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Examining Fire Department Injury Data as a Tool for Epidemiological Investigation

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Abstract

Objective—Residential fires, while constituting a small fraction of fire incidents, are responsible for the majority of civilian fire-related injuries. This study investigates census tract neighborhood socioeconomic factors as correlates of civilian injuries occurring during residential fires in Baltimore, Maryland between 2004 and 2007.

Methods—Civilian residential-fire related injuries were geocoded and linked to the American Community Survey 2005–2009 data. Negative binomial regression was used to analyze the relationship between fire-injury rates and neighborhood socioeconomic indicators including household income and percentages of households below the poverty line, persons 25 years or older with at least a bachelor's degree, homes built in 1939 or earlier, vacant properties, and owner occupied homes.

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Results—Between January 2004 and July 2007, there were 482 civilian fire-related injuries that occurred during 309 fires. At the census tract level, a ten percent increase in the number of vacant homes was associated with an increase in injury rates by a factor of 1.28 (95% CI 1.05, 1.55). A ten percent increase in persons over 25 years with at least a bachelor's degree was associated with a decrease in injury rates by a factor of 0.86 (95% CI 0.77, 0.96).

Conclusions—Neighborhood measures of education and housing age proved good indicators for identifying areas with a higher burden of fire-related injuries. Such analyses can be useful for fire department planning.

Keywords

Fire injury; epidemiology; injury prevention

Background

Fires are an important cause of injuries in the United States. In 2011, fires caused 17,500 injuries and more than 3,000 deaths, and resulted in more than $11 billion in property damage. [1] Residential fires are the leading contributor to fire injuries and deaths. Although residential fires accounted for 27% of fires in 2011, they were responsible for 84% of civilian fire deaths and 79% of civilian fire injuries. [1]

The demographic correlates of residential fire injuries and deaths are well described. Age, sex and race are documented factors associated with risk of residential fire injury and death. While fire-related deaths occur most frequently in the very young and very old, [2–8] young adults and middle-aged adults are at the greatest risk for nonfatal residential fire injuries. [2,9] Males experience a higher risk of fire injury than females, [2,8] and minorities are a greater risk for fatal and nonfatal fires. [8]

Socioeconomic correlates of fire injuries have been documented in the literature. Low income families are at increased risk of fatal and nonfatal fire injuries, [4,6,10] and residents of rental properties are at higher risk for fire fatalities than owner-occupied properties. [11] There is no clear relationship between socioeconomic status and prevalence of fire safety behaviors such as smoke alarms and fire escape planning [12–14] suggesting the increased injury risk among families of low socioeconomic position is more complicated than safety behaviors.

Certain factors about the neighborhood environment also contribute to fire injury risk. One study found that with increasing percent of homes built before 1940 there is an increase in the rate of fire injuries. [10] Older homes are generally considered to pose a higher risk of injury in part because they contain greater fire hazards such as older electrical wiring. [14–16] There have also been a number of architectural and engineering advancements that offer residents protection from fire-related injury, such as hardwired smoke alarms and sprinkler systems. These advancements are sometimes included by builders in new construction. Vacant properties are also associated with an increase in fire injuries at the neighborhood level, [10] which is consistent with the finding that proximity to vacant housing increases risk of a fire. [17]

Much of the previous literature documenting fire injuries was published in the 1970's with some updates in the 1990's, and is mostly descriptive. Risk factors of fire deaths are better documented than fire injury risks. Much of this research uses hospital records and death certificates which do not capture injuries treated on scene, or in the ED or clinic without an admission. [2] Importantly, such data many only include the most severe injuries and thus may underestimate the burden of fire injuries.

This paper describes the burden of injury in an urban setting using municipal fire department data and explores neighborhood-level constructs that are associated with high fire injury. Such information can be used to direct prevention activities to the highest risk areas.

Methods

Using data from the American Community Survey and the Baltimore City Fire Department, we conducted a census tract analysis of correlates of fire injuries.

Data

Data from the American Community Survey 2005–2009 [18] were used to capture socioeconomic and demographic characteristics for each census tract in Baltimore City. The variables selected were median per capita income, percents of households below the poverty line, adults over 25 years with at least a bachelor's degree, homes built in 1939 or earlier, vacant homes, and owner-occupied homes. These variables were selected based on their use in previous research. Census data distinguishes unoccupied properties that are for sale or for rent from vacant properties; percent of vacant properties was used in the analysis. Census data contain information on the decade of the housing stock for homes built in 1940 and later; homes built in 1939 or earlier are coded in a single category. Since a majority of Baltimore's housing was constructed before 1939, and to be consistent with previous research, we used the percent of homes built in 1939 or earlier as a measure of the age of the housing. Census tracts without any residential properties were excluded.

A list of fire-related injuries occurring in Baltimore City between January 1, 2004 and July 31, 2007 was obtained from the Baltimore City Fire Department and includes all civilian injuries that occurred at the time of a residential fire and were reported to fire department personnel. These data were obtained from truck and engine run sheets that record information about the time and place of the fire and the number and ages of people injured; no information about the nature of the injury, the race of the injured people, or the cause of the fire is included. Injuries that occurred during non-residential fires were excluded.

Percents of households below the poverty line, adults 25 years and over with at least a bachelor's degree, homes built in 1939 or earlier, and vacant homes were calculated based on Census 2000 estimates. These percentages were analyzed as continuous variables to be consistent with previous literature.

Analysis

Injuries were geocoded and linked to the corresponding census tract. Injury counts for each census tract were enumerated and rates per census tract were calculated using the census tract population estimates for the 2005–2009 American Community Survey.

Bivariate negative binomial regression was performed for each of the covariates of interest with the natural log of the person years as the offset. Negative binomial regression was selected because our data are over-dispersed count data representing rare events. An offset of log-person years was used to model the regression coefficients and can be interpreted as incidence rate ratios. Regression coefficients were scaled by a factor of 10 to improve interpretability.

A multivariate, negative binomial regression was performed with the log person-years as the offset, and included percent vacancies, percent homes built in 1939 or earlier, percent households below the poverty line and percent over 25 with at least a bachelor's degree. Percent owner-occupied homes and income were excluded from the multivariate model because of high collinearity with our education and poverty variables respectively, determined via variance inflation factors.

Geocoding was performed using ArcGIS 9.3 software (ESRI, 2009). All other analyses were performed in SAS 9.2 (SAS Institute, 2008, Cary, NC). This study protocol was reviewed and approved by the Johns Hopkins School of Public Health Institutional Review Board.

Results

In 2005–2009, there were 200 census tracts in Baltimore with an estimated 639,337 people and 294,617 housing units. One census tract was eliminated because it contained no residential properties. An estimated 20% of households were below the poverty line and 25% of residents age 25 and older had at least a bachelor's degree (Table 1).

Between January 2004 and July 2007, there were 482 civilian fire-related injuries that occurred during 309 fires. Of these, 428 injuries from 259 fires occurred in residential properties and are the focus of this analysis. A total of 182 residential fires resulted in a single injury while 77 residential fires resulted in multiple injuries. Over 60% of injuries occurred in the winter or spring months (December–May). Older adults (60 or more years) suffered 23% of fire-related injuries (Table 2).

Of the 428 residential fire-related injuries, 426 injuries (99%) were successfully geocoded and these data form the basis of our analysis. The injuries were coded to 133 census tracts; 66 census tracts had no fire-related injuries between January 2004 and July 2007. Census tracts had between 0–19 fire injuries. Census tract injury rates ranged from 0.04 to 2.2 injuries per 1000 people per year.

In bivariate analyses of injuries (Table 3), per capita income, college degrees, and owner-occupied homes were all found to be significantly associated with decreasing incidence of fire injuries. Vacant housing, homes built in 1939 or earlier and households below the poverty line were all significantly associated with increased fire injuries.

In a multivariate analysis (Table 4), the prevalence of vacant housing remained significantly associated with fire-injuries; a ten percent increase in the number of vacant homes was associated with an increase in injury rates by a factor of 1.28 (95% CI 1.05, 1.55). A ten percent increase in persons over 25 years with at least a bachelor's degree in a census tract was associated with a decrease in injury rates by a factor of 0.86 (95% CI 0.77, 0.96). Age of the housing stock remained positively associated with fire injury (Incidence Ratio 1.12; 95% CI 1.02, 1.23).

Discussion

In this analysis of Baltimore City fires, we observed a relationship between fire-related injuries and measures of neighborhood socioeconomic status. In general, markers of lower neighborhood socioeconomic status were associated with higher incidence of fire-related injuries while markers of higher socioeconomic status were associated with lower incidence. In particular, neighborhoods with a higher number of vacant or old residential buildings had increased burden of fire injuries. This is consistent with prior research; Schachterle et al. found an increase in fire risk with increasing proximity to vacant properties [17] and Shai found a strong correlation between fire injuries and the proportion of vacant properties in a census tract. [10]

Vacant properties indicate neighborhood decline which can lead to increased risk for fire injuries as property owners may fail to invest in property maintenance. Vacant properties pose risks, not only for fire-related injuries but also other public health and safety concerns. Addressing vacant properties is an important issue for neighborhood safety, and efforts to deal with vacant properties will likely have far reaching benefits.

We also found that neighborhoods with more educated residents experienced lower fire-injury rates than neighborhoods with less educated residents. Surprisingly however, no statistically significant relationship was observed between neighborhood poverty and fire injury rate in our multivariate model. Previous research has demonstrated decreasing fire injuries with increasing median census tract annual income, [4] and a census tract analysis of fatal fires in Baltimore found that rates of fire related deaths decreased with increasing median property rental value. [6] Our finding does not necessarily indicate a lack of association between poverty and fire injury risk; much of a household's risk of fire injury is related to the household and may not be observable between neighborhoods.

These data were not collected for research purposes and there is limited demographic information available for the injured, which limited our ability to further analyze such relationships. However, because the source of these data is the local fire department, they better represent the burden of fire injuries than hospital admissions or death records alone. Furthermore, we did not have information on other factors that would potentially be of interest such as the cause, size or intensity of the fire, nor did we have information about smoke alarms. As a census tract analysis, we did not consider individual level fire and injury factors.

Implications for injury prevention and policy

Our findings have implications for setting priorities for fire prevention such as smoke alarm distribution programs. As resources for public services become increasingly scarce, households within census tracts known to have a greater burden of fire injuries should receive priority during smoke alarm distribution efforts. In addition, attention to other risk factors, such as electric outlet overload and alternative heating sources, can be part of the intervention when smoke alarm distribution efforts include installation.

Maryland law requires at least one working smoke alarm on every level of a home [19]; new residential structures must have hardwired, interconnected alarms [20] and sprinkler systems [21]. However, one study estimated that less than half of Baltimore homes (40%) had a smoke alarm on every level [13] suggesting that efforts to raise awareness about the law, improve access to smoke alarms, and enforce the current law are needed. The Baltimore City Fire Department operates a smoke alarm distribution program in which firefighters install smoke alarms free of charge.

Fire departments collect detailed information about people who die as a result of fire. However, information on injuries is less well tracked and little information is gathered unless the fire is investigated due to suspicion of criminal activity or other special circumstance. There is little literature on the epidemiology of non-fatal civilian fire injuries and what predicts whether a person is injured in a fire. Capturing the burden of injuries is important in order to measure the public health impact of fire and better allocate resources.

Conclusion

We sought to analyze data collected by an urban fire department to assess its value in understanding the burden of fire-related injury at the local level and the relationship of socioeconomic factors in predicting fire injury risk. Neighborhood measures of poverty, education and housing age proved good indicators for identifying areas with a higher burden of fire-related injuries. Such analyses can be useful for fire department planning. As resources for public services in urban areas become increasingly scarce, the value of using available information to inform practice decisions is apparent. Importantly, such analyses also point the way to achieving greater gains in lives saved and injuries averted.

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References

1. Karter, MJ. Fire Loss in the United States during 2011. National Fire Protection Agency; 2012.
2. Ballard JE, Koepsell TD, Rivara F. Association of Smoking and Alcohol Drinking with Residential Fire Injuries. Am J Epidemiol. 1992; 135(1):26–34. [PubMed: 1736657]
3. Barillo DJ, Goode R. Fire Fatality Study: Demographics of Fire Victims. Burns. 1996; 22(2):85–8. [PubMed: 8634135]

4. Istre GR, McCoy MA, Osborn L, et al. Deaths and Injuries from House Fires. N Engl J Med. 2001; 344(25):1911–6. [PubMed: 11419429]
5. Marshall SW, Runyan CW, Bangdiwala SI, et al. Fatal Residential Fires: Who dies and who survives? JAMA. 1998; 279(20):1633–7. [PubMed: 9613913]
6. Mierley MC, Baker SP. Fatal House Fires in an Urban Population. JAMA. 1983; 249(11):1466–8. [PubMed: 6827724]
7. Scholer SJ, Hickson GB, Mitchel EF Jr, et al. Predictors of Mortality from Fires in Young Children. Pediatrics. 1998; 101(5):e12. [PubMed: 9565445]
8. Warda L, Tenenbein M, Moffatt ME. House Fire Injury Prevention Update. Part I. A Review of Risk Factors for Fatal and Non-Fatal House Fire Injury. Inj Prev. 1999; 5(2):145–50. [PubMed: 10385837]
9. United States Fire Administration. Civilian Fire Injuries in Residential Buildings (2008–2010). 2012.
10. Shai D. Income, Housing and Fire Injuries: A Census Tract Analysis. Public Health Rep. 2006; 121:149–54. [PubMed: 16528947]
11. Runyan CW, Bangdiwala SI, Linzer MA, et al. Risk Factors for Fatal Residential Fires. N Engl J Med. 1992; 327(12):859–63. [PubMed: 1508246]
12. Hapgood R, Kendrick D, Marsh P. How well do socio-demographic characteristics explain variation in childhood safety practices? J Public Health Med. 2000; 22(3):307–311. [PubMed: 11077902]
13. Parker EM, Gielen AC, McDonald EM, et al. Fire and scald burn risks in urban communities: Who is at risk and what do they believe about home safety? Health Educ Res. 2013; 28(4):599–611. [PubMed: 23487557]
14. United States Fire Administration. Socioeconomic Factors and the Incidence of Fire. 1997.
15. Jennings CR. Socioeconomic characteristics and their relationship to fire incidence: A review of the literature. Fire Technology. 1999; 35(1):7–34.
16. Jennings, CR. Doctoral Thesis. Cornell University; 1996. Urban residential fires: An empirical analysis of building stock and socioeconomic characteristics for Memphis, Tennessee.
17. Schachterle SE, Bishai D, Shields W, et al. Proximity to Vacant Buildings is Associated with Increased Fire Risk in Baltimore, Maryland, Homes. Inj Prev. 2012; 18(2):98–102. [PubMed: 21873307]
18. U.S. Census Bureau. [Accessed 3/21/2011] <http://www.census.gov/>
19. Maryland Code, Public Safety § 9–102.
20. Maryland Code, Public Safety § 9–103.
21. COMAR 05.02.07 (January 1, 2012).

Table 1

Baltimore City Characteristics

	Baltimore City	**United States**
Total Population	639,337	301,461,533
Average per capita income	$22,911	$27,041
Percent households with income below poverty line	20.0%	13.5%
Percent residents with Bachelor's Degree	24.9%	27.5%
Percent households Owner-Occupied	51.1%	66.9%
Percent homes built in 1939 or earlier	39.7%	14.4%
Percent homes vacant	11.2%	11.8%

Table 2

Characteristics of residential fire-related injuries in Baltimore City, 2004–2007 (N=428)

		N	%
Season	Winter (December – February)	136	31.78
	Spring (March – May)	131	30.61
	Summer (June – August)	74	17.29
	Fall (September – November)	87	20.33
Age	<5 years	33	8.07
	5–17 years	50	12.22
	18–29 years	62	15.16
	30–44 years	94	22.98
	45–59 years	77	18.83
	60+ years	93	22.74

Table 3

Census tract-level correlates of fire-related injuries: Results from bivariate negative binomial regression models (N=199 census tracts with 426 injuries)

	Incidence Ratio	Standard Error	95% CI
Percent over 25 with at least Bachelor's Degree	0.80	0.05	(0.72, 0.88)
Percent below poverty line	1.45	0.07	(1.26, 1.67)
Per Capita Income (in 1000)	0.65	0.09	(0.54, 0.77)
Percent vacant homes	1.63	0.07	(1.42, 1.88)
Percent occupied homes Owner Occupied	0.90	0.05	(0.82, 1.00)
Percent homes built in 1939 or earlier	1.15	0.04	(1.07, 1.24)

Table 4

Census tract-level correlates of fire-related injuries: Results from multivariate negative binomial regression models (N=199 census tracts with 426 injuries)

	Incidence Ratio	Standard Error	95% CI
Percent vacant homes	1.28	0.10	(1.05, 1.55)
Percent homes built in 1939 or earlier	1.12	0.05	(1.02, 1.23)
Percent over 25 with at least Bachelor's Degree	0.86	0.06	(0.77, 0.96)
Percent below poverty line	1.13	0.08	(0.96, 1.32)