk groups at increased risk of law enforcement encounters and injuries based on prior research

between 14.5 and 22.8 per 100,000 residents across the different regions. Compared to White residents, Black residents demonstrated 5.5 to 10.5 times higher incidence rates of legal intervention injuries across the three geographic regions, and Hispanic-Latino residents demonstrated higher rates in Chicago and Suburban Cook County, but lower rates in the rest of the state (Table 2). Across all regions, the rate of civilian injuries increased substantially with increasing community-level economic disadvantage. The injury rates in the most economically disadvantaged communities (upper quartile of disadvantage construct) were 6.1 to 7.4 times higher than the rates in the least economically disadvantaged communities (lowest quartile). When the economic disadvantage construct was stratified by race-ethnicity, the rate of civilian injuries increased most substantially with increasing community-level economic disadvantage among injured White residents, particularly in Chicago and suburban Cook County (Supplemental Table S1). However, the injury rate among Black residents was on average two to six times higher than their White counterparts, regardless of economic disadvantage quartile (Supplemental Table S1).

Multivariable Models Evaluating the Association between ZIP Code–Level Sociodemographic Characteristics and Injury Rates among All Residents

The association between the rate of injury among all residents with community-level racial-ethnic composition and economic disadvantage varied across the geographic regions (Table 3). When evaluating overall injury rates, we observed injury rates increased with increasing percentage of Black residents in a ZIP code for both residents of Chicago (2.79%; CI95% 1.25%, 4.32%; curvilinear parameter not shown) and suburban Cook County (2.03%; CI95% 1.57%, 2.60%), but declined in the rest of Illinois with increasing percentage of Black residents (−0.56%; CI95% −0.76%, −0.37%). We also observed a curvilinear association between the overall injury rate and increasing percentage of Hispanic-Latino residents in suburban Cook County ZIP codes. However, in Chicago and semi-urban regions and rural non-metro regions (RUCC 2–9), overall injury rates significantly declined as the percent of Hispanic-Latino residents in ZIP codes increased. Across all regions of the state, injury rates increased as ZIP code-level community economic disadvantage increased (Table 3; Fig. 1).

Table 2 Average crude hospital utilization rates by race-ethnicity and community economic disadvantage for civilian injuries caused during law enforcement encounters, 2016–2022

	RUCC 1: Chicago			RUCC1: Suburban Cook County			RUCC 2 to 9: semi-urban metro and rural non-metro areas			All of Illinois		
	Cases	Rate†	Rate ratio (CI95%)	Cases	Rate†	Rate ratio (CI95%)	Cases	Rate†	Rate ratio (CI95%)	Cases	Rate†	Rate ratio (CI95%)
Total	1210	6.3	-	847	4.9	-	2919	5.5	-	4976	5.6	-
Race/ethnicity												
Black or African American	849	15.5	10.5 (9.4, 11.6)*	430	14.5	6.7 (5.3, 8.1)*	943	22.8	5.5 (4.0, 7.0)*	2222	17.7	5.0 (4.3, 5.8)*
Hispanic-Latino	135	2.5	1.7 (1.2, 2.2)*	165	4.5	2.1 (1.4, 2.9)*	182	2.9	0.7 (0.2, 1.2)	482	3.1	0.9 (0.6, 1.2)
White Non-Hispanic	93	1.5	REF	189	2.2	REF	1622	4.1	REF	1904	3.5	REF
All other[a]	133	6.7	4.5 (3.3, 5.7)*	63	3.1	1.4 (0.6, 2.2)	172	4.9	1.2 (0.4, 1.9)	368	4.9	1.4 (0.9, 1.9)
Community economic disadvantage[b,c]												
Lower quartile	73	1.8	REF	138	2.1	REF	411	1.8	REF	622	1.9	REF
2nd quartile	105	2.3	1.3 (0.7, 1.9)	151	2.7	1.3 (0.7, 1.9)	596	5.0	2.7 (2.3, 3.1)*	852	3.9	2.0 (1.7, 2.3)*
3rd quartile	114	4.5	2.5 (1.5, 3.4)*	193	7.4	3.5 (2.4, 4.6)*	723	7.0	3.8 (3.3, 4.4)*	1030	6.7	3.5 (3.1, 4.0)*
Upper quartile (most disadvantaged)	914	11.3	6.1 (5.3, 7.0)*	354	13.4	6.4 (4.9, 7.8)*	1176	13.6	7.4 (6.6, 8.2)*	2444	12.6	6.7 (6.1, 7.2)*

†Crude average annual rate per 100,000 residents, based on US Census 2020 data. Average rate over the 7 years of hospital data collected

*P-value < 0.05

[a]All other race-ethnicity includes American Indian or Alaska Native, Asian, Multiracial, Native Hawaiian/Pacific Islanders, Other race, and Unspecified race. All other race-ethnicity predominantly comprised other/unknown race (86%)

[a]Community economic disadvantage—Developed using principal components analysis and is a construct composed of the percent of population living below the federal poverty line, unemployed, vacant housing, and persons with public or no health insurance based on 2020 US Census data. A higher quartile corresponds with greater economic disadvantage in a community

[c]Sum of injuries by community economic disadvantage has $n = 28$ fewer cases than true total observed in hospital data because there was a loss of cases when cross-walking ZIP codes to ZIP Code Tabulation Areas (used by US Census)

Table 3 Multivariable models evaluating association between ZIP code–level sociodemographic characteristics of residents and rate of civilian injuries caused during law enforcement encounters in Illinois, 2016–2022, stratified by race-ethnicity and level of urbanization

ZIP code–level sociodemographic characteristics	RUCC 1: Chicago[a,c]	RUCC 1: Suburban Cook County[a,c]	RUCC 2 to 9: semi-urban metro and rural non-metro areas[b,d]	All of Illinois[b]
Rate of injury among all residents				
Percent non-Hispanic Black	2.79% (1.25%, 4.32%)	2.03% (1.57%, 2.60%)	−0.56% (−0.76%, −0.37%)	0.76% (0.32%, 1.21%)
Polynomial term non-Hispanic Black	−0.02% (−0.04%, −0.01%)	NS	NS	−0.01% (−0.02%, −0.01%)
Percent Hispanic-Latino	−1.43% (−2.34%, −0.52%)	5.11% (3.36%, 6.86%)	−2.86% (−3.29%, −2.43%)	−4.24% (−4.87%, −3.62%)
Polynomial term Hispanic-Latino	NS	−0.03% (−0.05%, −0.02%)	NS	0.03% (0.02%, 0.04%)
Community economic disadvantage†	0.91% (0.09%, 1.73%)	1.16% (0.56%, 1.76%)	1.37% (1.20%, 1.55%)	1.49% (1.34%, 1.64%)
High-risk groups[δ]	NS	−0.77% (−1.58%, −0.04%)	1.57% (1.30%, 1.85%)	1.05% (0.81%, 1.30%)
Rate of injury among non-Hispanic Black residents				
Percent non-Hispanic Black	−2.07% (−2.68%, −1.46%)	2.08% (1.21%, 2.95%)	−2.52% (−2.79%, −2.25%)	−2.73% (−3.16%, −2.29%)
Polynomial term non-Hispanic Black	NS	−0.02% (−0.03%, −0.01%)	NS	0.01% (0.00%, 0.01%)
Percent Hispanic-Latino	1.21% (0.62%, 1.80%)	2.06% (1.59%, 2.53%)	−1.49% (−1.84%, −1.13%)	−0.73% (−0.97%, −0.50%)
Polynomial term Hispanic-Latino	NS	NS	NS	NS
Community economic disadvantage†	2.28% (1.71%, 2.86%)	NS	1.51% (1.28%, 1.75%)	1.71% (1.54%, 1.88%)
High-risk groups[δ]	−3.04% (−3.80%, −2.28%)	−1.04% (−1.41%, −0.67%)	0.66% (0.30%, 1.02%)	−0.40% (−0.65%, −0.14%)
Rate of injury among Hispanic-Latino residents				
Percent non-Hispanic Black	0.93% (0.47%, 1.40%)	−4.84% (−6.88%, −2.80%)	−1.55% (−2.41%, −0.70%)	−1.16% (−1.54%, −0.79%)
Polynomial term non-Hispanic Black	NS	0.04% (0.02%, 0.06%)	NS	NS
Percent Hispanic-Latino	−1.32% (−2.59%, −0.05%)	8.06% (5.64%, 10.48%)	−4.79% (−5.76%, −3.82%)	−5.88% (−7.09%, −4.66%)
Polynomial term Hispanic-Latino	NS	−0.07% (−0.09%, −0.04%)	NS	0.05% (0.04%, 0.06%)
Community economic disadvantage†	NS	4.14% (3.19%, 5.08%)	1.69% (1.20%, 2.17%)	1.97% (1.58%, 2.36%)
High-risk groups[δ]	1.70% (0.42%, 2.98%)	−2.73% (−3.73%, −1.73%)	NS	−0.99% (−1.56%, −0.42%)
Rate of injury among non-Hispanic White residents				
Percent non-Hispanic White	−7.20% (−10.08%, −4.32%)	−4.75% (−6.20%, −3.29%)	1.75% (1.52%, 1.99%)	1.06% (0.91%, 1.20%)
Polynomial term non-Hispanic White	0.06% (0.02%, 0.10%)	0.03% (0.01%, 0.05%)	NS	NS
Community economic disadvantage†	NS	NS	1.64% (1.47%, 1.82%)	1.98% (1.83%, 2.12%)
High-risk groups[δ]	1.08% (0.29%, 1.87%)	1.79% (1.41%, 2.18%)	0.88% (0.59%, 1.17%)	0.52% (0.29%, 0.75%)

Table 3 (continued)

NS non-significant estimate

[a]Poisson regression model used in multivariable analysis for Chicago and Suburban Cook County. Models controlled for ZIP code–level data on community economic disadvantage and high-risk groups at increased risk of law enforcement encounters and injury

[b]Zero-inflated Poisson regression model used for multivariable analysis for semi-urban metro and rural non-metro areas and the state of Illinois as a whole. Models controlled for ZIP code–level data on community economic disadvantage and high-risk groups at increased risk of law enforcement encounters and injury

[c]RUCC 1: United States Department of Agriculture region denoting counties in metro areas of 1 million population or more

[d]RUCC 2–9: United States Department of Agriculture region denoting counties in metro areas with population between 20,000 and less than 1 million; and counties in rural areas with population less than 2500–20,000

[†]Community economic disadvantage—Developed using principal components analysis and is a construct composed of the percent of population living below the federal poverty line, unemployed, vacant housing, and persons with public or no health insurance based on 2020 US Census data. A higher value corresponds with greater economic disadvantage in a community

[δ]High-risk groups—Developed using principal components analysis and is a construct representing "high-risk groups at increased risk of law enforcement encounters and injuries" and is composed of the percent of population with disabilities, 15 to 44 years old, foreign born, and with high school or less education based on 2020 US Census data. A higher value corresponds with greater proportion of residents who are high-risk groups at increased risk of law enforcement encounters and injuries based on prior research

Multivariable Models Evaluating the Association between ZIP Code–Level Sociodemographic Characteristics and Injury Rates Stratified by Race-Ethnicity

We also examined associations of racial-ethnic specific injury rates with community-level sociodemographic characteristics across regions of the state (Table 3). The rate of injury specifically among Black residents increased in a curvilinear pattern in suburban Cook County with increasing percentage of Black residents per ZIP code (2.08%; CI95% 1.21%, 2.95%; curvilinear parameter not shown) but declined in Chicago area ZIP codes and the rest of the state (RUCC 2–9). Based on the model using all of Illinois combined, injury rates declined in a curvilinear manner as the percent of Black residents in a ZIP code increased (−2.73%; CI95% −3.16%, −2.29%; curvilinear parameter not shown; Figure S1A) and the slope was more precipitous as economic disadvantage of a community increased (Fig. 2, blue line). In evaluating ZIP codes with extreme outliers of high injury rates involving Black residents ($n=25$ ZIPs), these communities did not differ significantly by percent minority residents, Index of Concentration at the Extreme, community economic disadvantage, and high-risk groups.

A similar pattern was observed when evaluating the specific injury rates among Hispanic-Latino residents. Injury rates involving Hispanic-Latino residents declined as the percent of Hispanic-Latino residents increased in ZIP codes located in Chicago and RUCCs 2–9, but increased significantly as the percent of Hispanic-Latino residents increased within suburban Cook County ZIP codes (Table 3). Based on models using all of the statewide data, injury rates declined in a curvilinear manner as the percent Hispanic-Latino residents in a ZIP code increased (−5.88%; CI95% −7.09%, −4.66%; curvilinear parameter not shown; Figure S1B) and was more pronounced as economic disadvantage of a community increased (Fig. 2, green line). In evaluating ZIP codes with extreme outliers of high injury rates involving Hispanic-Latino residents ($n=14$ ZIPs), these communities did not differ significantly by percent minority residents, Index of Concentration at the Extreme, community economic disadvantage, and high-risk groups.

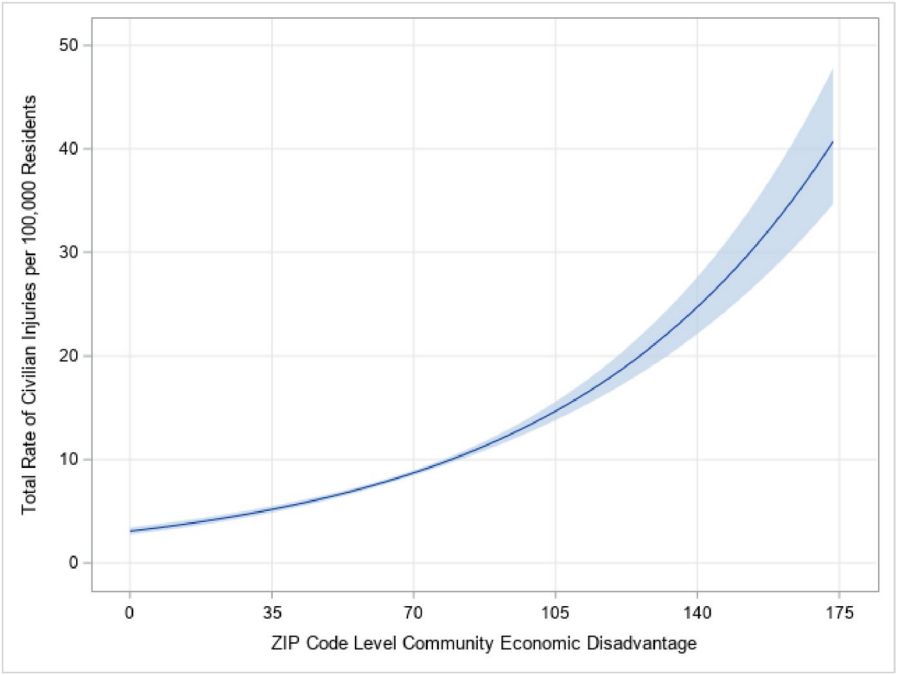

Fig. 1 Relationship between ZIP code–level community economic disadvantage* and total rate of civilian injuries caused during legal interventions per 100,000 residents. *Community Economic Disadvantage—Developed using principal components analysis and is a construct composed of the percent of population living below the federal poverty line, unemployed, vacant housing, and persons with public or no health insurance based on 2020 US Census data. A higher value corresponds with greater economic disadvantage in a community

Controlling for economic disadvantage and high-risk groups, injury rates involving white residents increased in a linear manner as the percent of white residents increased in ZIP codes across the state as a whole (1.06%; CI95% 0.91%, 1.20%); and the rate of injury increased higher and more precipitously as economic disadvantage of a community increased (Fig. 2, red line). A similar pattern was observed in the semi-urban and rural areas (RUCC 2–9), but in both Chicago and suburban Cook County injury rates among White residents declined as the percent of White residents increased. In addition, unlike patterns among both Black and Hispanic-Latino residents, in evaluating ZIP codes with extreme outliers of high injury rates involving White residents ($n=18$ ZIPs), these communities had significantly higher measures of inequality as indicated by the Index of Concentration at the Extreme, greater community economic disadvantage, and more high-risk groups.

Community Economic Disadvantage

Across all regions of the state, overall legal intervention injury rates increased with increasing community economic disadvantage (Table 3). Injury rates stratified by race-ethnicity increased as community economic disadvantage increased in most models, but were not found to be significant in some regions. For example, community economic disadvantage was not significantly associated with the injury rate specifically among Hispanic-Latino residents in Chicago, and the rates of injury among both Black and White residents were not associated with economic disadvantage in suburban Cook County. Community economic disadvantage was never inversely associated with injury rates. Based on models using statewide data, injury rates increased as the economic disadvantage of a community increased (Fig. 1) and the change in racial-ethnic specific injury rates relative to percent racial-ethnic populations became more pronounced as community economic disadvantage increased (Fig. 2).

Discussion

Our study evaluated associations between civilian injuries caused during law enforcement encounters and sociodemographic characteristics across three geographic regions in Illinois representing different levels of urbanization. The study is unique because it analyzes data at the ZIP code level, which better

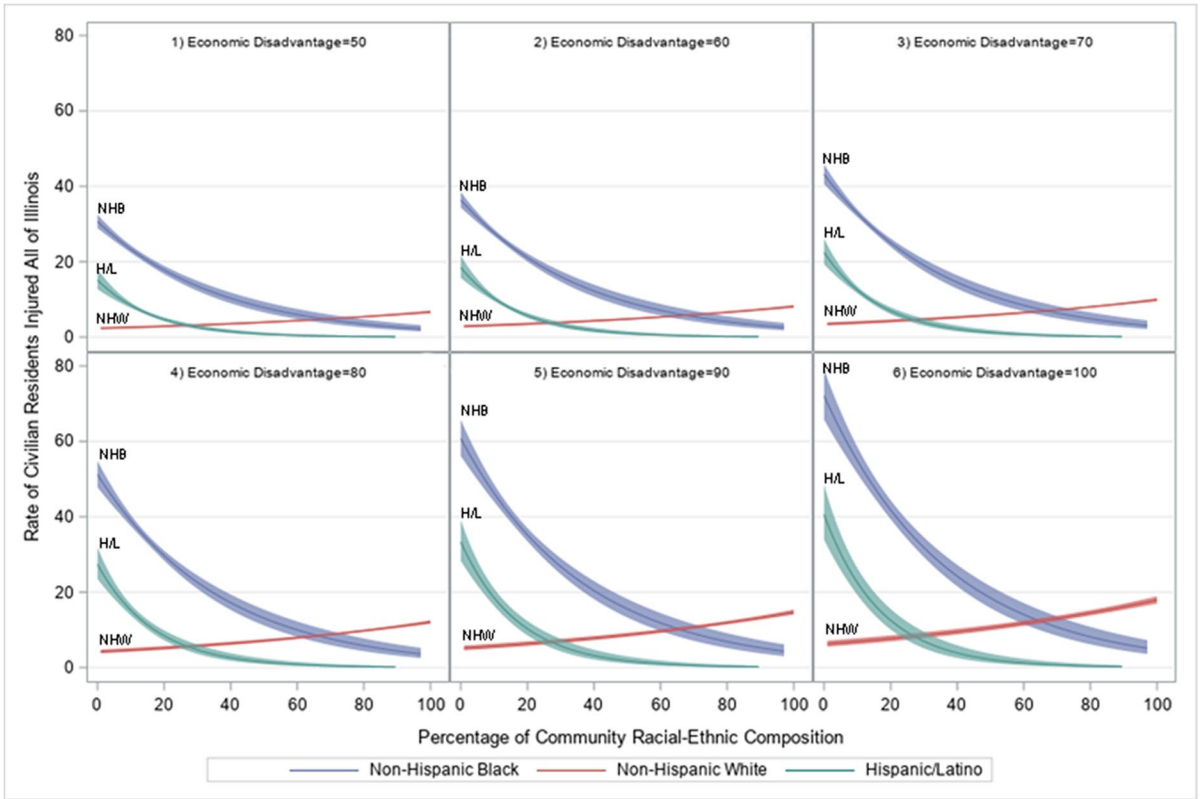

Fig. 2 Relationship between ZIP code–level rate of civilians injured during legal interventions per 100,000 residents and percent community racial-ethnic composition, stratified by community economic disadvantage. Blue line, Rate of injury among non-Hispanic Black residents by percent non-Hispanic Black residents in ZIP code. Green line, Rate of injury among Hispanic-Latino residents by percent Hispanic-Latino residents in ZIP code. Red line, Rate of injury among non-Hispanic White residents by percent non-Hispanic White residents in ZIP code. Economic Disadvantage—50, ZIP codes with lower economic disadvantage; 100, ZIP codes with higher economic disadvantage

aligns with local law enforcement jurisdictions, and provides insights into the relationship between race-ethnicity, economic disadvantage, and region. Evaluating overall injury rates instead of racial-ethnic specific injury rates obscures key patterns. While the injury rates were consistently and substantially higher among Black residents throughout the state, the findings illustrate that the association between injuries and demographic composition of communities varied across regions. The pattern of association also varied when stratifying by racial-ethnic specific injury rates and economic disadvantage. Among Black residents, the rate of injury was highest in the most rural communities where Black residents comprise a very small proportion of these communities (mean of 2% in RUCC 5–9) and precipitously declined as the percent of Black residents in a community increased (Figure S1A). Despite substantially lower injury rates among Hispanic-Latino residents, we observed a similar pattern of declining injury rates with increasing percent of Hispanic-Latino residents (Figure S1B). Among White residents, the opposite pattern was observed. Injury rates increased with increasing percent of White residents, particularly in semi-urban and rural communities where the average ZIP code comprised 88.3% White residents.

The relationship between injury rates and community economic disadvantage was more consistent across the models, with most models showing an increase in injury rates as community economic disadvantage increased. When evaluating the relationship between community economic disadvantage

and injury rates statewide, the change in racial-ethnic specific injury rates among residents became more pronounced as community economic disadvantage increased (Fig. 2). In fact, the relationship between economic disadvantage and injury rates was most pronounced when evaluating specific injury rates among White residents (change in rate ratios shown in Supplemental Table S1). In addition, the only ZIP codes with extreme outliers that significantly differed on sociodemographic characteristics were those with extremely high injury rates involving White residents; these outlier ZIP codes were significantly more economically disadvantaged and unequal (ICE; disparity between wealthy and poor residents) with higher proportions of high-risk groups known to be at increased risk of injury during contact with law enforcement (e.g., persons with disabilities, young).

Our findings, which use hospitalization ZIP code–level data, differ slightly from some of the previous studies demonstrating disparities in the rate of fatal legal intervention injuries with economic disadvantage, urbanization, and racial-ethnic composition [7, 23, 27]. However, the one study that evaluated these factors using non-fatal data at the county level found higher rates of non-fatal injuries among non-Hispanic Blacks in urban areas and segregated counties, and for non-Hispanic Whites in rural and socioeconomically disadvantaged counties [23]. Additionally, prior studies have also demonstrated higher rates of fatal injuries for non-Hispanic Whites in rural areas and non-Hispanic Blacks in urban areas[21]; for minority racial-ethnic groups by census division and metropolitan area[6]; and for non-Hispanic Black residents in census tracts with a greater concentration of non-Hispanic Whites [15]. The present study adds to these latter studies by providing data on the change in injury rates as racial-ethnic composition and economic disadvantage of communities change on a continuous scale.

The complex relationship of injury rates with community racial-ethnic composition and economic disadvantage across regions is likely related to varying law enforcement agency characteristics such as diversity of agency personnel, density of personnel across jurisdictions, training and community policing programs, policing practices and department culture particularly relating to neighborhoods with more minority or lower income residents, bias in arrest decisions and arrest rates across communities, and social polarization in communities with low minority racial-ethnic composition [15, 23, 32]. In the present study, 25.7% of individuals discharged to court/law enforcement were Hispanic-Latino despite comprising 17.1% of the State's population and only 9.7% of injuries. Law enforcement involvement in immigration related matters differs across agencies and certain policies/practices are linked to adverse mental health outcomes and increased immigration related arrests among Hispanic-Latino individuals [33]. In addition, there were ZIP codes with extremely high rates of injury (outliers) involving Black and Hispanic-Latino residents across all regions of the state despite these ZIP codes not differing in terms of minority populations, ICE, economic disadvantage, or high-risk groups. This supports the hypothesis that some of the extremely high rates of injury suffered among Black and Hispanic-Latino residents is driven by specific agency practices. It is important to develop sources that provide law enforcement agency–level data to evaluate the degree these observed disparities are driven by local agency policies, training, diversity, and culture.

Our study has limitations. First, this analysis did not analyze the data by law enforcement jurisdiction (precinct, municipal police, or county Sheriff agency) or include data on agency characteristics. While the analysis did utilize ZIP code–level injury data, research does show that jurisdictional policies, training, culture, and employment practices vary widely between and within law enforcement jurisdictions. Integrating these data in future analyses is critical. Second, because of an absence of comprehensive ZIP code–level crime or firearm ownership data, our analysis did not account for these despite being associated with state-level fatal encounters [20]. Third, we only account for legal intervention injuries seeking care at a hospital. Cases seeking care at other medical settings (e.g., urgent care center) or cases with no formal care are missed. The Bureau of Justice Statistics data estimates that only 37% of non-fatal injuries caused by use of force seek medical care [34]. Fourth, prior studies also show that underreporting of injuries may occur as a result of inconsistent coding, differing case review methods, and misclassification in clinical and vital statistics records [5]. Fifth, race-ethnicity could be misclassified. However, prior research indicates a high level of accuracy in EHR data for the three main groups used in this study [35].

Conclusions

Though there were variations across regions of the State, (1) the relationship between the rate of civilians injured by law enforcement increased with community economic disadvantage, and (2) the racial-ethnic specific injury rates declined as communities became more diverse. While the group-position model explains most of the key findings, we lack data on police practice which would greatly inform the interpretation of the findings. The absence of quality community-level data regarding local law enforcement agencies' policies and procedures, crime, and firearm ownership demonstrates the need for further investment in developing these data sources to improve our knowledge of risk factors for civilian injuries and to identify appropriate policies to reduce these types of injuries. Expansion of this research will improve community trust in law enforcement and officer safety.

Acknowledgements This research was supported, in part, by a generous private donation from Sally Freeman to the UIC School of Public Health (LSF, AHB). The funder had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Data Availability Our data use agreement does not allow us to share original hospital data. We provide public access to summarized annual hospital data at https://policeepi.uic.edu/. All other data used in the analysis are publicly available through the U.S. Census Bureau.

Declarations

Ethics Approval A claim of exemption was approved for this project by the University of Illinois Chicago IRB (#2020–0753).

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