Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/burns

Geographic modeling for children at risk for home fires and burns

Carlee Lehna [a,*], Stephen Furmanek [a], Erin Fahey [a], Carol Hanchette [b]

[a] University of Louisville School of Nursing, Louisville, KY, United States
[b] University of Louisville Department of Geography and Geosciences, Louisville,KY, United States

ARTICLE INFO

Article history:
Accepted 10 July 2017

Keywords:
Burns
Geographic information systems
Prevention
Child

ABSTRACT

This study developed a predictive model for fires and burns among parents and children in Jefferson County, Kentucky. Eight risk factors for pediatric burns with census tract level data available were identified. Risk factors were synthesized to develop a cartographic model with risk levels low, medium, high, and severe. Validation was performed with fire dispatch data. At-risk areas were concentrated in the county's northwest. Risk was correlated with fire incidence rate ($\rho=0.67$, $p<0.001$). Significant risk factors were race ($\beta=0.54$, $p<0.001$), education ($\beta=0.38$, $p<0.001$), and year home built ($\beta=-0.17$, $p=0.005$). Cartographic modeling is a underutilized tool to identify at-risk areas.

1. Background

Burns account for nearly 265,000 deaths worldwide, and the majority of deaths and loss of disability-adjusted life years (DALYs) due to burns occur in low and middle income countries [1]. In the United States, roughly 29% of reported burns [2] are among children aged less than 16 years old. Burn injury costs, depending on severity, are extremely high; mean cost per hospitalization for burns is roughly twice that of all non-maternal hospital stays [3]. In a study of pediatric burn injuries [4], hospitalization and follow-up during recovery cost a mean of $83,535 per patient. Burns may also cause adverse psychosocial outcomes in children [5]. Although burns have high financial costs, pose burden in disability-adjusted life years (DALYs), and cause other morbidity, they are a preventable accident. Despite burn prevention efforts in the United States, burns still account for numerous hospitalizations—in 2011 there were 486,000 hospitalizations for burn injuries [6].

Current and future safety and prevention efforts will require evaluation to make sure that they are most effectively serving those at risk. The ability to predict which geographic areas are at highest risk for home fires and burns greatly impacts current and future fire safety and prevention efforts. To this end, there are techniques that allow researchers to pinpoint areas of high risk using geographic information systems (GIS). GIS has been used in recent burn research [7,8] to identify areas at risk. GIS can be used to analyze the spatial relationships of data; one such method, cartographic modeling, combines a series of maps to analyze spatial data. Cartographic risk model development has been done previously [9,10] for the older adult population of Jefferson County, Kentucky. Other populations, however, have different risk factors and have not been examined systematically in this manner. The purpose of this study was to develop and validate a risk model for fires and burns among parents and their children under five years of age using cartographic modeling and GIS.

* *Corresponding author at*: School of Nursing, University of Louisville, 555 S. Floyd St., Louisville, KY, 40202, United States.
E-mail address: c0lehn01@louisville.edu (C. Lehna).

http://dx.doi.org/10.1016/j.burns.2017.07.007

Only publicly available data were obtained for this research. Cartographic risk model development involved the following steps: a literature review, data collection, and GIS modeling; model validation used county dispatch data, and statistical analysis.

1.1. Literature review

Risk factors were identified through a literature review for the years 2009–2014 using The University of Louisville World Catalogue (data bases: Academic Search Complete, BioOne, PsycARTICLES, Psychology and Behavioral Sciences Collection, PsycINFO, and WorldCat.org), search terms: burn injury risk and pediatrics with limits libraries worldwide, peer-reviewed articles, and format=article; CINAHL search terms: epidemiology, burns, and pediatric with limits apply related words and search within full text of article and English language, and research article; MEDLINE (EBSCO) search terms: epidemiology, burns, and pediatric with limits English language, apply related words, peer-reviewed articles, and Boolean/Phrases; MEDLINE (OVID) search terms risk factors, burns, and infants; PubMed search terms: epidemiology, burns, and pediatric; etiology, burns, and pediatric; risk factors, burns, and pediatric; and ScienceDirect search terms etiology and burns.

Risk factors identified from 25 academic articles were categorized according to two age groups: less than five years and less than one year. Risk factors had to be cited in the literature as significant and available as a measured variable in the United States (US) Census Bureau American Community Survey (ACS) to be considered.

Risk factors identified in the literature were age [7,8,11–23], male child [8,11,13–15,20–30], low SES [7,15,19,24,26,31,32], race non-white [13,15,18,29,30,32], parental age [14,24,33], home value [31], year home built [32], and education [33]. The risk factors described most often included under five years of age, male child, non-white or African American and low socioeconomic status.

2. Methods

2.1. Design and sample

Demographic census data were used to develop the risk model and fire incidence data obtained to validate it. Jefferson County, Kentucky has 191 census tracts; each census tract was treated as its own observational unit.

2.2. Census data

Census data for selected risk factors was taken from the ACS 5-year estimates from 2008 to 2012 at the census tract level for Jefferson County [34]. Five-year estimates are required for census-tract level data, and also provide a more accurate estimate of risk factors during this period.

Housing risk factors of year home built and median home value were taken directly from variables at the census tract level. In the ACS, housing-related variables often only apply to specific housing—year home built applies to all types of housing defined by the U.S. Census Bureau, whereas median home value only looks at single dwellings.

Some social and economic risk factors were taken directly from variables at the census tract level, such as percent population under five years of age and percent non-high school graduate. Low SES was approximated by percent poverty (also taken directly from the ACS) and was further supported by the inclusion of other surrogate markers of SES, such as percent non-high school graduate and median home value [35]. The non-white population of Jefferson County is predominantly African American, so to represent this risk factor the percent population black was chosen. Because this study emphasized pediatric burns, male sex was only looked at for the population aged under eighteen: the male percentage of the population under 18 years of age was calculated from values in census data for each census tract. To approximate the percentage of young parents, the percentage of women who had given birth in the past year who were below 20 years of age was calculated from census variables for each tract.

2.3. Fire incidence data

Fire incidence was adapted from the Louisville Metro Government Emergency Management Agency MetroSafe for fire dispatches made in Jefferson County during the time period of January 1–December 31, 2013. Fire incidents involved those occurring within the home and were unintentional [10]. This encompassed descriptors such as “residential, food on the stove, electrical structure,” etc [10]. Confirmation using Google maps followed for fires not typed as residential. Omitted were duplicate records (those with the same address occurring within 15 min), those categorized as commercial, automobile, arson, and with unknown origination [10]. There were a total of 1805 household fires in the January 1, 2013–December 31, 2013 period.

2.4. GIS analysis

ESRI ArcGIS 10.1 software was used to assign and map derived scores for each risk factor. A summed risk factor map was created indicating total risk score. In addition, residential fire dispatches were mapped and fire incidence rates per 10,000 households (all kinds) were calculated for each census tract.

2.5. Cartographic modeling

Cartographic modeling involves combining several maps of different variables into one composite map. It has traditionally been used for land use planning (known as a suitability analysis); however, it has been applied to public health related studies [36]. Census tract-level maps are made for each risk factor and weights are determined by the magnitude of the risk factor given; a high value of a risk factor in a census tract will receive a high weighted score.

2.6. Derived maps

Census data for each risk factor were sorted into quartiles based on the distribution of the data. A higher quartile would