Which households are energy insecure? An empirical analysis of race, housing conditions, and energy burdens in the United States

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Acknowledgments
This research was supported through funding provided by the National Science Foundation, the Alfred P. Sloan Foundation, the Environmental Resilience Institute, funded by Indiana University's Prepared for Environmental Change Grand Challenge initiative, and the Indiana University's Office of the Vice President of Research. We would like to thank Dr. Diana Hernández for sharing her survey instrument on energy insecurity, which informed our own survey design, and also thank Hannah Abell for her exceptional research assistance.

Declaration of Competing Interests
The authors have no competing interests to declare.

Data Sharing Statement
The authors will make all data used in this analysis available upon request.

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Abstract

Energy insecurity refers to a household's inability to meet its basic energy needs. Previous research has shown that this type of material hardship can lead to negative mental and physical health outcomes, especially for children and the elderly. This study analyzes a state-representative sample of low-income households to evaluate if households of color are more likely than white households to be energy insecure, and, if the reasons are either poor housing conditions or higher energy burdens. We find that energy insecurity is widespread. Over a year period, 30 percent of respondents were unable to pay at least one energy bill, 33 percent received at least one disconnection notice, and 13 percent were disconnected from their electric utility service. Regression analysis further suggests that Black and Hispanic households are more likely than white households to be energy insecure. Additionally, deficient housing conditions and higher energy burdens are both independent predictors of household energy insecurity. Through a mediating variables analysis, however, we find that housing conditions and energy burdens only explain a small proportion of the association between race and energy insecurity. These results indicate that there remains considerable uncertainty about the reasons that households of color experience energy insecurity at higher rates than white households and that future research is needed to uncover the mechanisms underlying these disparities.

Keywords: energy justice, energy insecurity, racial disparities

1. Introduction

The concept of energy justice was first introduced to academic scholarship in 2013, [1] and it has continued to attract increased attention in the literature (see i.e., [2,3,4,5,6,7,8]). Energy justice is based on the foundation that all individuals should have access to safe (i.e., does not compromise human health or wellbeing), affordable (i.e., all individuals have the ability to pay for it), and sustainable (i.e., consumption and production today does not compromise future generations) energy. Energy justice also means that people should have the ability to engage in democratic decision-making processes about energy rates, consumption, and production that impact their communities [6].

An important dimension of energy justice is energy security, or the ability of households to meet their basic energy needs [9,10]. While energy policy scholarship has featured energy (in)security since the 1970's, specifically as it pertains to national and international supply of energy (see e.g. McGowan [11]), the present analysis focuses on the household level and a family or individual's ability to pay its energy bills and keep its power on. Over the last fifteen years, public health scholars have primarily led discussions about residential energy insecurity [9, 12,13,14], with additional scholarly contributions from social scientists that explore correlates of residential energy insecurity [15], media portrayal [16], and possible policy solutions [17]. Studies have also revealed that household energy insecurity adversely affects mental and physical health [18]. Specifically, households that cannot afford to pay their energy bills are more likely to suffer from depression and anxiety [19,20], physical discomfort, including increased rates of asthma and respiratory infection [13], and, in more extreme but certainly not rare situations, lower life expectancies [14] or premature death [21].

Energy insecurity within the U.S. is an immense, growing, and underappreciated problem [22]. Data gathered in the American Community Survey (ACS) and the Residential Energy Consumption Survey (RECS) suggest that energy insecurity is a significant burden on low-income households. In-depth studies in U.S. cities [23,24] and an analysis conducted at the U.S. Census Division level [25] revealed that certain demographic populations are more likely to be energy insecure, including households of color, those without a college education, and the chronically underemployed. Additionally, scholars have noted the importance of applying an intersectional approach [26] to energy insecurity because households may have multiple indicators (e.g., race and gender) that could overlap to deepen issues related to energy insecurity [27,28].

These studies have raised important questions about energy insecurity, including whether these patterns exist broadly across the U.S. and why households of color are more likely to be energy insecure. Regarding the latter, several studies have found that households of color are more likely to have higher energy burdens (i.e., pay a higher share of their income on energy costs) [29,30,31] as well as live in older and less energy efficient dwellings [32], both of which may explain a statistical association between households of color and energy insecurity.

Whether energy burden and inefficient housing conditions lead directly to energy insecurity, however, has yet to be empirically tested in the scholarly literature.

Accordingly, in this article, we ask two research questions: are households of color more energy insecure than white households and, if so, is energy insecurity driven by deficient housing conditions and higher energy burdens? In addressing these questions, our contributions to the literature are two-fold. First, this study evaluates the correlates of energy insecurity using a research design that offers new analytical leverage. Specifically, we designed an original survey administered to a state representative sample of 2,000 low-income households in the state of Indiana, enabling us to investigate energy insecurity among a population that is particularly vulnerable to energy insecurity. The survey provides measures of numerous household and individual level characteristics that allow us to control for factors that might otherwise confound the relationship between race and energy insecurity. Second, we apply a mediating variable analysis to empirically explore if deficient housing conditions or higher energy burdens explain why some households are more likely to experience energy insecurity than others.

We find that 30 percent of the low-income households in the sample could not pay an energy bill in at least one month of the previous year; 33 percent received at least one disconnection notice from their utility provider due to lack of payment; and 13 percent were disconnected at least once from the electricity grid. Empirically, we find that Black and Hispanic households are more likely to be energy insecure than white households. Additionally, our results reveal that those that live in degraded, broken, or inefficient housing conditions and have higher energy burdens are also more likely to be energy insecure. The mediating variable analysis, however, suggests that neither housing conditions nor energy burdens explain a substantial proportion of the association between the racial composition of a household and its energy insecurity. In other words, our empirical results do not support the expectation that deficient housing conditions or higher energy burdens explain why Black and Hispanic households are more likely than white households to experience energy insecurity. Therefore, we conclude that the reasons remain unexplained for why households of color uniquely suffer from energy insecurity and encourage scholars to consider further quantitative scholarship to explore the drivers of energy insecurity across the U.S.

2. Background

The academic literature on energy insecurity in the U.S. is relatively new [6], despite the fact that utilities rank in the top four spending categories for an average U.S. household (following shelter, pensions and insurance, and food) [33]. In foundational work, Hernández [9] operationalized the concept of energy insecurity through three core dimensions – economic, physical, and behavioral. Economic energy insecurity represents the financial hardship that low-income families face when paying utility bills. For example, low-income families spend roughly three times as much of their income on energy as compared to average- to high-income households [30,31]. Physical energy insecurity refers to deficient housing conditions that many renters and homeowners live in as a result of limited housing options due to affordability and a lack of investment and maintenance by landlords in energy efficient materials and

appliances, among other factors. These various conditions can reduce indoor thermal comfort and increase energy costs [34]. Therefore, scholars tend to associate energy insecurity with energy-inefficient homes [34,35,36] that have "drafty windows, faulty thermostats, poor lighting, electrical hazards, outdated appliances, and pest infestations" ([9], page 2). Behavioral energy insecurity is defined by the coping strategies (e.g. alternative home heating methods or taking out high-interest loans) that these households use to counteract the effects of economic and physical energy insecurity [9].

As of 2015, one in three American households reported that they experienced some level of energy insecurity in the last year, with approximately 14 million households living with unpaid utility bills, 17 million receiving a disconnection notice from their utility provider, and 2 million having been disconnected from the electric grid [37,38]. Although both the World Health Organization (2006) [39] and the United Nations, through their Sustainable Development Goals, recognize that energy is an essential service that enables households to meet their basic needs—including cooking, lighting, heating, and cooling—utility bills remain an underappreciated monthly expense that contribute to a household's overall burden [40]. In fact, the U.S. federal government has yet to identify energy insecurity as a problem that is distinct from other burdens that low-income families face, such as food, transportation, or housing insecurity [41]. This lack of recognition limits the measurement of domestic energy insecurity [42], especially as compared to European countries which formally recognize energy poverty [43].

Scholars have extensively studied energy insecurity and energy poverty in the European context, especially in the United Kingdom (see e.g. [44,45,46]), including seminal work by Brenda Boardman that focuses on intersection of energy poverty, energy demand, and residential energy efficiency [47]. Overall, evidence from studies of energy poverty in Europe – defined as a situation when a household is unable to heat their home or meet their energy demands at affordable prices [48] – suggests that more than one-tenth of European households are unable to maintain comfortable temperatures in their home [49]. In addition, the scholarship has identified that the leading causes of energy poverty in Europe are low household incomes, high energy prices, and inefficient housing conditions [50,51].

Similar to the U.K. context, research has shown that low-income households in the United States are more sensitive to variations in electricity prices [52]. Thus, researchers predict that energy insecurity will grow over time in the U.S. because residential energy demand is rising [53] and electricity prices are increasing [54]. Additionally, an increase in heat waves, cold spells, and extreme weather due to climate change is expected to disproportionately affect low-income populations because they live in deficient or inefficient housing conditions [55], which could further expand the energy insecure population.

Extant literature suggests that when households cannot pay their energy bills, they are more likely to either employ unsafe coping strategies, such as using their stoves or space heaters to heat their homes [56,57,58], or keep their homes at uncomfortable temperatures [20]. These coping strategies can be dangerous. First, space heaters are the leading cause of home fires and

responsible for 86% of deaths and 78% of injuries caused by domestic fires [59]. Second, studies find that when people cannot afford to keep their homes at comfortable temperatures, they are more likely to suffer adverse mental and physical health effects [19]. Energy insecure households are more likely to experience stress, disrupted sleep patterns, and depression [18,60], have increased rates of asthma, bronchitis, and upper respiratory infections [61], as well as suffer a disproportionate number of deaths due to extreme heat and cold [21]. These adverse respiratory and mental health impacts are especially prevalent for children [12] and the elderly [35].

Scholarship has found that vulnerable populations are more likely to suffer from energy insecurity, including those who do not have a college education, are not married, or are unemployed [25]. On average, low-income customers experience the most severe forms of energy insecurity because they pay a larger proportion of their income on energy bills, or have larger energy burdens, than average- or high-income customers [24]. Recent studies show that, even when controlling for income, Black and Hispanic households are more likely to have higher household energy expenditures as compared to white households [29], leading to higher energy burdens and higher rates of energy insecurity among this population [32,23,62,63]. Furthermore, low-income families, especially African American households, are more likely to live in older and less efficient homes, both of which have been previously associated with inefficient energy use [24] and energy insecure conditions [64,30,36]. Much of the literature suggests that the differential energy burden and poor housing conditions documented in these previous studies are the central drivers of higher rates of energy insecurity among populations of color. And, often, these households struggle to obtain weatherization or utility bill assistance that would help them overcome these conditions to meet their energy needs [42,65,66,24].

To date, the empirical studies demonstrating that low-income households, African American households, as well as households with deficient housing conditions are predictors of energy insecurity use data from the ACS and RECS. These studies show disparities in energy insecurity, energy expenditures, and housing conditions [9,23,24,25,29]. However, the ACS and RECS data do not enable scholars to systematically unpack the relationships among these factors. Moreover, neither data source allows for the comprehensive examination of energy insecurity nor targets the population that is most likely to experience this material hardship – low-income households. Finally, there is little existing empirical analysis that uses individual-level survey data to link household characteristics with energy insecurity measures ([24] is an exception).

In this study, we survey a representative sample of low-income Indiana households. The survey measures several dimensions of energy (in)security, including ability to pay energy bills, receipt of a disconnection notice from utility providers, and disconnections from the electric grid over the last twelve months. Statistical analyses of these data enable us to examine the correlates of energy insecurity and to explore the pathways between factors that have been identified as predictors of energy insecurity, including income, race, household energy burdens, and housing conditions.

Based on previous studies, we expect this evaluation to reveal that households of color are more likely to be energy insecure than white households. Additionally, we expect households of color to be more energy insecure due to poor housing conditions and higher energy burdens.

3. Data and Methods

3.1 Data

To conduct this analysis, we collected an original, representative survey of 2,000 adults in the state of Indiana with household incomes at or below 200 percent of the Federal Poverty Line (FPL). Indiana is a large, midwestern U.S. state with both major urban centers and a sizeable rural population. The state typically has four seasons, with hot and humid summers, cold winters, and fairly moderate temperatures during the autumn and spring months. Indiana experiences thunderstorms, tornadoes, floods, and droughts, especially in the spring and summer months; however, compared to states in the Southwest and Southeast U.S. that experience extreme heat and states in the Northeast U.S. that experience extreme cold, Indiana is considered a fairly temperate climate. To meet energy demands, 82% of the survey sample rely on electricity; 64% rely on gas; 6% rely on wood or propane; and 2% rely on fuel oil.

As illustrated in Table A.1 in Appendix A, the population of Indiana has a lower median household income but similar concentrations of unemployment, poverty, children under the age of five, senior citizens, educational attainment, and homeowners as compared to the full U.S. population. Particularly of note for this study, Indiana is less racially and ethnically diverse than the U.S. population, with fewer Black and Hispanic households and more white households.

The survey was administered online by YouGov, a private polling and market research firm, between April 30 and June 2, 2020. We designed the survey to focus on low-income households since they are most likely to be affected by energy insecurity. We chose the threshold of 200 percent of the FPL because both scholars [67] and practitioners [68] have employed this threshold as a low-income indicator.

For this survey, YouGov surveyed 2,254 people, who were then matched down to produce the final sample of 2,000 respondents from the state of Indiana. YouGov constructed this sample through stratified sampling on gender, age, race, and education constructed from their 2017 ACS 1-year sample of individuals whose income is at or below 200 percent of the FPL. The matched cases were weighted using propensity scores and combined using a logistic regression estimation for inclusion. The final survey weight used in our analysis is post-stratified on age, race, and education. The survey's margin of error is two percent.

The survey included measures of household energy insecurity, housing conditions, energy expenditures, as well as other items related to energy use, respondent and household characteristics, and material conditions, including participation in public assistance programs.

Respondents were asked to recall conditions over the past year (since May/June of 2019).[1] This approach introduces both the possibility of response bias— the potential that people do not want to reveal the full extent of their difficult circumstances for fear of being judged negatively—and recall bias. However, we believe these are unlikely to be significant problems since respondents are likely to remember and accurately record stressful events, such as those associated with energy insecurity, with reasonable accuracy. In the event that response bias was prevalent, the resulting estimates of energy insecurity are likely biased downward (i.e., respondents appear better off than they actually are). Yet, we have no reason to believe that there were systematic differences in response bias across socio-economic groups.

We measure household energy insecurity as present when a household: 1) could not pay its energy bill in at least one month in the last year; 2) received at least one disconnection notice in the last year; or 3) had their electricity service disconnected at least once in the last year. We analyze these measures as separate binary outcome variables and they represent increasing severity in energy insecurity. Table 1 presents summary statistics for these and all other variables included in our analyses.

Table 1. Descriptive statistics for all the variables used in in the regression models (n=1,968)

Variable Name	Variable Definition	Mean	Std. Dev.	Min	Max
Outcome Variables					
Energy Bill	A household could not pay at least one energy bill in the last year [=1 if yes; 0 otherwise]	0.30	0.46	0	1
Disconnection notice	A household received at least one disconnection notice in the last year [=1 if yes; 0 otherwise]	0.33	0.47	0	1
Disconnected	A household was disconnected at least once in the last year [=1 if yes; 0 otherwise]	0.13	0.33	0	1
Independent Variables					
Black households	Black household [=1 if yes; 0 otherwise]	0.10	0.30	0	1
Hispanic households	Hispanic household [=1 if yes; 0 otherwise]	0.03	0.17	0	1
Other households	An aggregation of other types of households that participated in our survey, including Asian, Native American, and mixed [=1 if yes; 0 otherwise]	0.06	0.25	0	1

[1] The period of time we analyze in the survey includes the early months of the COVID-19 pandemic, which resulted in considerable economic disruption in the U.S., including in the state of Indiana. This economic disruption may have affected overall rates of energy insecurity among the low-income households in the survey. This issue is further discussed in section 3.2.

Housing Conditions	Additive measure if survey respondent's home suffers from: poor insulation, drafty, moldy, holes in the wall and/or floor, plumbing problems, exposed electrical sockets, non-working appliances, or broken heating or cooling equipment	1.15	1.59	0	9
Energy Burden	Survey respondent's monthly energy bill costs as a percentage of their yearly income	0.17	0.36	0.00	6.77
Educational Attainment	Survey respondent's level of educational attainment	3.09	1.27	1	6
Children under 5	A household has at least one dependent under 5 living in the households [=1 if yes; 0 otherwise]	0.27	0.64	0	4
Seniors over 65	Number of seniors over 65 living in the households [0=none; 1=1; 2=2 or more]	0.70	0.87	0	2
Disability	A household has at least one member with a disability living in the households [=1 if yes; 0 otherwise]	0.50	0.74	0	4
Electronic Device	At least one member of the household relies on an electronic medical device [=1 if yes; 0 otherwise]	0.20	0.40	0	1
Unemployed	Survey respondent is unemployed [=1 if yes; 0 otherwise]	0.19	0.39	0	1
Gender	Respondent's gender [=1 if male; =2 if female]	1.70	0.46	1	2
Age	Age of respondent [divided into bins]	3.54	1.76	1	7
Under 100% FPL	Household income is less than 100% of the federal poverty line [=1 if yes; 0 otherwise]	0.33	0.47	0	1
100 - 150% FPL	Household income is between 100-150% of the federal poverty line [=1 if yes; 0 otherwise]	0.34	0.47	0	1
Homeowner	Survey respondent is a homeowner [=1 if yes; 0 otherwise]	0.48	0.50	0	1
Dwelling Type	Type of dwelling survey respondent live in (i.e. trailer, apartment, or attached/detached house)	2.76	0.84	1	5
Retired	Respondent is retired [=1 if yes; 0 otherwise]	0.16	0.37	0	1
LIHEAP	Did household receive LIHEAP in the last year [=1 if yes; 0 otherwise]	0.06	0.24	0	1
Government Assistance	Did the household receive any of the following assistance in the last year: SNAP, Medicaid, TANF, SSI, Veterans	0.46	0.50	0	1

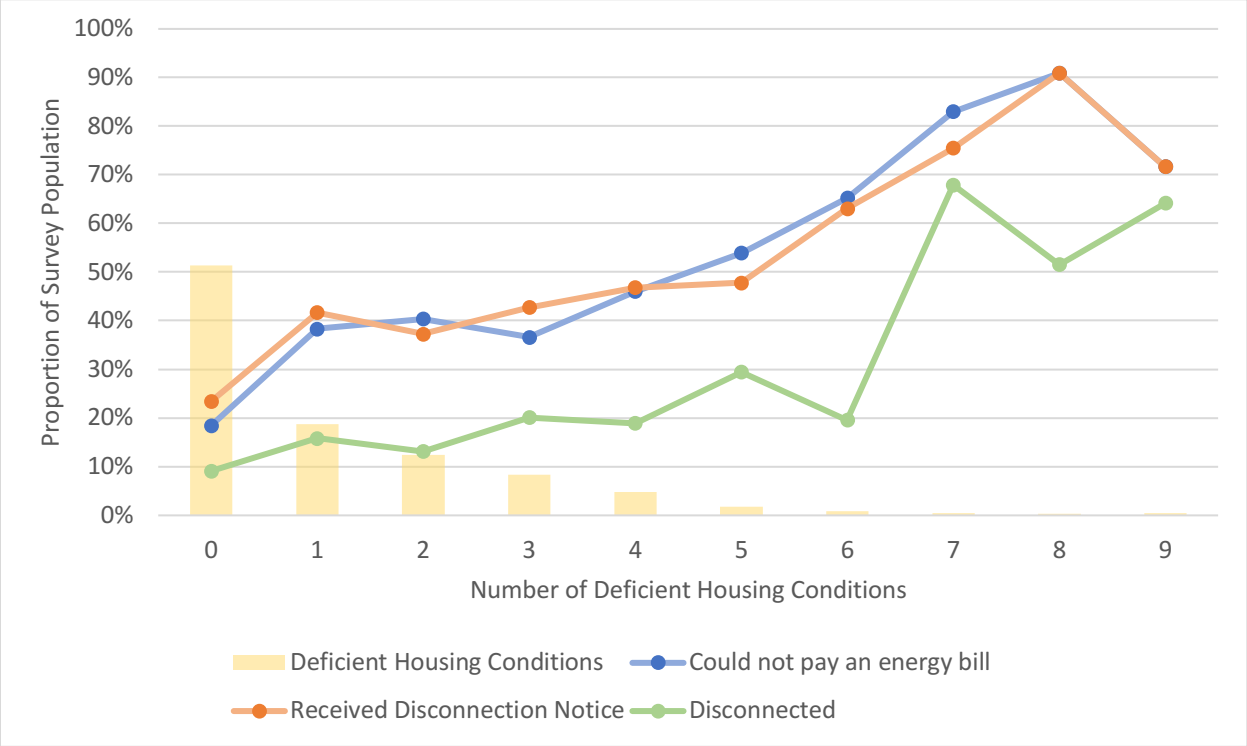
	Benefits, Unemployment Insurance [=1 if yes; 0 otherwise]				
Region	State of Indiana regions	6.53	3.87	1	12

The primary explanatory variables of interest are race, housing conditions, and energy burdens. With respect to race, we separately consider Black, Hispanic, and white households, based on respondent profile information provided by YouGov.

To measure housing conditions, we ask respondents to identify if any of the following attributes describes their dwelling: poor insulation; allows in cold air, drafty; holds moisture, moldy; holes in the wall and/or floor; plumbing problems; exposed electrical sockets; non-working stove or refrigerator; broken or frequently inoperable heating equipment; broken or frequently inoperable air conditioner or other cooling equipment. We then aggregate the number of dwelling attributes they identify to generate an additive measure of housing conditions for each survey respondent.[2] If a respondent identified that their current dwelling had poor insulation and holes in the wall or floor, for example, they would be coded as having two "deficient housing conditions." This leads to a variable ranging between zero and nine. We display the distribution of the housing conditions variable along with the proportion of survey respondents who experience each of the three measures of energy insecurity in Figure 1. It is important to note that less than 5 percent of the survey population responded that their current dwelling had 5 or more poor housing conditions; therefore, the high rates of energy insecurity toward the tail of the distribution reflect a small proportion of the sample and thus should be interpreted with caution.

[2]We constructed other variables to measure poor housing conditions, such as scores from a factor analysis. Results remain consistent regardless of the measure we included in our empirical specification; therefore, we present one set of outcomes. Results using other measures can be made available upon request.

Figure 1. Distribution of Survey Respondents' Housing Conditions



Note: This graph shows the proportion of survey respondents who reported being unable to pay an energy bill in the last year, receiving a disconnection notice, or being disconnected from the electric grid alongside having zero, one, two, three, four, five, six, seven, eight, or nine deficient housing conditions from the following list: poor insulation; allows in cold air, drafty; holds moisture, moldy; holes in the wall and/or floor; plumbing problems; exposed electrical sockets; non-working stove or refrigerator; broken or frequently inoperable heating equipment; broken or frequently inoperable air conditioner or other cooling equipment.

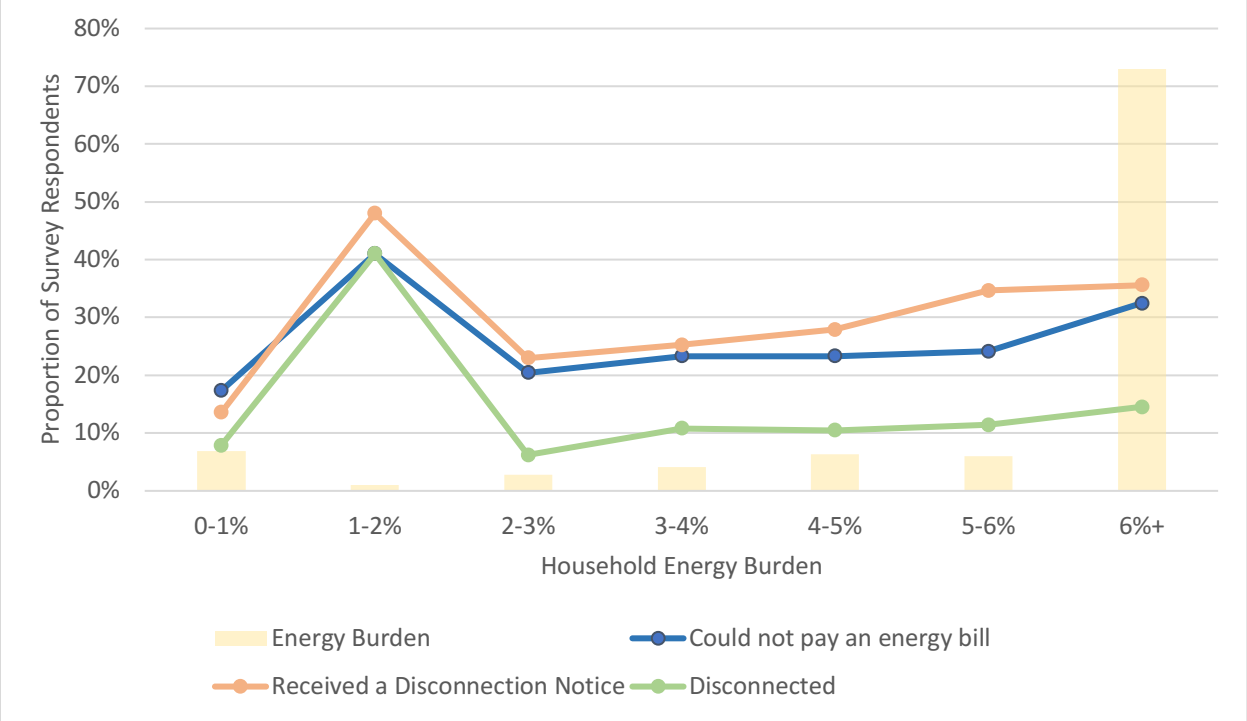
We measure each respondent's household energy burden, using an approximation of the proportion of income spent on energy. To generate this measure, we asked each respondent to estimate how much their household spends on energy bills in an average month.[3] We multiply this value by 12 to estimate the annual amount spent on energy and then divide by the respondent's income, which is taken from the median value of their income response in the survey. For instance, if a respondent living in a two-person household approximated that their family spent $100 on energy bills in an average month, we estimate that they spend $1,200 on energy bills annually. If their 2019 annual income before taxes, excluding assistance programs,

[3] Although the state of Indiana is considered a temperate state, energy demand and thus energy bills may vary by season (e.g., heating and cooling costs are likely higher during the winter and summer than in the moderate fall and spring). We acknowledge that by asking respondents for how much they pay in an average month, we are likely masking seasonal variation, which is a limitation of our data and analysis.

was more than $16,910 but less than $23,365, then we estimated their income as $20,138, and their energy burden is 5.95.

We retain the continuous measure of energy burden for the forthcoming empirical analysis; however, to illustrate the distribution of the variable in the sample, we grouped each respondent's energy burden into bins from no energy burden (those that do not pay their own energy bills) to an energy burden of 6 or more, which the literature defines as a high energy burden [69].[4] This distribution, along with the proportion of survey respondents who experience each of the three measures of energy insecurity, is reported in Figure 2. Similarly to Figure 1, there is a spike in the three energy insecurity measures when there is a relatively small sample. Specifically, those with a 1-2 percent household energy burden make up only one percent of the survey population and thus the spike in the energy insecurity measures for this portion of the population should be interpreted with caution.

Figure 2. Distribution of Survey Respondents' Energy Burden



Note: The estimated energy burden, or proportion of income that survey respondents spend on energy, each year alongside the proportion of survey respondents that could not pay an energy bill, received a disconnection notice, or were disconnected from the electric grid.

3.2 Data Limitations

The survey data are not without limitations. Although we believe the research design allows us to draw appropriate inferences about the low-income population in Indiana, we cannot say

[4]Although this approach does not provide a precise estimate, it is necessary given the structure of the available data. The survey question measuring income provided categories rather than asking for an estimate of income, which is the standard approach in survey research.

with any certainty if these patterns apply more generally to the full U.S. population. In addition, the study period includes the early months of the COVID-19 pandemic, which may have increased energy burdens as well as levels of energy insecurity among U.S. households, in general, and in the state of Indiana. It is possible, if not likely, that our results are driven by the economic disruption caused by the pandemic; however, without the benefit of other studies with which to compare, it is difficult to ascertain by how much the COVID-19 pandemic affected the overall rates of energy insecurity, and its association with race, energy burdens, and housing conditions.

Our survey instrument also did not identify whether the respondent's household was homogenous in race or ethnicity. We only collected information on the respondent's race. In doing so, our empirical estimates may underestimate energy insecurity in certain groups, including homogenous Black and Hispanic households [70]. Additionally, our survey did not require that the respondent identify if they were the head of their respective household; however, we know that 25% of our survey are single person households and that the respondent is at least 19 years old.

3.3 Empirical Specification

To examine the independent effects of race, housing conditions, and household energy burdens, we use the following model, which we estimate using logistic regression:

$$EI_i = \beta_0 + \beta_1 R_i + \beta_2 HC_i + \beta_3 EB + \beta X_i + \gamma_r + \epsilon_i,$$

where *EI* represents the three energy insecurity measures, as described above, for each individual household *i*, *R* represents a respondent's race, *HC* represents a respondent's housing conditions, *EB* represents household energy burden, *X* is a vector of control variables, γ represents region-level fixed effects, and ϵ is the error term. The coefficients on *R* provide tests of our first research question.

The vector of control variables includes a set of respondent and household characteristics, including age, gender, educational attainment, whether the household has children under 5 or individuals aged 65 and over, employment status, home ownership, dwelling type, and if they are retired. Indicator variables for whether a household is under 100% FPL or between 100-150% of FPL are also included as covariates in our models to control for potential differences within the survey's low-income population. We also include whether the respondent or someone in their household relies on an electronic medical device or has a disability. In addition, we include measures of whether the respondent or someone in their household received federal energy assistance from LIHEAP or any other type of government assistance (i.e., from the Supplemental Nutrition Assistance Program (SNAP), the Temporary Assistance for Needy Families (TANF), Medicaid, Social Security Insurance (SSI), or veteran's assistance) in the last year. Lastly, we control for potential omitted variable bias by including a series of region dummy variables, which allows us to exploit variation within the state of Indiana. We constructed the regions using the Indiana Department of Workforce Development's twelve *Economic Growth Regions (EGRs)* [71]. We estimate these models using robust standard errors.

To better disentangle the inter-relationships between race, housing conditions, and energy burdens, we conduct two additional analyses after estimating the original model. First, we estimate models that include multiplicative interaction terms between race and housing conditions and race and energy burdens to determine if there are differential effects for those of different races by housing condition and household energy burdens, respectively.

Second, we run a mediating variables analysis to determine whether any observed racial disparities associated with energy insecurity is in part a function of a respondent's housing conditions or household energy burden. Evidence of mediation requires us to show that (1) housing conditions and household energy burden influence energy insecurity; (2) a respondent's race influences energy insecurity in the absence of controlling for housing conditions or energy burden; and (3) a respondent's race influences housing conditions and household energy burdens. The first of these requirements is met by our primary empirical specification. We test for the second requirement by modifying our initial logistic regression to remove housing conditions and energy burden as covariates. Finally, we examine the third requirement by using linear regression models where household energy burden and housing conditions are the dependent variables.

4. Results

A descriptive evaluation of the survey results reveal that energy insecurity is prevalent among low-income households in Indiana. At least once in the last year, 30 percent of households were unable to pay an electricity bill, 33 percent received a disconnection notice, and 13 percent had been disconnected from the electric grid.

The objectives of the proceeding empirical analysis are twofold: to determine if households of color are more energy insecure than white households, and, if so, to evaluate the degree to which this is due to deficient housing conditions and high energy burdens. Therefore, first we present Table 2, which provides the correlation estimates between categories of race and our three outcomes of interest, ability to pay an energy bill, receipt of disconnection notice, and disconnection from the electric grid. As evident in Table 2, the correlations between Black and Hispanic households and the three measures of energy insecurity are all positive; whereas, the correlation between white households and our insecurity measures are negative.

Table 2. Estimates of Correlation Coefficients between Race and Energy Insecurity

	Could not pay an energy bill	Disconnection Notice	Disconnected
Black households	0.11	0.18	0.10
Hispanic households	0.08	0.09	0.07
Other households	0.02	-0.01	0.03
White households	-0.15	-0.19	-0.13

4.1 Primary Analysis

Table 3 displays the results of our primary empirical specification that explores the relationships between race, housing conditions, and energy burdens on the three indicators of household energy insecurity.

We find that Black and Hispanic households are less likely to be able to pay an energy bill, more likely to receive a disconnection notice for lack of payment from their utility provider, and more likely to be disconnected from their electricity service than white households. These relationships are present, even when controlling for income and other sociodemographic and household characteristics. Additionally, households that have higher energy burdens and households that live in poorer housing conditions are more likely to be energy insecure across all three measures. Also of note, households with at least one member that relies on an electronic medical device and households that received government assistance, including LIHEAP, are more likely to be energy insecure in the last year.

Table 3. Correlates of Household Energy Insecurity

	(1) Energy Bill	(2) Disconnection Notice	(3) Disconnected
Black	0.482**	0.807***	0.577*
	(0.232)	(0.230)	(0.306)
Hispanic	0.858**	0.791**	0.903*
	(0.374)	(0.382)	(0.471)
Housing conditions	0.286***	0.224***	0.245***
	(0.0431)	(0.0418)	(0.0506)
Energy burden	0.604**	0.731*	0.519**
	(0.293)	(0.388)	(0.264)
Other	0.175	-0.313	0.131
	(0.268)	(0.257)	(0.304)
Education	-0.0682	-0.101*	-0.103
	(0.0561)	(0.0538)	(0.0783)
Children under 5	0.124	0.230**	0.0237
	(0.108)	(0.107)	(0.143)
Seniors over 65	0.214***	0.0507	0.0956
	(0.0814)	(0.0820)	(0.108)
Disability	0.276***	0.139	0.0726
	(0.107)	(0.101)	(0.123)
Electronic Device	0.747***	0.555***	0.605**

	(0.178)	(0.178)	(0.236)
Unemployed	0.219	0.156	-0.0873
	(0.184)	(0.178)	(0.231)
Gender	0.350**	0.544***	0.0137
	(0.157)	(0.153)	(0.221)
Age	-0.204***	-0.156***	-0.436***
	(0.0554)	(0.0571)	(0.0773)
Under 100% FPL	-0.0115	-0.134	0.276
	(0.189)	(0.193)	(0.247)
100-150% FPL	-0.161	-0.0664	-0.283
	(0.192)	(0.180)	(0.269)
Homeowner	-0.350**	-0.250	0.0268
	(0.167)	(0.163)	(0.229)
Dwelling type	-0.183**	-0.0293	-0.160
	(0.0870)	(0.0836)	(0.121)
Retired	-0.184	-0.708**	-0.822
	(0.283)	(0.293)	(0.567)
LIHEAP	1.075***	0.855***	0.494
	(0.313)	(0.321)	(0.338)
Government Assistance	0.653***	0.750***	0.764***
	(0.158)	(0.156)	(0.210)
Region FE	Yes	Yes	Yes
Intercept	-1.355***	-1.461***	-0.910
	(0.519)	(0.488)	(0.736)
Observations	1937	1937	1937

Cells contain logistic regression coefficients, with robust standard errors in parentheses. Levels of statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

These results suggest that race, housing conditions, and energy burdens are all associated with a household's energy security. The results pertaining to Black and Hispanic households, in particular, provide evidence consistent with our first expectation.

4.2 Adding interaction terms to the primary analysis

We next investigate if the reason we find racial disparities in energy insecurity is because living

in deficient or less energy efficient dwellings or paying a greater proportion of household income on energy needs has a different, potentially larger, effect on energy insecurity for Black and Hispanic households than white households. To do so, we add interaction terms to the original specification. The results of these analyses are available in Appendix B, Tables B.1 and B.2.

First, we interact Black and Hispanic households with the measure of housing conditions. As displayed in Table B.1, none of the coefficients that interact Black or Hispanic households with housing conditions are statistically significant, which suggests that households of color with deficient housing conditions do not experience higher rates of energy insecurity.

Next, we interact Black and Hispanic households with the measure of energy burden. As shown in Table B.2, we again find that none of the interaction terms are statistical predictors of the energy insecurity measures.

Because our logistic regression models are nonlinear, our estimates are presented in terms of log odds. Thus, when we add interaction terms to our models, the coefficients may not be significant in log odds but may be significant at different points over the distribution of the continuous variables included in the interaction term. Therefore, to explore our claims about statistical significance related to our interaction terms in this section as well as in the forthcoming analyses that contain a continuous measure in the interaction term, we also compute the difference in predicted probabilities through marginal effects. The relationships are generally not statistically significant at different points in the distribution, with a few exceptions.[5]

4.3 Mediating Variables Analysis

To further unpack these relationships, we use a mediating variables analysis. The results from Table 2 confirm that both housing conditions and household energy burden meet the first prerequisite for this analysis, providing statistical evidence that these factors predict energy insecurity. Table 4 presents the second mediating variables analysis prerequisite test, which assesses if the relationship between race and energy insecurity remains statistically significant when the potential mediators—housing conditions and energy burdens—are excluded from the original logistic regressions. Across the three measures of energy insecurity, we observe that both Black and Hispanic households are correlated with higher rates of energy insecurity as compared to white households, which suggests that a respondent's race is associated with energy insecurity even in the absence of controlling for housing conditions and energy burdens.

[5]We find that when we interact our measures of race with housing conditions, as compared to white households, Black households are less likely to be able to pay an energy bill when their dwelling has two deficient housing conditions as well as more likely to receive a disconnection notice when they identified one, two, or three deficient housing conditions. Additionally, Black households were more likely to receive a disconnection notice when they had a one percent energy burden.

Table 4. Relationship between Race and Energy Insecurity – Housing Conditions and Energy Burden Covariates Removed

	(1) Energy Bill	(2) Disconnection Notice	(3) Disconnected
Black	0.495**	0.820***	0.490*
	(0.230)	(0.227)	(0.296)
Hispanic	0.813**	0.767**	0.917**
	(0.345)	(0.364)	(0.464)
Control Variables	Yes	Yes	Yes
Region FE	Yes	Yes	Yes
Intercept	-1.128**	-1.248***	-0.746
	(0.495)	(0.474)	(0.709)
Observations	1968	1968	1968

Cells contain logistic regression coefficients, with robust standard errors in parentheses. Levels of statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The next step of the mediating variables analysis is to test if a respondent's race influences housing conditions and household energy burdens. Table 5 presents the results of the regression analyses, in which a respondent's energy burden (column 1) and housing conditions (column 2) are removed as covariates and instead examined as outcome variables.

Because housing conditions and energy burdens may not be independent mediators of our energy insecurity measures (i.e. the causal pathway linking housing conditions and household energy burdens with household energy insecurity may be correlated), we also consider the two variables jointly as a mediator, as recommended by VanderWeele and colleagues [72]. To do so, we multiply the number of deficient housing conditions by each household's energy burden to calculate a joint variable, which is included in Table 5 (column 3).

To complete these analyses, we employ linear regression models. These analyses reveal that Black and Hispanic households are no more likely to have higher energy burdens or live in deficient housing conditions than white households, which suggests that neither energy burdens, housing conditions, nor the joint variable meet this prerequisite for demonstrating a mediating effect.

Table 5. Mediating Variables as Outcome Variables

	(1) Energy Burden	(2) Housing Conditions	(3) Joint Variable
Black	0.0474	-0.0158	0.0015
	(0.0331)	(0.147)	(0.051)

Hispanic	-0.0256 (0.0263)	0.280 (0.299)	-0.0539 (0.0463)
Housing conditions	0.00691 (0.00465)		
Energy Burden		0.175 (0.139)	
Control Variables	Yes	Yes	Yes
Region FE	Yes	Yes	Yes
Intercept	-0.0292 (0.0487)	0.937*** (0.304)	0.0307 (0.135)
Observations	1937	1937	

Cells contain linear regression coefficients, with robust standard errors in parentheses. Levels of statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Despite finding that housing conditions, household energy burdens, and the joint variable fail to meet the second prerequisite test, we complete the third part of the mediating variable analysis, which evaluates if any of these three factors act as mediators between a respondent's race and their energy insecurity. Table 6 shows that the total proportion of the effect mediated by housing conditions, energy burdens, and the joint distribution between the two is relatively small across all three insecurity measures for both Black and Hispanic households.

Table 6. Total proportion of the relationship mediated by housing conditions, energy burdens, and the jointly considered mediating variable for Black and Hispanic households

Dependent Variable	**Mediating Variable**	**Mediating Effect**
Independent Variable: Black households		
Energy bill	Housing Conditions	1.56%
Disconnection notice	Housing Conditions	0.82%
Disconnected	Housing Conditions	1.20%
Energy bill	Energy burden	8.49%
Disconnection notice	Energy burden	5.21%
Disconnected	Energy burden	5.35%
Energy bill	Joint Variable	13.80%
Disconnection notice	Joint Variable	7.50%
Disconnected	Joint Variable	7.27%
Independent Variable: Hispanic households		
Energy bill	Housing Conditions	3.19%
Disconnection notice	Housing Conditions	2.61%
Disconnected	Housing Conditions	2.30%

Energy bill	Energy burden	0.77%
Disconnection notice	Energy burden	0.70%
Disconnected	Energy burden	0.43%
Energy bill	Joint Variable	4.31%
Disconnection notice	Joint Variable	3.48%
Disconnected	Joint Variable	1.79%

The largest estimate indicates that approximately 13.8% of the relationship between living in a Black household and an ability to pay an energy bill runs through the variable that considers both housing conditions and energy burdens as a joint mediating variable. The mediating effects of deficient housing conditions and the higher energy burdens considered as independent mediators is similarly small, ranging from 0.43% to 8.49% across all three insecurity measures and for both Black and Hispanic households. These estimates suggest that housing conditions and energy burdens may not serve as strong mediating factors because they both independently and jointly explain only a small proportion of the pathway that links Black and Hispanic households to energy insecurity.

Lastly, we report the regression results from both the independent and jointly estimated mediating variable analysis. Because a small proportion of the effects are explained through housing conditions and energy burdens for both Black and Hispanic households, the regression results are identical and thus have been reported in columns 1, 3, and 5 in Table 7, while the joint mediator provided slightly different results and have thus been reported in columns 2, 4, and 6 in Table 7. Because none of the three variables hypothesized as mediators pass the prerequisite tests, these regression results should be interpreted with caution. In other words, these estimates should not be interpreted as accurate causal or correlational effects across any of our outcomes of interest.

Table 7. Correlates of Energy Insecurity with Independent (Ind.) and Joint Mediator Analyses

	(1) Energy Bill Ind. Mediator	(2) Energy Bill Joint Mediator	(3) Disconnection Notice Ind. Mediator	(4) Disconnection Notice Joint Mediator	(5) Disconnected Ind. Mediator	(6) Disconnected Joint Mediator
Black	0.502***	0.466**	0.730***	0.709***	0.542**	0.486**
	(0.184)	(0.184)	(0.180)	(0.180)	(0.225)	(0.223)
Hispanic	0.764**	0.758**	0.723**	0.719**	0.891**	0.908**
	(0.302)	(0.297)	(0.294)	(0.289)	(0.374)	(0.363)
Housing conditions	0.336***		0.259***		0.280***	
	(0.0350)		(0.0339)		(0.0416)	
Energy burden	0.449***		0.387**		0.295*	
	(0.172)		(0.169)		(0.157)	
Joint Variable		1.130***		0.872***		0.577***
		(0.152)		(0.136)		(0.117)
Other	0.280	0.190	0.115	0.0546	0.286	0.173
	(0.221)	(0.221)	(0.218)	(0.219)	(0.282)	(0.280)
Education	-0.0794*	-0.0757	-0.144***	-0.140***	-0.0870	-0.0829
	(0.0464)	(0.0461)	(0.0453)	(0.0452)	(0.0639)	(0.0636)
Children under 5	0.213**	0.199**	0.244***	0.231***	-0.0392	-0.0434
	(0.0870)	(0.0861)	(0.0847)	(0.0841)	(0.112)	(0.110)
Seniors over 65	0.151**	0.141**	0.0132	0.00598	0.197**	0.182**
	(0.0668)	(0.0661)	(0.0655)	(0.0652)	(0.0879)	(0.0873)

Disability	0.259***	0.264***	0.151*	0.158**	0.188*	0.197**
	(0.0800)	(0.0799)	(0.0785)	(0.0787)	(0.0997)	(0.0998)
Electronic Device	0.524***	0.533***	0.380***	0.378***	0.453**	0.440**
	(0.144)	(0.144)	(0.143)	(0.143)	(0.187)	(0.186)
Unemployed	0.275**	0.261*	0.176	0.172	0.118	0.133
	(0.140)	(0.139)	(0.136)	(0.135)	(0.179)	(0.177)
Gender	0.235*	0.295**	0.430***	0.476***	-0.170	-0.0974
	(0.125)	(0.125)	(0.123)	(0.123)	(0.168)	(0.167)
Age	-0.108**	-0.126***	-0.108***	-0.124***	-0.439***	-0.433***
	(0.0433)	(0.0431)	(0.0418)	(0.0417)	(0.0628)	(0.0615)
Under 100% FPL	0.0625	-0.109	-0.0299	-0.161	0.203	0.109
	(0.151)	(0.150)	(0.147)	(0.146)	(0.201)	(0.199)
100-150% FPL	-0.0961	-0.111	-0.0742	-0.0881	-0.260	-0.253
	(0.145)	(0.143)	(0.140)	(0.139)	(0.209)	(0.207)
Homeowner	-0.296**	-0.335***	-0.217*	-0.248**	-0.0643	-0.100
	(0.123)	(0.123)	(0.119)	(0.119)	(0.169)	(0.169)
Dwelling type	-0.0970	-0.127*	0.0436	0.0199	-0.0442	-0.0724
	(0.0669)	(0.0662)	(0.0649)	(0.0644)	(0.0868)	(0.0867)
Retired	-0.593***	-0.663***	-0.807***	-0.871***	-0.712	-0.888**
	(0.220)	(0.221)	(0.220)	(0.222)	(0.438)	(0.439)
LIHEAP	0.969***	1.049***	0.972***	1.042***	0.616**	0.716***

	(0.218)	(0.217)	(0.219)	(0.218)	(0.266)	(0.263)
Government Assistance	0.446***	0.486***	0.610***	0.643***	0.602***	0.644***
	(0.120)	(0.119)	(0.116)	(0.115)	(0.167)	(0.166)
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Intercept	-1.542***	-1.181***	-1.527***	-1.250***	-0.976*	-0.702
	(0.394)	(0.391)	(0.384)	(0.383)	(0.513)	(0.511)
Observations	1937	1937	1937	1937	1937	1937

Cells contain logistic regression coefficients, with standard errors in parentheses.
Levels of statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

To summarize, we find statistically significant results suggesting that, on average, Black and Hispanic households are more energy insecure than white households. Additionally, while the results reveal that, on average, housing conditions and energy burdens are both predictors of energy insecurity, adding interaction terms to the original specification and the mediating variable analysis both suggest that very little of the relationship between households of color and energy insecurity is explained, or mediated, by deficient housing conditions or higher energy burdens in this sample.

4.4 Alternative Explanations

While the results confirm our expectations that households of color are more likely to be energy insecure than white households, the findings are not consistent with our second set of expectations. For this reason, we explore alternative explanations.

First, we analyze whether households that are unable to pay an energy bill are systematically more likely to experience the other, more severe forms of energy insecurity - receipt of a disconnection notice or getting disconnected from the electric grid. To explore this question, we adjust our original empirical specification to include a variable that interacts a household's ability to pay an energy bill with the respondent's race to determine if this helps explain why Black and Hispanic households are more likely to receive a disconnection notice or be disconnected. The results of these models are available in Appendix C, in Table C.1.

The interaction terms reveal that being unable to pay an energy bill helps explain why Hispanic households experience energy insecurity at higher rates; however, it does not fully explain why Black households experience this material hardship more frequently. Specifically, a Black household's inability to pay an energy bill is not a significant predictor of being disconnected from the electric grid. Therefore, we conclude that something still remains unexplained as to why Black households are more likely to experience the most severe form of energy insecurity, household disconnection.

We also leverage the intersectional data collected in our survey to further try to disentangle why households of color are more likely to experience energy insecurity. We conduct several analyses that consider whether other elements included as covariates in our analyses help explain why Black and Hispanic households are more likely to experience energy insecurity than white households. To do so, we again adjust our original empirical specification to include variables that interact various demographic factors with the respondent's race. Specifically, we explore the intersectionality of a respondent's race with four variables: 1) age, 2) gender, 3) if they live in a household with children under the age of 5, and 4) if they own or rent their home. We chose to explore these interactions, in particular, because each was a significant predictor of at least one measure of energy insecurity in our primary analysis. The estimates of these models are available in Appendix D, Tables D.1., D.2., D.3., and D.4.

The results of these analyses suggest that female respondents and those who do not own (i.e. they rent) their home are more likely to be associated with varying measures of energy insecurity. Explicitly, female, Black respondents as well as Black respondents who rent their

homes were less likely to be able to pay an energy bill. Additionally, Black renters and Hispanic homeowners were more likely to receive a disconnection notice from their utility provider, and female, Hispanic respondents were more likely to be disconnected from the electric grid.[6]

While these sets of results do provide some insight into which sub-groups may be more likely to experience energy insecurity, there is still much to learn about why households of color are more likely to experience varying measures of energy insecurity, which we discuss further in the concluding section.

5. Conclusion

This study analyzes original survey results from low-income households in the state of Indiana to empirically measure if households of color are more energy insecure than white households and, if so, to determine if deficient housing conditions and higher energy burdens explain these racial disparities. Our first set of results find evidence that racial disparities exist, with Black and Hispanic households less likely to be able to pay an energy bill and more likely to receive a disconnection notice or be disconnected from their electricity service due to lack of payment. The importance of this finding cannot be understated. As reviewed above, these results are consistent with our expectations and with previous research that documents racial disparities in domestic household energy insecurity. Our analysis not only contributes an empirical analysis indicating that energy insecurity is a pervasive problem across the U.S., but it also suggests that this material hardship is more prevalent for Black and Hispanic households relative to white households. Broadly, this finding highlights the relevance of an additional type of race-based economic disparity in the U.S.

Our study, however, does not support prior assertions about the reasons for these racial disparities in energy insecurity. Through multiple types of analyses, we do not find that living in deficient housing conditions or having a higher energy burden explains why, on average, Black and Hispanic households experience higher rates of energy insecurity than white households. Our inability to confirm expectations or corroborate previous research using novel survey data and empirical methods is an important result that future research should explore further, especially given the emphasis that both quantitative and qualitative scholars have ascribed to these factors as key explanations for racial disparities in domestic energy insecurity. Due to the stated limitations in our study's research design, it is important that these findings are

[6]Similar to our results presented in section 4.2, we evaluate the interaction terms that contain a continuous variable over its distribution through marginal effects. Across our intersectionality analyses, we again find that the relationships are generally not statistically significant at different points in the distribution, with a few exceptions. Specifically, we find that, as compared to white households, Black respondents between the ages of 35-44 are less able to pay an energy bill and those between 25-64 years old are more likely to receive a disconnection notice. In addition, Black households with one or two children under 5 years of age in their home are more likely to receive a disconnection notice as compared to white households and Hispanic households with three or more children under 5 years old are less able to pay their energy bill than white households.

corroborated over different periods of time-specifically, during periods of both “normal’ and “robust” economic growth and in different geographical settings.

Nevertheless, the results in this article suggest that more research is needed to identify the causal pathways that link racial disparities with household energy insecurity. That is, there remains considerable uncertainty as to why households of color suffer from higher rates of energy insecurity in the U.S. One possibility is that there is racial discrimination in the way that energy providers treat households of different races; however, we do not have direct evidence to examine this explanation. Future analyses could directly explore such phenomenon. Alternatively, there could be other, omitted factors that may help explain these results that the survey data do not allow us to explore, such as utility provider behavior and practices and household energy behavior. Another factor could be mistrust between households and their utility providers, which could manifest as a lack of understanding, communication, and flexibility, especially when a household is at risk of being disconnected due to lack of payment. As a result, several potentially fruitful areas for further investigation exist, including whether being served by an investor-owned, municipal, or cooperative utility affects domestic energy insecurity in U.S. residences. In addition, future research – through ethnographic, qualitative, and quantitative studies – should continue to probe the relationship between race, other factors of material hardship, and increased rates of energy insecurity. Importantly, it would be beneficial to both scholarship and policymakers to better understand the link between physical and mental health issues in a household and increased rates of energy insecurity [73].

This work contributes to the growing energy justice literature that identifies racial inequities in a variety of energy-related outcomes. Racial disparities have been well documented across various sectors [74], including economic outcomes [75], health [76], and the environment [77], and evidence is growing with respect to energy (see e.g., [78] and [79] for recent studies that examine how income and race predict access, or lack thereof, to renewable energy technologies in U.S. residences). As this body of work matures, more attention to the causal pathways linking race and unfairly distributed energy outcomes is immensely important. Identifying and understanding these mechanisms at a national level would allow scholars and practitioners to identify appropriate program or policy responses to mitigate energy insecurity and help promote the principles of energy justice.

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Appendix A.

Table A.1. Comparison of U.S. population to the state of Indiana

Socioeconomic Statistics, 2019	**U.S. Population**	**State of Indiana**
Median Household Income	$71,720.00	$66,859.00
Population in Poverty	15.36%	15.40%
Unemployed	3.74%	3.32%
Black Population	13.17%	9.72%
White Population	69.97%	82.41%
Hispanic Population	17.42%	6.59%
Education Attainment (< High School)	13.22%	12.21%
Urban Population	81.29%	73.05%
Rural Population	18.71%	26.95%
Aged 65 Years and Older	15.92%	15.88%
Aged 0 to 5 Years	7.34%	7.56%
Owner Occupied	62.53%	67.28%
Median Year Home Built	1981	1977

Note: Data was gathered using the American Community Survey 2019 estimates (source: SimplyAnalytics (2019). EASI American Community Survey 2019. November 20, 2020, from SimplyAnalytics database.)

Appendix B.

Table B.1. Correlates of Household Energy Insecurity with Housing Condition Interaction Terms

	(1) Energy Bill	(2) Disconnection Notice	(3) Disconnected
Housing conditions	0.301***	0.248***	0.222***
	(0.0454)	(0.0422)	(0.0537)
Black	0.596*	1.044***	0.567
	(0.316)	(0.306)	(0.423)
Housing Conditions * Black	-0.0952	-0.217	-0.0112
	(0.154)	(0.149)	(0.203)
Hispanic	0.932*	0.812*	0.579
	(0.510)	(0.482)	(0.637)
Housing Conditions * Hispanic	-0.0542	-0.0144	0.184
	(0.191)	(0.211)	(0.214)
Energy burden	0.600**	0.727*	0.520**
	(0.291)	(0.385)	(0.265)
Other	0.183	-0.302	0.115
	(0.269)	(0.257)	(0.305)

Education	-0.0681	-0.101*	-0.102
	(0.0562)	(0.0545)	(0.0776)
Children under 5	0.125	0.228**	0.00893
	(0.108)	(0.108)	(0.143)
Seniors over 65	0.218***	0.0606	0.0941
	(0.0819)	(0.0822)	(0.109)
Disability	0.278***	0.140	0.0594
	(0.107)	(0.102)	(0.125)
Electronic Device	0.762***	0.583***	0.602***
	(0.178)	(0.179)	(0.229)
Unemployed	0.226	0.169	-0.0915
	(0.184)	(0.179)	(0.232)
Gender	0.354**	0.557***	0.0335
	(0.159)	(0.155)	(0.221)
Age	-0.202***	-0.152***	-0.435***
	(0.0556)	(0.0567)	(0.0761)
Under 100% FPL	-0.0276	-0.167	0.293
	(0.189)	(0.193)	(0.251)
100-150% FPL	-0.167	-0.0858	-0.309
	(0.193)	(0.182)	(0.271)
Homeowner	-0.350**	-0.251	0.0214
	(0.168)	(0.165)	(0.227)
Dwelling type	-0.181**	-0.0260	-0.156
	(0.0876)	(0.0845)	(0.121)
Retired	-0.198	-0.736**	-0.820
	(0.285)	(0.293)	(0.565)
LIHEAP	1.078***	0.882***	0.544
	(0.314)	(0.317)	(0.334)
Government Assistance	0.649***	0.740***	0.744***
	(0.157)	(0.156)	(0.209)
Region FE	Yes	Yes	Yes

Intercept	-1.392***	-1.527***	-0.877
	(0.530)	(0.494)	(0.736)
Observations	1937	1937	1937

Cells contain logistic regression coefficients, with robust standard errors in parentheses. Levels of statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B.2. Correlates of Household Energy Insecurity with Energy Burden Interaction Terms

	(1) Energy Bill	(2) Disconnection Notice	(3) Disconnected
Energy Burden	0.460*	0.633*	0.585***
	(0.263)	(0.351)	(0.207)
Black	0.224	0.842***	0.674**
	(0.275)	(0.280)	(0.312)
Energy Burden * Black	1.349	-0.0857	-0.333
	(0.992)	(0.856)	(0.411)
Hispanic	1.079**	0.108	0.601
	(0.446)	(0.671)	(0.586)
Energy Burden * Hispanic	-1.743	6.145	2.031
	(1.600)	(5.335)	(1.784)
Housing conditions	0.287***	0.228***	0.250***
	(0.0435)	(0.0415)	(0.0511)
Other	0.171	-0.289	0.133
	(0.268)	(0.254)	(0.305)
Education	-0.0670	-0.107**	-0.106
	(0.0552)	(0.0530)	(0.0791)
Children under 5	0.132	0.227**	0.0222
	(0.108)	(0.107)	(0.145)
Seniors over 65	0.217***	0.0391	0.0883
	(0.0805)	(0.0820)	(0.106)
Disability	0.281***	0.141	0.0780
	(0.106)	(0.101)	(0.124)
Electronic Device	0.761***	0.561***	0.595**

	(0.176)	(0.176)	(0.238)
Unemployed	0.228	0.132	-0.112
	(0.185)	(0.176)	(0.229)
Gender	0.366**	0.540***	-0.00779
	(0.156)	(0.152)	(0.221)
Age	-0.201***	-0.152***	-0.441***
	(0.0551)	(0.0572)	(0.0795)
Under 100% FPL	-0.0102	-0.162	0.239
	(0.191)	(0.188)	(0.248)
100-150% FPL	-0.174	-0.0668	-0.278
	(0.191)	(0.177)	(0.269)
Homeowner	-0.345**	-0.255	0.0307
	(0.167)	(0.163)	(0.228)
Dwelling type	-0.199**	-0.0306	-0.160
	(0.0858)	(0.0834)	(0.123)
Retired	-0.196	-0.714**	-0.814
	(0.280)	(0.295)	(0.571)
LIHEAP	1.082***	0.853***	0.497
	(0.314)	(0.321)	(0.330)
Government Assistance	0.648***	0.757***	0.790***
	(0.157)	(0.154)	(0.212)
Region FE	Yes	Yes	Yes
Intercept	-1.316**	-1.451***	-0.883
	(0.518)	(0.492)	(0.741)
Observations	1937	1937	1937

Cells contain logistic regression coefficients, with robust standard errors in parentheses. Levels of statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix C.

Table C.1. Correlates of Household Energy Insecurity with Energy Bill Interaction Terms

	(1) Disconnection Notice	(2) Disconnected
Energy Bill	4.241***	3.407***
	(0.216)	(0.277)
Black	1.251***	1.094*
	(0.345)	(0.616)
Energy Bill * Black	-1.015*	-0.864
	(0.569)	(0.714)
Hispanic	1.040*	2.176***
	(0.556)	(0.821)
Energy Bill * Hispanic	-1.582*	-2.286**
	(0.835)	(0.929)
Housing conditions	0.0618	0.127**
	(0.0513)	(0.0553)
Energy burden	0.519	0.370
	(0.374)	(0.356)
Other	-0.869**	0.0707
	(0.377)	(0.398)
Education	-0.118	-0.0741
	(0.0746)	(0.0871)
Children under 5	0.283*	-0.0681
	(0.145)	(0.162)
Seniors over 65	-0.153	-0.0318
	(0.119)	(0.120)
Disability	-0.0632	0.00738

	(0.145)	(0.143)
Electronic Device	0.0752	0.154
	(0.300)	(0.258)
Unemployed	-0.0276	-0.255
	(0.232)	(0.247)
Gender	0.581***	-0.204
	(0.202)	(0.244)
Age	-0.0615	-0.432***
	(0.0806)	(0.0898)
Under 100% FPL	-0.237	0.310
	(0.257)	(0.298)
100-150% FPL	0.0855	-0.139
	(0.246)	(0.307)
Homeowner	-0.0272	0.316
	(0.228)	(0.253)
Dwelling type	0.166	-0.0519
	(0.115)	(0.121)
Retired	-1.023**	-0.648
	(0.400)	(0.587)
LIHEAP	0.365	-0.0147
	(0.389)	(0.364)
Government Assistance	0.660***	0.473**
	(0.216)	(0.221)
Region FE	Yes	Yes
Intercept	-3.063***	-2.476***
	(0.580)	(0.697)
Observations	1937	1937

Cells contain logistic regression coefficients, with robust standard errors in parentheses. Levels of statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix D.

Table D.1. Correlates of Household Energy Insecurity with Age Interaction Terms

	(1) Energy Bill	(2) Disconnection Notice	(3) Disconnected
Black	0.251	0.381	0.346
	(0.416)	(0.412)	(0.510)
Hispanic	-0.159	-0.137	0.422
	(0.900)	(0.928)	(0.913)
Age	-0.233***	-0.193***	-0.458***
	(0.0541)	(0.0558)	(0.0716)
Black * Age	0.0741	0.130	0.0793
	(0.119)	(0.122)	(0.155)
Hispanic * Age	0.350	0.301	0.139
	(0.319)	(0.354)	(0.368)
Controls	Yes	Yes	Yes
Region FE	Yes	Yes	Yes
Intercept	-1.024*	-1.097**	-0.619
	(0.530)	(0.499)	(0.742)
Observations	1937	1937	1937

Cells contain logistic regression coefficients, with robust standard errors in parentheses. Levels of statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table D.2. Correlates of Household Energy Insecurity with Gender Interaction Terms

	(1) Energy Bill	(2) Disconnection Notice	(3) Disconnected
Black	-0.0515	0.509	0.819*
	(0.379)	(0.381)	(0.472)
Hispanic	1.028	1.002	-0.414
	(0.658)	(0.651)	(0.692)
Female	0.254	0.528***	-0.0416
	(0.158)	(0.152)	(0.218)
Black * Female	0.847*	0.470	-0.371

	(0.450)	(0.451)	(0.594)
Hispanic * Female	-0.374	-0.518	1.837**
	(0.821)	(0.792)	(0.854)
Controls	Yes	Yes	Yes
Region FE	Yes	Yes	Yes
Intercept	-0.746	-0.658	-0.623
	(0.469)	(0.433)	(0.639)
Observations	1937	1937	1937

Cells contain logistic regression coefficients, with robust standard errors in parentheses. Levels of statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table D.3. Correlates of Household Energy Insecurity with Children in the Household Interaction Terms

	(1) Energy Bill	(2) Disconnection Notice	(3) Disconnected
Black	0.443*	0.745***	0.472
	(0.259)	(0.247)	(0.351)
Hispanic	1.087**	0.880**	0.929*
	(0.455)	(0.442)	(0.490)
Children under 5	0.209*	0.285**	0.0625
	(0.122)	(0.119)	(0.152)
Black * Children under 5	0.152	0.200	0.204
	(0.279)	(0.284)	(0.360)
Hispanic * Children under 5	-1.036*	-0.632	-0.661
	(0.592)	(0.534)	(0.622)
Controls	Yes	Yes	Yes
Region FE	Yes	Yes	Yes
Intercept	-1.137**	-1.221**	-0.691
	(0.528)	(0.492)	(0.745)
Observations	1937	1937	1937

Cells contain logistic regression coefficients, with robust standard errors in parentheses. Levels of statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table D.4. Correlates of Household Energy Insecurity with Homeowner Interaction Terms

	(1) Energy Bill	(2) Disconnection Notice	(3) Disconnected
Black	0.646**	1.002***	0.501
	(0.266)	(0.268)	(0.356)
Hispanic	0.378	0.0788	0.595
	(0.501)	(0.466)	(0.454)
Homeowner	-0.399**	-0.340**	-0.0972
	(0.162)	(0.155)	(0.228)
Black * Homeowner	-0.874*	-1.068**	0.167
	(0.495)	(0.472)	(0.557)
Hispanic * Homeowner	1.153	1.653**	0.449
	(0.865)	(0.833)	(0.989)
Controls	Yes	Yes	Yes
Region FE	Yes	Yes	Yes
Intercept	-1.145**	-1.234**	-0.667
	(0.535)	(0.495)	(0.739)
Observations	1937	1937	1937

Cells contain logistic regression coefficients, with robust standard errors in parentheses. Levels of statistical significance: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$