Income, Housing, and Fire Injuries: A Census Tract Analysis

Donna Shai, PhD[a]

SYNOPSIS

Objectives. This study investigates the social and demographic correlates of nonfatal structural fire injury rates for the civilian population for Philadelphia census tracts during 1993–2001.

Methods. The author analyzed 1,563 fire injuries by census tract using the 1990 census (STF 3) and unpublished data from the Office of the Fire Marshal of the Philadelphia Fire Department. Injury rates were calculated per 1,000 residents of a given census tract. Multiple regression was used to determine significant variables in predicting fire injuries in a given census tract over a nine-year period and interaction effects between two of these variables—age of housing and income.

Results. Multiple regression analysis indicates that older housing (prior to 1940), low income, the prevalence of vacant houses, and the ability to speak English have significant independent effects on fire injury rates in Philadelphia. In addition, the results show a significant interaction between older housing and low income.

Conclusions. Given the finding of very high rates of fire injuries in census tracts that are both low income and have older housing, fire prevention units can take preventative measures. Fire protection devices, especially smoke alarms, should be distributed in the neighborhoods most at risk. Multiple occupancy dwellings should have sprinkler systems and fire extinguishers. Laws concerning the maintenance of older rental housing need to be strictly enforced. Vacant houses should be effectively boarded up or renovated for residential use. Fire prevention material should be distributed in a number of languages to meet local needs.

[a]Department of Sociology, Villanova University, Villanova, PA

Address correspondence to: Donna Shai, PhD, Department of Sociology, Villanova University, Villanova, PA 19085; tel. 610-519-7434; fax 610-519-6319; e-mail <donna.shai@villanova.edu>.

Nonfatal injuries from structural fires continue to be an important cause of morbidity in the United States. Nationally, fire injury rates are especially high among young adults aged 20 to 29 and individuals aged 85 and older.[1] The number of residential fire-related injuries treated in emergency departments for 2001 was an estimated 25,717.[2] These injuries are highly preventable.

Structural fires include both residential and non-residential fires, with residential fires constituting 73% of structural fires in 1999 nationwide.[3] The five major causes of fire injuries in U.S. residential structure fires (one- and two-family dwellings, manufactured homes, and apartments) in 1999 were, in order of importance: cooking equipment; open flame, ember, or torch; smoking materials; intentional fire setting; and child play fires.[3] The major causes of fire injury in non-residential structural fires for the same year were, in order of importance: intentional fire setting; other equipment (other than cooking equipment); open flame, ember, or torch; electrical distribution; and cooking equipment.[3]

An effective strategy for fire injury prevention on the neighborhood level requires determining what direct and indirect factors are the most important in fire injury prevention, and what neighborhoods are at greatest risk. An example of a "direct" factor is faulty electrical wiring. An example of an "indirect" factor is the lack of fire protection devices. Two of the most important predictors are older housing and low income.[4] The age of houses has been widely used by researchers investigating the cause of fire injuries.[4,5] Low income areas have also been found to have a high number of fire injuries.[6–8]

To shed some light on the relationship between older housing and low income as they contribute to fire injury, this study draws on socio-demographic data from the 1990 Census (STF 3) for Philadelphia census tracts,[9] using multiple regression techniques, and unpublished fire injury data from the Philadelphia Fire Department. (Unpublished data on fire injury by Philadelphia census tracts, 1993–2001, Office of the Fire Marshal, Philadelphia Fire Department)

OLDER HOUSING

Research has indicated that older houses are often associated with fire injuries.[10] Some of the causes are direct. Older houses were built when there was less demand for electricity, and therefore have fewer original electrical outlets. Occupants sometimes compensate by overloading an outlet or by using extension cords. If extension cords become frayed or overloaded, they can constitute a fire hazard.

Some studies from the fire literature maintain that buildings have a finite life span that decreases with lack of maintenance, resulting in fires, collapse, or both.[11,12] One cause of fires in older buildings is the deterioration of electrical systems over time.[11] About 8% of residential fires nationwide originate in electrical wiring, and a study of electrical fires in 16 cities showed that buildings more than 40 years old had risk several times that of newer buildings.[11] Older houses may have other features placing them at risk for fires, including substandard appliances,[13] faulty heating systems leading to the use of space heaters,[14] lack of compliance with building and/or sanitary codes,[5] and narrow stairwells making escape more difficult.[5]

Older houses may also affect fire injuries indirectly as an indicator of deteriorating housing stock and economic decline in an area.

LOW INCOME

Low income neighborhoods, as exemplified by a study of Detroit,[15] tend to have a declining tax base, which results in the deterioration of public safety systems including police, firefighting, and the enforcement of regulations against illegal dumping. Houses in such areas often have hazardous cooking facilities and a lack of storage space, leading to clutter that can contribute to fire.[16] Renters may be unable to improve the safety conditions due to weak tenant protection laws or the difficulty of enforcing them.[16] Under these circumstances, houses can deteriorate quickly. A study of residential fires resulting in child fatalities in Philadelphia found that houses cited for health and safety violations often had faulty wiring, misuse of electrical cords, space heaters, unsafe exit doors and windows, and disabled smoke alarms.[10] Sometimes residents added bars on windows and doors, which were intended to solve problems of crime but actually created injuries in the case of fires by impeding escape.[10]

Residents of poor neighborhoods may have fewer fire protection devices such as smoke alarms, and both tenants and landlords are less likely to maintain those that are installed.[17] The presence of sprinklers, smoke alarms, and fire extinguishers greatly increases the chance of surviving a fire without injury.[18] Sprinklers may be especially useful in the case of the elderly who have difficulty in mobility, because sprinklers help to keep a fire small and lessen the amount of deadly smoke and gases reaching the occupants as they try to flee the house.[19] The main reason for not installing

sprinklers is the perceived high cost of purchase, installation, maintenance, and replacement.[18] Smoke alarms can save lives but cannot extinguish a fire or help those who are unable to flee on their own, such as small children and the elderly.[20] While fire departments urge people to leave the building immediately in the case of fire, call the fire department, and not attempt to put the fire out, there are some occasions on which using a fire extinguisher can help prevent injury. Those are when the fire is small, there is not a great deal of smoke, the fire is not spreading beyond the place where it began, and the person knows how to operate a fire extinguisher.[21]

VACANT HOUSING

Vacant houses, particularly in large urban areas such as Philadelphia, New York City, and Chicago, have frequently been described as potential fire hazards.[12,22,23] For the United States, the percentage of fires in vacant property was only 2.2% of structure fires in 1999 and the fire injuries for that year in vacant property for the civilian population was 0.4%.[3] The main causes of these fires were intentional firesetting, open flame, and exposure to another fire.[3] Vacant houses can be set on fire by individuals preparing drugs[24] and transients starting fires for warmth.[25] Additional hazards are created when debris, which can ignite quickly, is illegally dumped in vacant buildings.[15]

The connection between vacant houses and fire injuries may be both direct and indirect. The presence of vacant houses is a contributor to decline as well as an indicator of it. An unsecured abandoned house not only deprives the city of tax revenue, but often attracts crime.[23] Confidence in the neighborhood then falls, touching off an exodus into surrounding areas, leading to a spiral of decline.[26]

The primary purpose of this study was to examine the relative contributions of income and housing to fire injuries in Philadelphia census tracts. It can be hypothesized that it is the age of the house and not the economic status of the residents that determines risk and that the effects of housing on fires are direct through deteriorated electrical wiring, substandard appliances, and outdated heating systems. On the other hand, if the problem is not older housing per se, but indirect effects such as lack of maintenance, lack of fire protection devices, and difficulty in enforcing fire and building codes in poor areas, then the risk of fire injuries should be particularly great where older houses are located in low income neighborhoods. To test whether this risk might be greater than the combined effects of older housing and low income, a second hypothesis was formulated, suggesting the possibility of an interaction effect between income and housing.

METHODS

Demographic data are from the 1990 Census Summary Tape File 3 by census tract for the county of Philadelphia.[9] The census data were used to examine socio-demographic variables that have been shown in the literature to affect injuries, or that are likely to affect fire injuries in the case of Philadelphia. These include low income, older housing, and vacant houses, all of which are described above. In addition, unemployment has been shown to be a significant predictor of all injuries among children in a neighborhood-level study in northern Manhattan.[6] Less than high school education and lack of access to a phone were significant risk factors for residential fire injuries in a census tract level study in Dallas, Texas.[27] While the characteristic of speaking English "not well" or "not at all" has not been widely studied outside the fire prevention literature, newspaper accounts suggest that language competence can be a factor in fire injuries. In one Philadelphia case, Spanish-speaking children cried for help during a fire but no one responded because neighbors did not understand them.[28] In the case of a fire in Santa Ana, California, a 5-year-old boy who remained in the house was not rescued by emergency personnel because they couldn't understand the pleas of his Spanish-speaking mother.[29]

To control for differences in the age structure of census tracts, particularly the ages most at risk for fire injury, an age control variable was included.

In 1990, there were 367 census tracts in Philadelphia. Those with fewer than 500 people were eliminated. Fourteen of those tracts had no households, including tracts 50.99 (the Navy Yard), 324 (empty land off the Delaware River), 328 (Philadelphia Prison Complex), and 364 (the state hospital, Byberry). This resulted in 324 remaining census tracts and the elimination of 32 fire injuries.

Fire injury data (unpublished) are from the Philadelphia Fire Department Fire Marshal's Office and cover years 1993 to 2001 for the civilian population. The 1990 rather than the 2000 census data were used for two reasons: first, the Philadelphia Fire Department had coded injuries for the study years on the 1990 configuration of census tracts, so that the use of 1990 data ensured consistency in census tracts. Second, from a statistical perspective, using the 1990 data

helps avoid any potential problems in cause and effect since the majority of the fire injuries occurred prior to the conditions documented in the 2000 census.

Multivariate regression was used to analyze the data. The dependent variable (the rate of fire injury per 1,000 residents) was regressed on the explanatory variables of a given census tract in Philadelphia over nine years (see Figure). In the multiple regression analysis, none of the independent variables were correlated above 0.70 and the variance inflation factors were all below 4, suggesting that multicollinearity was not a problem. To test for interaction between housing and income, a product term variable was created by subtracting the mean from the original variables and then constructing a new variable that was the product of the two centered variables.

RESULTS

The total number of injuries was 1,563. The number of fire injuries by census tract ranged from 0 to 30. Forty-two tracts had no fire-related injuries during the nine years of the study. The variables of age of housing, income, vacant housing, and English-speaking were all statistically significant, at least at the 5% level. Furthermore, vacant housing and income were highly significant. None of the other factors, except for interactions, appeared as significant predictors (see Table).

In an alternative analysis, the dependent variable was logarithmically transformed to reduce skew and potential heteroscedasticity. The basic findings were unchanged using this modeling strategy, suggesting that the results are robust.

Given the finding that the variable of vacant houses proved highly significant, an additional data set was obtained from the Philadelphia Fire Department consisting of unpublished statistics on the number of nonfatal fire injuries that occurred in vacant or abandoned houses in Philadelphia during 1993–2001. There were 61 fire injuries, constituting 3.90% of all injuries in Philadelphia during that period.

DISCUSSION

This research contributes to the previous literature on the relationships between community characteristics and fire injuries.[6,10,13,14] It also reinforces the findings of other researchers that socioeconomic disparities can influence health in a variety of ways.[30,31]

Philadelphia census tracts with high percentages of low income and older housing have elevated rates for fire injuries, suggesting that the risk of fire injuries is greater than the combined effects of older housing and low income. Therefore, the problem is not older housing per se (the first hypothesis) but a more complex situation stemming from the interaction between older houses and low income, supporting the second hypothesis.

A second finding is that the proportion of vacant houses is highly significant. The percentage of injuries that took place in vacant houses is above the national figure and warrants further study. However, vacant

Figure. Independent variables

Independent Variable	*Definition*
%OLDHOUSES	A continuous variable indicating the percentage of housing units built before 1940 in a given census tract.
%ENGLISH	A continuous variable indicating the percentage of persons who speak English "not well" or "not at all" in a given census tract.
%LOWINCOME	A continuous variable indicating the percentage of households in a given census tract with an income in 1989 of less than $15,000.
%LT9YEARS	A continuous variable indicating the percentage of persons 18 and over with less than 9th grade education in a given census tract.
%NOPHONE	A continuous variable indicating the percentage of housing units without a telephone in a given census tract.
%UNEMPLOY	A continuous variable indicating the percentage of persons 16 years of age and over in a given census tract who were unemployed.
%VACANT	A continuous variable indicating the percentage of vacant housing units in a given census tract.
AGECONTROL	A continuous variable indicating the percentage of persons between the ages of 20–29 and ages 85 and over in a given census tract.
NEW%OLDHOUSES	A continuous variable constructed by subtracting the mean from %OLDHOUSES.
NEW%LOWINCOME	A continuous variable constructed by subtracting the mean from %LOWINCOME.
NEW%OLDHOUSES × NEW%LOWINCOME	A continuous variable formed by the product of NEW%OLDHOUSES and NEW%LOWINCOME.

Table. Fire injury rate per 1,000 regression on income, controlling for socio-demographic characteristics. Philadelphia census tracts (N=324), 1993–2001

Variable	*Unstandardized regression coefficient (standard error)*	Beta	*Unstandardized regression coefficient (standard error)*	Beta
%LOWINCOME	0.031[c] (0.004)	0.450	—	—
%OLDHOUSES	0.005[b] (0.002)	0.132	—	—
%ENGLISH	3.629[a] (1.495)	0.145	3.514[a] (1.486)	0.140
AGECONTROL	−0.001 (0.007)	−0.007	0.002 (0.007)	0.013
%LT9YEARS	−1.976 (1.219)	−0.111	−2.302 (1.219)	−0.130
%UNEMPLOY	0.282 (2.131)	0.008	0.046 (2.119)	0.001
%NOPHONE	−0.971 (1.398)	−0.048	−0.920 (1.389)	−0.046
%VACANT	3.333[c] (0.859)	0.217	3.085[c] (0.860)	0.201
NEW%OLDHOUSES	—	—	0.007[b] (0.002)	0.181
NEW%LOWINCOME	—	—	0.033[c] (0.004)	0.471
NEW%OLDHOUSES × NEW%LOWINCOME	—	—	0.001[a] (0.001)	0.118

Beta = standard regression coefficient

[a]$p<0.05$

[b]$p<0.01$

[c]$p<0.001$

houses are also an indicator of decline in an area and may have even more important indirect effects on fire injuries in a census tract. Abandoned houses need to be identified and secured with effective boarding up techniques, demolished, or rehabilitated. Zoning laws should be enforced more strictly to prevent illegal dumping.

A third finding is that the inability to speak English well or at all is associated with high rates of fire injuries, and brings up a number of issues involving the communication of fire safety information. Non-English speakers and those who speak English as a second language may not be reached in typical fire safety materials and brochures distributed by fire departments.[32,33] Individuals with limitations in the understanding and expression of English may have difficulty using fire protection devices correctly, processing information, and communicating their difficulties to others. In the case of evacuation of large apartment houses due to fires, those who cannot speak English may need instructions in their own language.[34]

The implications for policy that emerge from this study include identifying and targeting high-risk census tracts for special fire prevention campaigns. If smoke alarms are not already in place or are not working, they should be distributed and installed, with batteries. Bars on windows need to be easy to open from the inside, both to facilitate escape and to allow firefighters to get in. Fire prevention campaigns should encourage the use of escape ladders where escape routes may be blocked by smoke or fire, and warn about the dangers of frayed or overloaded extension cords. Since cooking equipment is the major cause of residential injury fires, especially among the elderly, product development of safer stoves is important. Outreach to prevent cooking fire injuries should emphasize safe handling of equipment and not leaving cooking unattended even for a short time. Smoking should be discouraged and products should be developed for child-proof lighters and match containers. Absentee landlords should be held responsible for providing effective, safe heating equipment and should

discourage the use of portable space heaters. Landlords should also be required to provide safe appliances, fire protection devices, safe electrical distribution systems, and to keep the property free of debris.

In Philadelphia, four census tracts (tracts 22, 161, 167, and 178) fall into the highest quartile for all four significant variables and therefore are at highest risk for nonfatal fire injuries. They are located in north and south Philadelphia, which have some of the oldest houses in the city.[35] Data on the variables examined here by census tract are readily available online for researchers and fire departments in other localities.[9]

It is necessary to add a few caveats about the data. The unpublished injury data come from the Fire Marshal's office and were collected for purposes other than research, so the extent of demographic specifics in individual cases was limited. Philadelphia has a distinctive housing stock shared by only a few areas in the northeast United States. It would be advantageous to compare these findings with other large central cities.

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