# A Countrywide Evaluation of Energy Burden among Foreign Nationals in the US

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## Abstract

Housing is essential for the successful integration of foreign nationals in the US, and access to clean, reliable, and affordable energy is one of the crucial aspects of basic household necessities for desirable housing conditions. However, accessing energy can be expensive and burden the household's financial status, and foreign nationals can be challenged to have substandard housing conditions when paying high energy bills. Hence, the household energy burden is the inability to meet basic heating, cooling, and energy demands over time. Current energy burden studies have compared foreign nationals to native US citizens, but limited research has evaluated the effect of distinct experiences among foreign nationals on energy burden based on their concentrated disadvantage. Concentrated disadvantage is a sociological term representing a percentage of households in census tracts with significant concentrations of difficulty. To investigate foreign nationals' disadvantage associated with energy burden, the present study evaluates the influence of socioeconomic demographics that may magnify energy burden among foreign nationals in the US. The concentrated disadvantage demographics considered in this study include age, gender, location, education, marital status, race, unit tenure, and the number of household children. The study conducted logistic regressions using the 2021 American Housing Survey (AHS) dataset. Major findings showed that the most vulnerable groups among foreign nationals were concluded to be older adults, females with secondary educational attainments, single females, and white and black females. This framework can generate comprehensive perspective about energy burden among foreign nationals because this group is characterized by intersecting and compounding socioeconomic disparities, such as high levels of single-parent households, renter-ship, and low education degree, which can impact the energy burden levels among this group. This study suggests that immigration policies should be formulated to account for the diversity among foreign nationals to reduce energy burden, improve housing conditions, and ensure that all are successfully integrating in the host country.

## 1. Introduction

The United States (US) is a leading nation of foreign nationals and has a long history of effectively integrating foreign nationals. Foreign nationals denote diverse groups of non-

citizens including lawful permanent residents, immigrants, non-immigrants, and refugees. According to the Census Bureau's monthly Current Population Survey (CPS), the overall foreign nationals' population in the US reached 47.9 million in September 2022, representing 14.6% of the US population, a new high in American history (Camarota & Zeigler, 2015). The increasing number of foreign nationals admitted to the US emphasized the significance of providing enough resources for their integration. Housing is one of the essential aspects for successful integration of the foreign nationals in the host country (Ager & Strang, 2004; Platts-Fowler & Robinson, 2015). More profoundly, housing conditions impact how far the foreign nationals are integrated because undesirable conditions can be a major pathway to health disparities such as lack of access to care, uninsured or underinsured members, burden of disease, life expectancy and others (Chang, 2019; Swope & Hernández, 2019).

Access to clean, reliable, and affordable energy is one of the crucial aspects to satisfy household needs, and it reflects good housing conditions. Energy is a basic need for people as it provides heating, cooling lighting, powering information and communications devices, and operating appliances. Nevertheless, accessing energy comes with its own set of costs and financial burdens (Kikstra et al., 2021). One of the most challenging issues with accessing energy is its cost compared to the household availability of financial resources. If energy can not be afforded, the household members can be energy burdened (Bednar & Reames, 2020; Hernández et al., 2014; Hernández et al., 2016; Kontokosta et al., 2020).

Household energy burden is defined as the inability to satisfy basic heating, cooling, and energy demands over time (Graff et al., 2021; Hernández et al., 2014). Researchers have estimated that a household is considered highly energy burdened if the energy cost comprises at least 6% of the household income (Bednar & Reames, 2020; Drehobl et al., 2020). Consequently, people who allocate most of their income to energy utilities besides housing commonly experience challenging financial decisions with significant short- and long-term consequences for adults and children (ACCCE, 2012). At the physiological level, highly energy burdened housing is found to be associated with health impacts, such as thermal discomfort, respiratory problems, potential for hypo- or hyperthermia, resulting from the limited use of heating and cooling equipment (Drehobl et al., 2020). At the psychological level, living with energy burden leads to increased pressures, worries, and even mental health issues associated with the inability to pay energy bills and the possibility of being disconnected from power and home gas heating utility services (Massetti et al., 2017). Hereby, excessive energy cost can impact household members' wellbeing, comfort, and mental health.

In the US, energy burden is an ongoing issue among socioeconomically vulnerable households (Banzhaf et al., 2019; Brown et al., 2020; Carley & Konisky, 2020). Electricity and natural gas expenses consume the greatest share of the American households' income compared to other utility bills (EIA, 2021). 27% of the households having difficulty paying their energy bills live in vulnerable households such as low income households, households with a household member over the age of 65 or under the age of 6, households of certain race, and renters (Drehobl et al., 2020). Low-income households of all races and ethnicities spend a higher percentage of their total income for domestic energy, at 14%, compared to 3% for other households (USDE, 2021). Additionally, Hispanic households and African American households with children experience high energy burdens (Hernández et al., 2014; Hernández et al., 2016; Kontokosta et al., 2020). Foreign nationals living in the US are also affected by energy burden. Foreign nationals might have limited access to government subsidies such as social safety net programs, lower income levels and educational attainments (Landale et al., 2011; Sherwin & Azevedo, 2020). These disadvantages can lead to them not affording the high

energy bills when aiming to provide good housing conditions for their families. For example, foreign-born Hispanics tend to consume less energy to reduce paying high energy bills (Hernández et al., 2016). However, energy curtailment can affect household members' wellbeing, comfort, and mental health. Therefore, foreign nationals might experience energy burden when providing clean and reliable energy for their families during their integration in the US.

Current energy burden studies have compared foreign nationals to the native US citizens based on socioeconomic demographic factors such as race, age, education and location of the house (Banzhaf et al., 2019; Brown et al., 2020; Carley & Konisky, 2020; Sunter et al., 2019). However, previous studies focusing on foreign nationals have looked at their energy burden aggregated across their entire group. Combining all foreign nationals into one group is problematic as they do not have the same experiences and opportunities (National Academies of Sciences et al., 2016). This includes disparity in the educational attainment of the child's parents defined as the first generation, competence in the US labor market, English language proficiency, access to safety net programs and other socioeconomic demographics (National Academies of Sciences et al., 2016). This is known as concentrated disadvantage which is a sociological term representing a percentage of households in census tracts with significant difficulty. Eventually, they might be more susceptible to energy burden, but not having same level of vulnerability among them.

To investigate foreign nationals' disadvantage associated with energy burden, the present study evaluates the influence of socioeconomic demographics that may magnify energy burden among foreign nationals in the US. We ask: (1) What is the level of energy burden among foreign nationals? and (2) what groups of foreign nationals are particularly more vulnerable to energy burden? We consider diverse foreign national groups based on age, gender, location, education, marital status, race, unit tenure, and the number of household children. Therefore, this study is important for existing policies which need to account for the complexities among foreign nationals due to various socioeconomic demographic (Derr, 2016; Feinstein et al., 2022; Reames, 2016; Sunter et al., 2019). There is a need for an intersectional and interdisciplinary framework in devising energy policy directed to foreign nationals' households experiencing energy burden.

## 2. Conceptualizing energy burden and concentrated disadvantage among foreign nationals

Foreign nationals are susceptible to concentrated disadvantage associated with energy burden. Concentrated disadvantage is a sociological term representing a percentage of households in census tracts with significant concentrations of difficulty (Chamberlain & Hipp, 2015; Massey & Denton, 1993). Since foreign nationals have unique and distinct experiences based on diverse demographics, higher or lower intersectional concentrated disadvantage associated with energy burden is predictable among them. Although energy burden is connected to historical patterns of racial discrimination in lending and other discriminatory housing practices, as well as racial inequities in poverty and accumulated wealth (Bednar & Reames, 2020; Bednar et al., 2017; Lewis et al., 2020), concentrated disadvantage has not been investigated in terms of energy burden previously. Recent study of Chen et al. (2022) investigated the local effects of concentrated disadvantage on energy burden in the US to conclude that the counties with households headed by Black women have a severe energy burden (Chen et al., 2022). However, there has been no research into the energy burden disadvantage among foreign nationals.

In this study, concentrated disadvantage framework was used to explain the intensification of inequalities among foreign nationals that systematically produce less favorable outcomes (Liévanos, 2019; Mennis et al., 2016; Myers et al., 2018). The concentrated and uneven educational, marital status, geographical distribution and other dimensions may impact the vulnerability level of energy burden among foreign nationals. Hence, concentrated disadvantage framework is extendable to a wide range of intersections of racial group, gender, age, education, and other social identities of foreign nationals. These intersecting and overlapping socioeconomic demographics may be both empowering and oppressing against energy burden (Bednar et al., 2017; Kontokosta et al., 2020; Stretiner, 2023).

By this, it is worthwhile to investigate foreign nationals' vulnerability levels among young or older adults, single or married people, males or females, and people with different educational attainments and other socioeconomic demographics. Hence, this study accounts for demographic indicators to substantiate that diverse energy burden levels are the result of racialized groups, people of color, renters, children, and other groups of household members.

## 3. Methods

### 3.1. Data and sample

This study used the American Housing Survey (AHS) one-year dataset of 2021. AHS is sponsored by the Department of Housing and Urban Development (HUD) and conducted by the U.S. Census Bureau in odd-numbered years with the total sample size beginning in 2015 about 115,000 housing units. The AHS dataset was selected for this study because it includes monthly bills of electricity, gas, oil, and other fuels at the block level. It also includes the households' socioeconomic demographics such as unit tenure, education, marital status, age, gender, race, and number of household members, at the regional level. The dataset did not account for the detailed categorization of foreign nationals including lawful permanent residents, immigrants, non-immigrants, and refugees. It identified them as foreign-born people whether U.S. citizen by naturalization or not.

### 3.2. Variables

#### 3.2.1. Dependent variables

Energy burden percentage (EBP) is calculated in percentage (%) based on the ratio of the total monthly expenses on electricity, gas, oil, and other fuel such as wood, coal, kerosene, or other fuel than mentioned over the monthly income of the household. Then, energy burden status (EBS) was defined to indicate whether the household is energy burdened or not. Energy EBS is coded as 1 if the household was spending more than or equal to 6% of the household income on energy bills. Otherwise, it is coded as 0 if the household was spending less than 6% of the household income on energy bills indicating the household is not burdened.

#### 3.2.2. Independent and control variables

A series of independent, control, and categorical variables for age, gender, education, unit tenure, marital status, race household location, and number of children under age six were coded using responses self-reported in the AHS dataset. **Table *1*** summarizes the scales of the independent, control, and categorical variables used in the study.

**Table 1.** List of independent, control, and categorical variables with their corresponding scales

| Variable name | Variable coding based on the survey scale | Type of variable |
|---|---|---|
| **Age** | 0: below or equal to 65 yrs.<br>1: above 65 yrs. | Independent |
| **Gender** | 0: male<br>1: female | Independent |
| **Education** | 0: secondary educational attainment: $7^{th}$ grade till $12^{th}$ grade<br>1: postsecondary educational attainment: high school diploma or highest degree | Independent |
| **Unit tenure** | 0: owned<br>1: rented | Independent |
| **Marital Status** | 0: married: married, spouse present or married, spouse absent<br>1: single: widowed, divorced, separated, never married | Independent |
| **Race** | 1: White<br>2: Black<br>3: Asian | Independent |
| **Household Location** | 1: Northeast<br>2: Midwest<br>3: South<br>4: West | Control |
| **Number of children under age six** | 0: no children<br>1: one or more children | Control |
| **Gender - Age** | male-young<br>male-old<br>female-young<br>female-old | Categorical (Concentrated disadvantage dimension) |
| **Gender - Education** | male-secondary education<br>male-postsecondary education<br>female-secondary education<br>female-postsecondary education | Categorical (Concentrated disadvantage dimension) |
| **Gender - Marital status** | male-married<br>male-single<br>female-married<br>female-single | Categorical (Concentrated disadvantage dimension) |
| **Gender - Unit tenure** | male-owner<br>male-renter<br>female-owner<br>female-renter | Categorical (Concentrated disadvantage dimension) |
| **Gender - Race** | male – White<br>male – Black<br>male – Asian<br>female – White<br>female – Black<br>female- Asian | Categorical (Concentrated disadvantage dimension) |

### 3.3. Data Analysis for Research Questions

To answer RQ1, we addressed three parameters: (1) average EBP across socioeconomic categories (SC), (2) proportion of households with EBS below 6% across SC, and (3) EBS above 6% across SC. To answer RQ2, regression analysis was employed to examine the differences in the Log odds of experiencing energy burden against no burden among the foreign nationals by age, gender, education, unit tenure, marital status, and race. The models were controlled by the household location and number of children under age 6.

## 4. Results

**Table 2** presents the descriptive statistics of the foreign nationals' population, EBP as well as proportion of households with EBS below 6% across SC denoted as EBS0, and those whose EBS above 6% across SC denoted as EBS1. Older adults (EBP = 8.63%), females (EBP = 6.32%), persons with secondary educational attunements (EBP = 7.44%), singles (EBP = 6.53%), and those living in Midwest (EBP = 6.18%) are energy burdened. Answering the first research question, it can be concluded that the level of energy burden among foreign nationals is not the same. Rather than, it is affected by at least sociodemographic of age, gender, educational attainment, and marital status reflecting the potential risk of energy burden among the foreign nationals.

**Table 2.** Descriptive statistics of the Foreign Nationals, EBP, and EBS (Values in bold refer to the values of energy burden greater than 6%).

| Demographic | Category | Value | Number of Observations (n=8751) | EBP | EPS0 | EPS1 |
|---|---|---|---|---|---|---|
| **Age** | Below or equal to 65 yrs. | 80.57% | 7051 | 4.61 | 0.80 | 0.20 |
| | Above 65 yrs. | 19.43% | 1700 | **8.63** | 0.60 | 0.40 |
| **Gender** | Male | 54.14% | 4738 | 4.60 | 0.81 | 0.19 |
| | Female | 45.86% | 4013 | **6.32** | 0.71 | 0.29 |
| **Education** | secondary | 15.55% | 1361 | **7.44** | 0.62 | 0.38 |
| | postsecondary | 84.45% | 7390 | 5.01 | 0.79 | 0.21 |
| **Unit tenure** | Owned | 52.91% | 4630 | 5.12 | 0.77 | 0.23 |
| | Rented | 47.09% | 4121 | 5.69 | 0.75 | 0.25 |
| **Marital status** | Married | 60.36% | 5282 | 4.64 | 0.80 | 0.20 |
| | Single | 39.64% | 3469 | **6.53** | 0.71 | 0.29 |
| **Race** | White | 57.83% | 5061 | 5.84 | 0.74 | 0.26 |
| | Black | 13.02% | 1139 | 5.89 | 0.74 | 0.26 |
| | Asian | 29.15% | 2551 | 4.26 | 0.83 | 0.17 |
| **Location** | Northeast | 18.75% | 1641 | 5.80 | 0.72 | 0.28 |
| | Midwest | 9.19% | 804 | **6.18** | 0.75 | 0.25 |
| | South | 36.48% | 3192 | 5.44 | 0.76 | 0.24 |
| | West | 35.58% | 3114 | 4.92 | 0.79 | 0.21 |
| **Number of children under age six** | No children | 86.63% | 7581 | 5.47 | 0.76 | 0.24 |
| | one or more children | 13.37% | 1170 | 4.87 | 0.78 | 0.22 |

**Table 3** presents the Log odds of binomial logistic regression that estimate the effect of gender vs. age on experiencing energy burden for foreign nationals. Model (1) indicated that young males are significantly least burdened than older males, young females, and older females. Models (2) indicated older males were more likely to be burdened than young males and females, but insignificantly less burdened than older females. Model (3) indicated that young females are more likely to be burdened than young males, but less burdened than older adults. Models (3) indicated older females were more likely to be burdened than young males and females, but insignificantly more burdened than older males.

**Table 3.** Logistic regression of intersectionality effects of gender and age on EBS ≥ 6%: Odds Ratios

| Variable | Model (1) | Model (2) | Model (3) | Model (4) |
|---|---|---|---|---|
| **Education** | $0.47^{***}$ (1.07) | $0.47^{***}$ (1.07) | $0.47^{***}$ (1.07) | $0.47^{***}$ (1.07) |

| | | | | |
|---|---|---|---|---|
| **Unit Tenure** | 0.93 (1.06) | 0.93 (1.06) | 0.93 (1.06) | 0.93 (1.06) |
| **Marital status** | 1.30*** (1.06) | 1.30*** (1.06) | 1.30*** (1.06) | 1.30*** (1.06) |
| **Race (White)** | | | | |
| Black | 1.00 (1.08) | 1.00 (1.08) | 1.00 (1.08) | 1.00 (1.08) |
| Asian | 0.71*** (1.07) | 0.71*** (1.07) | 0.71*** (1.07) | 0.71*** (1.07) |
| **Location (Northeast)** | | | | |
| Midwest | 0.94 (1.11) | 0.94 (1.11) | 0.94 (1.11) | 0.94 (1.11) |
| South | 0.85* (1.08) | 0.85* (1.08) | 0.85* (1.08) | 0.85* (1.08) |
| West | 0.75*** (1.08) | 0.75*** (1.08) | 0.75*** (1.08) | 0.75*** (1.08) |
| **Number of children under age six** | 1.27** (1.08) | 1.27** (1.08) | 1.27** (1.08) | 1.27** (1.08) |
| **Gender - Age** | | | | |
| Male - Young | - | 0.33*** (1.09) | 0.62*** (1.06) | 0.27*** (1.09) |
| Male - Older | 2.99*** (1.09) | - | 1.86*** (1.09) | 0.82 (1.11) |
| Female -Young | 1.61*** (1.06) | 0.54*** (1.09) | - | 0.44*** (1.09) |
| Female - Older | 3.64*** (1.09) | 1.22 (1.11) | 2.27*** (1.09) | - |

Significance level: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

**Table 4** presents the Log odds of binomial logistic regression that estimate the effect of gender vs. education on experiencing energy burden for foreign nationals. Model (1) showed that males with secondary education are more burdened than males and females with postsecondary education, but less burdened than females with same educational levels. Model (2) indicated that males with postsecondary educational attainment are least energy burdened. Model (3) indicated that females with secondary educational attainment are most energy burdened. Model (4) indicated that females with postsecondary attainment are less burdened than those with less educational level, but more burdened than males with same educational level.

**Table 4.** Logistic regression of intersectionality effects of gender and education on Energy burden: Odds Ratios

| **Variable** | **Model (1)** | **Model (2)** | **Model (3)** | **Model (4)** |
|---|---|---|---|---|
| **Age** | 2.59*** (1.06) | 2.59*** (1.06) | 2.59*** (1.06) | 2.59*** (1.06) |
| **Unit tenure** | 0.93 (1.06) | 0.93 (1.06) | 0.93 (1.06) | 0.93 (1.06) |
| **Marital status** | 1.28*** (1.06) | 1.28*** (1.06) | 1.28*** (1.06) | 1.28*** (1.06) |
| **Race (White)** | | | | |
| Black | 1.00 (1.08) | 1.00 (1.08) | 1.00 (1.08) | 1.00 (1.08) |
| Asian | 0.71*** (1.07) | 0.71*** (1.07) | 0.71*** (1.07) | 0.71*** (1.07) |
| **Location (Northeast)** | | | | |
| Midwest | 0.94 (1.10) | 0.94 (1.10) | 0.94 (1.10) | 0.94 (1.10) |
| South | 0.85* (1.08) | 0.85* (1.08) | 0.85* (1.08) | 0.85* (1.08) |
| West | 0.75*** (1.08) | 0.75*** (1.08) | 0.75*** (1.08) | 0.75*** (1.08) |
| **Number of children under age six** | 1.26** (1.08) | 1.26** (1.08) | 1.26** (1.08) | 1.26** (1.08) |
| **Gender - Education** | | | | |
| Male-Secondary Education | - | 2.29*** (1.10) | 0.75* (1.12) | 1.48*** (1.10) |
| Male-Postsecondary Education | 0.44*** (1.10) | - | 0.33*** (1.10) | 0.65*** (1.06) |
| Female-Secondary Education | 1.33* (1.12) | 3.03*** (1.10) | - | 1.96*** (1.10) |
| Female-Postsecondary Education | 0.68*** (1.10) | 1.55*** (1.06) | 0.51*** (1.10) | - |

Significance level: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

**Table 5** presents the Log odds of binomial logistic regression that estimate the effect of gender vs. marital status on experiencing energy burden for foreign nationals. Models (1) and (2) indicated that males whether married or not are significantly less burdened than females.

Model (3) indicated that married females are less burdened than single ones. Model (4) indicated that single females are most energy burdened.

**Table 5.** Logistic regression of intersectionality effects of gender and marital status on Energy burden: Odds Ratios

| Variable | Model (1) | Model (2) | Model (3) | Model (4) |
|---|---|---|---|---|
| **Age** | 2.53*** (1.06) | 2.53*** (1.06) | 2.53*** (1.06) | 2.53*** (1.06) |
| **Education** | 0.47*** (1.07) | 0.47*** (1.07) | 0.47*** (1.07) | 0.47*** (1.07) |
| **Unit tenure** | 0.93 (1.06) | 0.93 (1.06) | 0.93 (1.06) | 0.93 (1.06) |
| **Race (White)** | | | | |
| Black | 1.00 (1.08) | 1.00 (1.08) | 1.00 (1.08) | 1.00 (1.08) |
| Asian | 0.70*** (1.07) | 0.70*** (1.07) | 0.70*** (1.07) | 0.70*** (1.07) |
| **Location (Northeast)** | | | | |
| Midwest | 0.94 (1.11) | 0.94 (1.11) | 0.94 (1.11) | 0.94 (1.11) |
| South | 0.85* (1.08) | 0.85* (1.08) | 0.85* (1.08) | 0.85* (1.08) |
| West | 0.76*** (1.08) | 0.76*** (1.08) | 0.76*** (1.08) | 0.76*** (1.08) |
| **Number of children under age six** | 1.25** (1.10) | 1.25** (1.10) | 1.25** (1.10) | 1.25** (1.10) |
| **Gender and Marital status** | | | | |
| Male -Married | - | 0.96 (1.09) | 0.78*** (1.08) | 0.52*** (1.07) |
| Male -Single | 1.04 (1.09) | - | 0.81* (1.10) | 0.54*** (1.09) |
| Female -Married | 1.28*** (1.08) | 1.24* (1.10) | - | 0.66*** (1.08) |
| Female -Single | 1.93*** (1.07) | 1.86*** (1.09) | 1.51*** (1.08) | - |

Significance level: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

**Table 6** presents the Log odds of binomial logistic regression that estimate the effect of gender vs. unit tenure on experiencing energy burden for foreign nationals. Models (1) and (2) indicated that owner and renter males are least energy burdened with insignificant difference between males. Models (3) and (4) indicated that owner and renter females are most energy burdened with insignificant difference between females.

**Table 6.** Logistic regression of intersectionality effects of gender and unit tenure on Energy burden: Odds Ratios

| Variable | Model (1) | Model (2) | Model (3) | Model (4) |
|---|---|---|---|---|
| **Age** | 2.58*** (1.06) | 2.58*** (1.06) | 2.58*** (1.06) | 2.58*** (1.06) |
| **Education** | 0.47*** (1.07) | 0.47*** (1.07) | 0.47*** (1.07) | 0.47*** (1.07) |
| **Marital status** | 1.28*** (1.06) | 1.28*** (1.06) | 1.28*** (1.06) | 1.28*** (1.06) |
| **Race (White)** | | | | |
| Black | 1.00 (1.08) | 1.00 (1.08) | 1.00 (1.08) | 1.00 (1.08) |
| Asian | 0.70*** (1.07) | 0.70*** (1.07) | 0.70*** (1.07) | 0.70*** (1.07) |
| **Location (Northeast)** | | | | |
| Midwest | 0.94 (1.11) | 0.94 (1.11) | 0.94 (1.11) | 0.94 (1.11) |
| South | 0.85* (1.08) | 0.85* (1.08) | 0.85* (1.08) | 0.85* (1.08) |
| West | 0.75*** (1.08) | 0.75*** (1.08) | 0.75*** (1.08) | 0.75*** (1.08) |
| **Number of children under age six** | 1.26** (1.08) | 1.26** (1.08) | 1.26** (1.08) | 1.26** (1.08) |
| **Gender - Unit Tenure** | | | | |
| Male-Owner | - | 1.11 (1.08) | 0.68*** (1.08) | 0.72*** (1.08) |
| Male-Renter | 0.90 (1.08) | - | 0.62*** (1.08) | 0.65*** (1.08) |
| Female-Owner | 1.47*** (1.08) | 1.62*** (1.08) | - | 1.06 (1.08) |
| Female-Renter | 1.39*** (1.08) | 1.54*** (1.08) | 0.95 (1.08) | - |

Significance level: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

**Table 7** presents the Log odds of binomial logistic regression that estimate the effect of gender vs. race on experiencing energy burden for foreign nationals. Models (1) and (2)

indicated that there is insignificant difference of energy burden disadvantage between the white and black males. However, they are least energy burdened compared to white and black females. Models (3) and (4) indicated that there is insignificant difference of energy burden disadvantage between the white and black females. They are more burdened than males of similar race.

Adding to the above, Model (5) showed that white males are more energy burdened than Asian males, but less burdened than white females. There is no significant difference of energy burden disadvantage between white males and Asian females. Model (6) showed that Asian males are less burden than white males, and Asian females, but more significantly than white females. Model (7) showed that white females are most energy burdened compared to white males as well as Asian males and females. Model (8) showed that Asian females are less burdened than white females, but more burdened than white and Asian males.

Finally, Model (9) proved that black males are less burdened compared to Asian females, and black females, but insignificantly to Asian males. Model (10) proved that Asian males are least energy burdened compared to black males and females as well as Asian females. Model (11) proved that black females are most burdened but more significantly compared to opposite sex. Model (12) confirmed that Asian females are less burdened than black females, but more burdened than those of opposite sex.

## 5. Discussion

Based on logistic regression analysis, it can be inferred that older adults are more energy burdened than young males and females because they spend more time at home. They consume more energy such heating and lighting than young people who tend to be outside their houses for working or studying. It also indicates that for young age group, females are more burdened than males which may be due to the different in income levels and housing energy demand as females may tend to consume more appliances for cooking, laundry, hairstyling, thus more domestic energy. Further findings showed that people with educational degree more than high school are less prone to energy burden. They probably have better jobs and higher income levels which can help them afford energy bills with no need to compromise their demands.

Adding to the above, married, or single males are less subject to energy burden than females, particularly single women. Males, whether married or single, they may have greater career possibilities and more income. This should ultimately pay their domestic energy costs. Moreover, females who pay for their house, whether owned or leased, are more vulnerable than men, owing to the limited financial means and assistance that they get.

Finally, while examining racial characteristics, the influence on energy burden levels among foreign nationals was obscured. Only the influence of gender intersectionality shows that energy burden levels differ between white, black, and Asian foreign nationals. In particular, white, and black females were more burdened compared to all gender-race combinations. This can be explained by the diverse work domains that Asians can join compared to white and black people (Lambert et al., 2019). For example, Asians can work in the gold mines, and take agricultural jobs, and factory work, especially in the garment industry. Hence, they can earn enough money needed to pay energy bills and avoid being energy burdened.

**Table 7.** Logistic regression of intersectionality effects of gender and race on Energy burden: Odds Ratios

| Variable | Model (1) | Model (2) | Model (3) | Model (4) | Model (5) | Model (6) | Model (7) | Model (8) | Model (9) | Model (10) | Model (11) | Model (12) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Age** | 2.42*** (1.06) | 2.42*** (1.06) | 2.42*** (1.06) | 2.42*** (1.06) | 2.58*** (1.06) | 2.58*** (1.06) | 2.58*** (1.06) | 2.58*** (1.06) | 2.59*** (1.06) | 2.59*** (1.06) | 2.59*** (1.06) | 2.59*** (1.06) |
| **Education** | 0.49*** (1.07) | 0.49*** (1.07) | 0.49*** (1.07) | 0.49*** (1.07) | 0.48*** (1.07) | 0.48*** (1.07) | 0.48*** (1.07) | 0.48*** (1.07) | 0.45*** (1.07) | 0.46*** (1.07) | 0.46*** (1.07) | 0.47*** (1.07) |
| **Unit tenure** | 0.93 (1.06) | 0.93 (1.06) | 0.93 (1.06) | 0.93 (1.06) | 0.94 (1.06) | 0.94 (1.06) | 0.94 (1.06) | 0.94 (1.06) | 0.94 (1.06) | 0.93 (1.06) | 0.93 (1.06) | 0.93 (1.06) |
| **Marital status** | 1.26*** (1.06) | 1.26*** (1.06) | 1.26*** (1.06) | 1.26*** (1.06) | 1.36*** (1.06) | 1.36*** (1.06) | 1.36*** (1.06) | 1.36*** (1.06) | 1.31*** (1.06) | 1.29*** (1.06) | 1.29*** (1.06) | 1.28*** (1.06) |
| **Location (Northeast)** | | | | | | | | | | | | |
| Midwest | 0.97 (1.11) | 0.97 (1.11) | 0.97 (1.11) | 0.97 (1.11) | 0.92 (1.11) | 0.92 (1.11) | 0.92 (1.11) | 0.92 (1.11) | 0.94 (1.11) | 0.94 (1.11) | 0.94 (1.11) | 0.94 (1.11) |
| South | 0.86 (1.08) | 0.86 (1.08) | 0.86 (1.08) | 0.86 (1.08) | 0.84* (1.08) | 0.84* (1.08) | 0.84* (1.08) | 0.84* (1.08) | 0.87 (1.08) | 0.86* (1.08) | 0.86* (1.08) | 0.85* (1.08) |
| West | 0.73*** (1.08) | 0.73*** (1.08) | 0.73*** (1.08) | 0.73*** (1.08) | 0.74*** (1.08) | 0.74*** (1.08) | 0.74*** (1.08) | 0.74*** (1.08) | 0.73*** (1.08) | 0.75*** (1.08) | 0.75*** (1.08) | 0.75*** (1.08) |
| **Number of children under age six** | 1.39*** (1.08) | 1.39 *** (1.08) | 1.39 *** (1.08) | 1.39 *** (1.08) | 1.27 ** (1.08) | 1.27 ** (1.08) | 1.27 ** (1.08) | 1.27 ** (1.08) | 1.25 ** (1.08) | 1.27 ** (1.08) | 1.27 ** (1.08) | 1.26** (1.08) |
| **Gender - Race** | | | | | | | | | | | | |
| Male-White | - | 1.13 (1.13) | 0.68*** (1.06) | 0.64*** (1.11) | - | - | - | - | - | - | - | - |
| Male-Black | 0.88 (1.08) | - | 0.6*** (1.13) | 0.56*** (1.16) | - | - | - | - | - | - | - | - |
| Female-White | 1.48*** (1.07) | 1.68*** (1.13) | - | 0.94 (1.11) | - | - | - | - | - | - | - | - |
| Female-Black | 1.57*** (1.08) | 1.78*** (1.14) | 1.06 (1.08) | - | - | - | - | - | - | - | - | - |
| Male-White | - | - | - | - | - | 1.06 (1.08) | 0.67*** (1.07) | 0.82* (1.08) | - | - | - | - |
| Male-Asian | - | - | - | - | 0.66*** (1.09) | - | 0.51*** (1.08) | 0.63*** (1.09) | - | - | - | - |
| Female-White | - | - | - | - | 1.23*** (1.06) | 1.41*** (1.07) | - | 1.2* (1.08) | - | - | - | - |
| Female-Asian | - | - | - | - | 0.92 (1.10) | 1.07 (1.10) | 0.68*** (1.10) | - | - | - | - | - |
| Male-Black | - | - | - | - | - | - | - | - | - | 1.36*** (1.09) | 0.62*** (1.11) | 0.97 (1.10) |
| Male-Asian | - | - | - | - | - | - | - | - | 1.01 (1.13) | - | 0.45*** (1.13) | 0.7** (1.12) |
| Female-Black | - | - | - | - | - | - | - | - | 1.77*** (1.16) | 2.21*** (1.13) | - | 1.47*** (1.10) |
| Female-Asian | - | - | - | - | - | - | - | - | 1.5*** (1.13) | 1.86*** (1.09) | 0.84 (1.11) | - |

Although the findings of the study reflected the energy burden disadvantage among foreign nationals, there are certain limitations that need to be discussed. This study developed regression analysis for one fiscal year of 2021. One-year regression analysis might not be reflective of the previous years' socioeconomic demographics of foreign nationals in the US. Therefore, it is suggested to develop a statistical regression analysis using longitudinal dataset for longer durations of AHS dataset. Moreover, this study used dichotomous variables which might mask detailed characteristics of the foreign nationals. Hence, it is advisable to use categorical variables for diverse demographic variables such as education, location, and race.

## 6. Conclusion

Housing is an essential aspect for successful foreign nationals' assimilation in the US, but it comes with its own set of costs and financial burdens. If not afforded, they are prone to household energy burden, which is defined as the inability to satisfy basic heating, cooling, and energy demands over time. People who allocate most of their income to energy utilities besides housing commonly experience challenging financial decisions.

Energy burden is an ongoing issue among socioeconomically vulnerable households in the US. Low-income households of all races and ethnicities spend a higher percentage of their total income for domestic energy, and foreign nationals can be challenged to have substandard housing conditions when paying high energy bills. Current energy burden studies have compared foreign nationals to native US citizens, but limited research has evaluated the effect of distinct experiences among foreign nationals on energy burden based on their concentrated disadvantage. This study investigated the foreign nationals' disadvantage associated with energy burden based on age, gender, location, education, marital status, race, unit tenure, and the number of household children.

The main findings of the study included the intersectionality disadvantage among foreign nationals based on their sociodemographic. The most vulnerable groups among this population were concluded to be older adults, females with secondary educational attainments, single females, and white and black females. These findings reflect the reality that women are more prone to challenges and household financial hardship upon their migration to the US. It might be due to limited job opportunities, income levels, and financial support that make them unable to afford the high domestic energy bills. Therefore, unless women receive postsecondary educational degrees, get married and be financially supported by their spouses, they remain vulnerable. According to the findings of this study, immigration laws should be designed to account for the variety of foreign nationals in order to ensure that all effectively integrate into the host country. Future work pushes toward further investigations about the effect of diverse socioeconomic demographics on energy and housing burden on females in the US.

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