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Targeting energy justice: Exploring spatial, racial/ethnic and socioeconomic disparities in urban residential heating energy efficiency

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HIGHLIGHTS

- Develops statistical model to predict block group (BG) residential heating energy use intensity (EUI), an energy efficiency proxy.
- Bivariate and multivariate analyses explore racial/ethnic and socioeconomic relationships with heating EUI.
- BGs with more racial/ethnic minority households had higher heating EUI.
- BGs with lower socioeconomics had higher heating EUI.
- Mapping heating EUI can facilitate effective energy efficiency intervention targeting.

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ABSTRACT

Fuel poverty, the inability of households to afford adequate energy services, such as heating, is a major energy justice concern. Increasing residential energy efficiency is a strategic fuel poverty intervention. However, the absence of easily accessible household energy data impedes effective targeting of energy efficiency programs. This paper uses publicly available data, bottom-up modeling and small-area estimation techniques to predict the mean census block group residential heating energy use intensity (EUI), an energy efficiency proxy, in Kansas City, Missouri. Results mapped using geographic information systems (GIS) and statistical analysis, show disparities in the relationship between heating EUI and spatial, racial/ethnic, and socioeconomic block group characteristics. Block groups with lower median incomes, a greater percentage of households below poverty, a greater percentage of racial/ethnic minority headed-households, and a larger percentage of adults with less than a high school education were, on average, less energy efficient (higher EUIs). Results also imply that racial segregation, which continues to influence urban housing choices, exposes Black and Hispanic households to increased fuel poverty vulnerability. Lastly, the spatial concentration and demographics of vulnerable block groups suggest proactive, area- and community-based targeting of energy efficiency assistance programs may be more effective than existing self-referral approaches.

1. Introduction

Climate change concerns highlight a number of serious social and environmental inequalities that can be traced to energy consumption. These concerns form the foundation of a growing field of scholarship, and activism, on energy justice. For instance, Hernández (2015) issued "*A Call for Energy Justice*," which acknowledged four basic human rights to energy: the right to a healthy, sustainable energy production; the right to best available energy infrastructure; the right to affordable energy; and the right to uninterrupted energy service. For the many US households suffering in fuel poverty, nearly 14 million with unpaid utility bills and 2.2 million with disconnected utilities, these rights are unfulfilled promises (Seibens, 2013). Fuel poverty (also known as energy poverty or energy insecurity) is the inability of households to afford energy services for adequate heating and cooling resulting in uncomfortable indoor temperatures, material deprivation, and accumulated utility debt (Li et al., 2014, Hernández 2013, Buzar, 2007; Boardman, 2012). More than a matter of mere comfort, indoor temperatures that are too cold in winter or too hot in summer have detrimental mental and physical health impacts, including death, for vulnerable populations like children, the elderly, and racial/ethnic minorities (Anderson et al., 2012; Liddell

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and Morris, 2010, Howden-Chapman et al., 2009, Howden-Chapman et al., 2007, Klinenberg, 2002; Taylor et al., 2001). A key measurement of fuel poverty is the proportion of gross income spent on home energy costs, or the energy burden. Low-income US households have an average heating energy burden of 4.7% that is more than double the 2.3% national average and more than four times the 1.1% average burden for high-income households (US Department of Health and Human Services [HHS] 2011). Analysts consider a heating energy burden greater than 2% unaffordable (Fisher et al., 2014).

However, fuel poverty is more than a straightforward relationship between household income and energy costs. The concept became prominent in the 1980s and has been well-studied in the UK (see special issue Volume 49 of this journal) and even codified in law with the passage of the Warm Homes and Energy Conservation Act of 2000. Investigations of fuel poverty, including those beyond the UK, demonstrate that a pure financial assessment of its prevalence does not account for the variety of factors and relationships that produce and sustain it. Buzar (2007) advocated a "relational approach" to studying fuel poverty, one that combines understanding energy policy, housing infrastructures, and the lived experience of the fuel poor. Hernandez and Bird (2010) found the incidence of high inner-city energy burdens was due in part to a lack of energy assistance funding, a lack of housing and energy policy coordination, and a lack of understanding the social and economic benefits of energy conservation and efficiency. Harrison and Popke (2011) suggested fuel poverty be understood "as a geographical assemblage of networked materialities and socioeconomic relations" determined by household socioeconomic characteristics, material conditions of the home, and the structure that defines the provision of energy.

The conceptualization of fuel poverty as an energy justice concern speaks to the energy-related distribution, procedure, and recognition of "what constitutes the basic rights and entitlements of sufficient and healthy everyday life" (Walker and Day, 2012). Consequently, fuel poverty violates the basic principle of distributive justice. Distributive justice is the idea that all members of society have the right to equal treatment, and that outcomes should be fairly distributed, and provides moral guidance for the political processes and structures that affect the distribution of economic benefits and burden across and within society (Rawls, 1971; Sen, 1999 Schlosberg, 2013). As a distributive injustice, fuel poverty results from three interconnected inequalities: income inequality, inequality in energy prices, and inequalities in housing and energy efficiency (Walker and Day, 2012). Although fundamentally, fuel poverty is a problem of distributional injustice, its production and persistence are also the result of an injustice in recognition of the specific energy-related needs of vulnerable populations, and procedural injustice related to access to information, meaningful participation in decision-making, and access to legal processes for achieving redress or challenging decision-making processes (Walker and Day, 2012).

Addressing the distributive injustice of fuel poverty requires first determining what should be fairly distributed. Since inequalities in income and energy prices require larger social and economic solutions, residential energy efficiency retrofits have become a key fuel poverty intervention strategy (Howden-Chapman et al., 2007, Howden-Chapman et al., 2009, Bird and Hernández 2012, Gibson et al., 2011, Harrison and Popke, 2011). However, the absence of easily accessible data on individual household energy consumption and efficiency, and an incomplete understanding of the spatial distribution of vulnerability presents an impediment to effectively targeting those most in need (Walker et al., 2013; Sefton, 2002). Recently, scholars have conducted small-scale, area-based studies using readily available public data and geographic information systems (GIS) to offer visualizations of spatial disparities in the distribution of fuel poverty vulnerability and energy consumption to facilitate policymaking and intervention targeting (Pereira and de Assis, 2013; Walker et al., 2013; Fahmy et al., 2011; Morrison and Shortt, 2008).

In the US, while fuel poverty is neither recognized colloquially or politically, a few studies have modeled the spatial distribution of residential energy consumption, including socioeconomic and demographic control variables in their models (Howard et al., 2012; Min et al., 2010; Heiple and Sailor, 2008). Others have explored the socioeconomic and demographic relationships of national residential energy consumption patterns (Health and Human Services [HHS] 2011; Steemers and Yun, 2009; Ewing and Rong, 2008; Adua and Sharp, 2011; Newman and Day, 1975). Generally, these studies concluded that, all else being equal, low-income households consume less energy. This broad assessment of consumption rather than efficiency, tends to mask fuel poverty vulnerability. Instead, when analyzing energy use intensity (EUI), or energy consumption normalized by building square area, as a proxy for energy efficiency, national data from the US Energy Information Administration (EIA) show that low-income household, on average, are less efficient, with an EUI 27% greater than high-income households. The spatial distribution of energy efficiency is further complicated by a persistent system of racial and income residential segregation that defines housing development and consumption patterns in many US metropolitan areas. A substantial amount of research is aimed at understanding the causes and consequences of residential segregation, primarily from the fields of sociology and public health (Sampson, 2012; Sharkey, 2011; Anthopolos et al., 2011; Sampson and Wilson, 1995; Wilson, 1987). But very little of this research is connected to energy-related research in meaningful ways that illustrates the critical importance of place to the presence of energy efficiency disparities and fuel poverty vulnerability.

This paper uses publicly available data to model residential heating energy efficiency, as a function of various housing and household characteristics for a tri-county metropolitan area. The study extends previous energy consumption and social justice oriented research by predicting small-area estimation of end use energy efficiency, and then examining racial/ethnic and socioeconomic relationships. This analysis not only furthers our understanding of the dynamics and distribution of energy efficiency disparities, it has practical applications that may assist policymakers and practitioners with developing and implementing more equitable, efficient, and effective targeting of energy assistance programs and weather-related vulnerability prevention activities. This study seeks to answer two research questions. First, does residential heating energy efficiency vary within a metropolitan area? And if so, what are the spatial characteristics of that variation? Second, what are the patterns of association between residential heating energy efficiency and racial/ethnic, and socioeconomic characteristics? The remainder of the paper summarizes the modeling and mapping of residential heating energy efficiency and analysis of the spatial, racial/ethnic, and socioeconomic patterns. Section 2 describes the study area, and methods for developing a model for heating energy efficiency and small-area predictions. Section 3 presents the results of the geographic and statistical analyses. Section 4 concludes with policy implications.

2. Methodology

2.1. Description of study area

Kansas City is the largest city in the State of Missouri and lies mostly in Jackson, Clay, and Platte counties (see Fig. 1). This tri-county region also represents the service area for United Services,