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Behavioral and financial coping strategies among energy-insecure households

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When households struggle to pay their energy bills and avoid being disconnected from the grid, they may accrue debt, forgo expenses on food, and use space heaters or ovens to warm their homes. These coping strategies can introduce significant physical and financial risks. In this study, we analyze an original survey with a representative sample of low-income households during the first year of the COVID-19 pandemic, from June 2020 to May 2021. We evaluate the prevalence of a wide range of coping strategies and empirically estimate the determinants of these strategies. We find that more than half of all low-income households engage in at least one coping strategy, and many use multiple strategies. Households with vulnerable members, including young children or those who rely on electronic medical devices, and households that live in deficient housing conditions, are more likely to use a range of coping strategies, and many at once. Our findings have direct implications for public policy improvements, including modifications to the US Weatherization Assistance Program, the Low-Income Home Energy Assistance Program, and state utility disconnection protections.

energy insecurity | energy poverty | coping strategies | material hardship | COVID-19 pandemic

Significance

Millions of Americans are regularly unable to pay their energy bills. For these Americans, avoiding being shut off from their electricity service is a daily challenge and one that requires them to take financial and behavioral risks, such as acquiring utility debt or burning trash to generate heat. In this study, we find these techniques to be prevalent and often used in combination. We also find that households with young children and those with individuals who rely on electricity to power their medical devices are more likely to use these coping techniques, as are households with deficient housing conditions. There are, however, efforts that the government can undertake to help these especially vulnerable populations.

The "Big Freeze" of February 2021 led to rolling power outages across the state of Texas for more than 4.5 million households (1). Within 2 days, the freezing temperatures and power blackouts resulted in over 150 official deaths, with one media source reporting a death toll above 700 people (2). In the days following the blackout, the news revealed several causes of death, including medical conditions exacerbated by the blizzard, dangerous behaviors that households used to escape the cold (e.g., people sitting in their cars with the heat running, keeping a fire in the fireplace while the family slept around it). Even after power had been restored to most Texans, many remained burdened with exceptionally high utility bills (3). The freezing cold temperatures and mass blackouts are an extreme case, but the incidence of these severe events is increasing due to climate change (4, 5), and people engaging in risky behavior to mitigate exposure to uncomfortable or dangerous temperatures is not a rare phenomenon. Under "normal" economic and physical conditions, such strategies are practiced regularly around the country—and world—by individuals and families.

Energy insecurity, or energy poverty, both of which refer to a household's struggle to pay energy bills and exposure to inadequate residential energy services, is a widespread problem in the United States as well as across the world (6; see ref. 7 for a comprehensive discussion of definitions and metrics). In the United States, an estimated 24.3 million low-income households were unable to pay their energy bills and 10.3 million were disconnected from their service providers between April 2019 and April 2020 (8), the year preceding the onset of the COVID-19 pandemic. Furthermore, the incidence of energy insecurity is not evenly spread across all populations. Over this time and during the onset of the pandemic, households of color, those with young children, and those that rely on at-home electronic medical devices were significantly more likely to face utility disconnections (8). These disparities were exacerbated by the pandemic and the resulting economic recession, which left millions out of work (9) and increased rates of residential energy consumption and costs (10).

Energy-insecure households make difficult decisions daily, navigating keeping their power on and maintaining safe indoor temperatures, while still meeting their other essential needs, such as food and health care. To pay their bills, households need to weigh several possibilities, including asking for a loan, seeking government assistance, or engaging in potentially risky behavior to keep their bodies warm.

The extant literature provides some insights on how families cope when they struggle to pay their monthly bills. Material hardship scholars often study the role of various assistance programs in reducing hardship (see, for example, ref. 11), and they additionally consider the prevalence of different forms of hardship (see, for example, ref. 12). Material hardship research, however, typically excludes energy insecurity, even though

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it has been found to be among the most common forms of material hardship for US families (12). The analyses that include measures of energy insecurity focus specifically on financial coping strategies, finding that those who face energy insecurity usually rely on assistance from friends or family, bill balancing or alternating payments between bills, or seeking assistance from government programs (11–17).

By contrast, scholarship on energy insecurity and related topics focuses more heavily on behavioral coping strategies. A study of Austrian households, for example, found that the most common strategies for keeping a comfortable temperature in the home were wearing extra layers of clothing, heating a single room in the house, and "slipping under the covers" (18). Chard and Walker (19) found additional behaviors that UK families with elderly members routinely adopted as commonsense solutions, including going to sleep earlier and only heating specific rooms in their homes in the winter months. Evaluations in the United States and United Kingdom also found that households facing energy insecurity tended to use less fuel or electricity, allowing their home to reach uncomfortable temperatures before they turned on heat or air conditioning (20–22). To afford monthly energy bills, other studies have found families often cut expenditures, such as food or medical care (23, 24), accrue considerable debt by taking out high-interest payday loans (20, 24, 25), or signing up for utility payment plans (22).

In a recent study, Hernández and Laird (26) examined how households cope with energy insecurity. Analyzing household data from the 2015 Residential Energy Consumption Survey, they consider whether households facing the threat of disconnections or actual disconnections respond by forgoing other necessities, adjusting their home's temperature to an unsafe or unhealthy level, or seeking energy assistance. They find that households, particularly those who report having had their energy services disconnected, use each of these coping strategies to some extent and often in combination.

Collectively, the literature reveals that energy-insecure households use a range of coping strategies and often pursue many at once (see, especially, refs. 11, 13, 20, 26), but the existing literature has a few important gaps. First, few studies include a wide range of potential coping strategies in a single analysis. The material hardship literature more often focuses on financial behavior, and the energy literature more often considers temperature-seeking behavior. Studies that have considered both in the same analysis have data limitations, including a limited set of household-level coping strategies. No previous study, to the authors' knowledge, has evaluated a comprehensive range of coping strategies for this distinct, yet prevalent, form of material hardship.

Second, while the literature emphasizes the challenges associated with material hardship, it is less common for studies to explore the risk associated with using coping strategies to mitigate such hardship. For example, households must make decisions about whether to be disconnected from their service provider(s), risk a house fire by running a space heater, or forgoing meals to pay an energy bill. In fact, with some exceptions (e.g., seeking bill assistance from the government or a friend or family member), many coping strategies carry considerable risks, either financially or physically. Evaluating a wide range of coping strategies, both financial and behavioral, puts such risks in perspective and highlights how dire the tradeoffs can be for energy-insecure households.

Third, less often addressed in the literature, and central to the present analysis, is the question of why energy-insecure households engage in one strategy or another and how certain conditions faced by a household may influence such behavior. For example, if a household has one or several vulnerable members residing in the home, such as small children or medically compromised family members, they may be more likely to pursue certain coping strategies over others. The exceptions are studies by Harrington et al. (27) and Gibbon and Singler (24), which find that households with small children or members with disabilities, respectively, more frequently accrue utility debt presumably because these populations are less able to withstand extreme temperature or food deprivation. No study, to the authors' knowledge, has gathered all coping strategies into a single analysis, assessed the frequency and overlap among them, and evaluated which factors (i.e., sociodemographic and housing conditions) lead to the greater use of any given strategy.

We address these gaps in our analysis. Here, we analyze the frequency of various energy-coping strategies and what factors lead households to engage in one approach or another. We draw from an original survey of a representative sample of approximately 2,000 low-income households (with a resulting sample after multiple survey waves and accounting for the nonresponse of 5,187 respondents)—defined as those within 200% of the federal poverty level (FPL)—that we sampled at multiple points in time over the course of the COVID-19 pandemic, from roughly June 2020 to May 2021.

The contributions of our analysis are twofold. First, we analyze an original survey dataset that allows us to measure a wide range of coping strategies, including both behavioral and financial responses to energy insecurity, at the household level. The survey is longitudinal and measures outcomes across time periods that span the course of a year, which allows us to capture seasonal variation (e.g., temperature) and control for conditions faced by households in previous time periods. Second, this analysis pulls together disparate strands of literature to present and assess a wide range of coping strategies, which we use to test which conditions lead certain households to adopt one approach or another, or combinations thereof.

Our analysis is also set in the dynamic context of the COVID-19 pandemic, which restricted social engagements and set stay-at-home orders, unsettled labor markets, and shifted more energy use to residential settings. During this time, millions of households experienced material hardships and were unable to pay their monthly bills, including their energy bills. Unexpected economic shocks require low-income households to make sudden and difficult decisions (13). Therefore, the timing of the data collection provides unique insight into how low-income households cope both financially and physically during times of economic and social stress.

Results

Coping Strategies. We combined insights from the extant literature to generate an extensive list of coping strategies, including both financial and behavioral, which we then included in our survey analysis. The survey results reveal that energy-insecure households tend to engage in four general coping strategy categories. First, they seek the right temperature through behavioral techniques, some of which are riskier than others. We define risky temperature behavior as the use of space heaters, the fireplace, the oven, the dryer vent, or burning trash to generate heat.* Second, to pay energy bills, households tend to forgo

*In this analysis, we do not include the behavior of keeping one's home at an uncomfortably high or low temperature because we do not have such a measure in our survey instrument. We assume that these riskier behavioral techniques, however, are to compensate for an inability or unwillingness to turn on the heat or air conditioning to a safe or comfortable temperature. Future studies may seek to disentangle these two behaviors and may also consider including a more extensive set of both warmth- and cold-seeking behaviors that individuals pursue with the expressed purpose of coping with energy insecurity.

paying for other essential needs, such as medical bills or food. Third, households seek assistance from both formal (e.g., government, banks) and informal (e.g., friends, family, churches) networks to pay their bills. Fourth, households engage in a variety of bill strategies, such as carrying debt across utility bills, skipping payments on select bills each month until the consequences become severe (e.g., notice of disconnection, report to the credit authority), or practicing bill balancing, which is paying down a portion of one or more bills to have enough to pay for another.

We display these practices in Fig. 1, along with the percentage of respondents who reported engaging in each activity at least once during the year. General coping strategy categories are colored blue and are the dependent variables in the primary analyses that follow. More specific strategies are colored green, which serve as the dependent variables in the secondary analyses. The figure illustrates that ∼55% of the sample engaged in at least one coping strategy. Given that the survey is a representative sample of low-income households in the United States, we merge the data with estimates of those who live at or below 200% of the FPL from the 2018 American Community Survey (ACS) to extrapolate that just under 10.5 million domestic households, or 53.4 million individuals, engaged in at least one coping strategy, with many using more than one during this time (28). The most common techniques, at 32% of the sample, are financial strategies, such as bill balancing or acquiring utility debt. The second most common, at 26%, is behavioral—engaging in risky temperature-related techniques, such as using a space heater. A relatively limited number of respondents, at 11%, seek government assistance to cope with energy insecurity, despite this being one of the least risky strategies of the full set.

In Fig. 2, we present the proportion of the sample that engaged in the general coping strategy categories, or the dependent variables in the primary set of results, over the time period of analysis. The summer wave represents June 2020 through August 2020, the fall and winter wave represents September 2020 through January 2021, and the winter and spring wave represents February 2021 through May 2021. This figure reveals important seasonal dynamics. In the early winter months, we observe that most types of coping strategies rise, except for forgoing expenses. Comparatively, temperature-based behaviors rise significantly in the winter months, which is expected since all the temperature behaviors included in this analysis facilitate warmth. All four strategies declined between the winter and spring months as temperatures became more temperate and additional relief (i.e., COVID-relief checks and child tax credits) were released by the federal government during this time.

Determinants of Coping Strategies. Select regression analysis results are presented graphically in Fig. 3, with a table of full model results available in *SI Appendix*, Table S1. Our primary analysis estimates the correlation between various socioeconomic household attributes and the four general coping strategies. We estimate each model twice, first without and then with two measures of self-reported energy insecurity. The first measure is a single-wave lagged measure of difficulty paying a household energy bill and the second is a self-reported utility disconnection at any point between roughly May 2019, 1 year before survey administration, and the time of survey administration. Including these lagged variables enables us to account for both recent energy-insecurity conditions that may lead one to engage in a coping strategy (e.g., if a person struggled to pay their bill last month, they may curtail energy usage and engage in other behaviors this month), as well as previous, more extreme experiences that may affect how one behaves in the present time period (e.g., if a person has been disconnected previously, they may be more likely to use coping strategies to avoid being disconnected again). We ran robustness checks on the construction of these measures in *SI Appendix*, as discussed in the Determinants of Multiple Coping Strategies.

Results reveal that the two energy-insecurity measures are statistically significant determinants across all four general coping strategies. If a household struggles to pay its bill in the previous wave or if it was disconnected at any time in the previous year, then it is more likely to engage in all four general coping strategy categories, particularly bill balancing. Fig. 3 also shows that sociodemographic characteristics are associated with certain

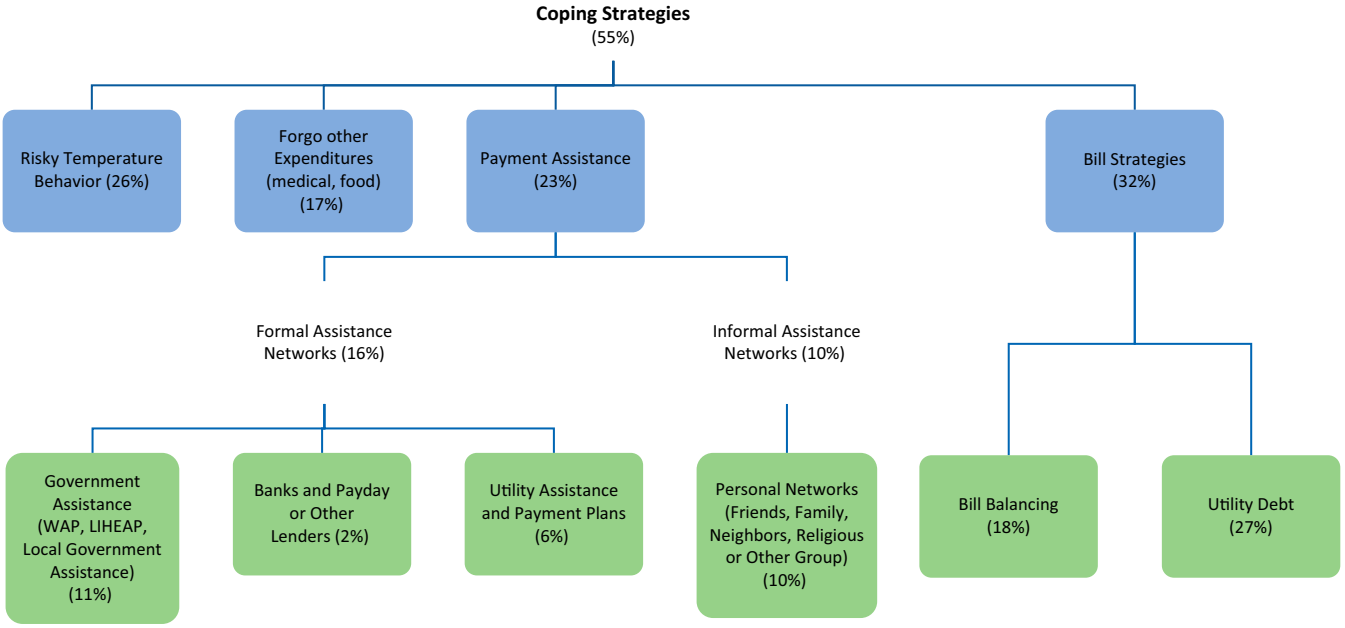

Fig. 1. Coping strategies, with percentage of respondents who engaged in each activity between June 2020 and May 2021.

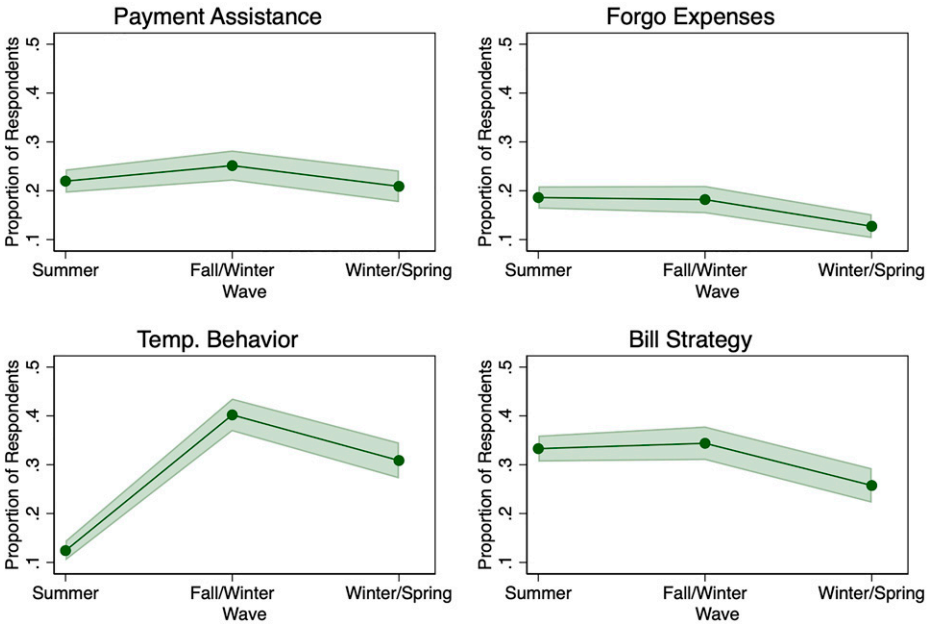

Fig. 2. Proportion of respondents (with 95% CIs) who engaged in each coping strategy category, by wave.

coping strategies. Broadly speaking, households with vulnerable members are more likely to engage in at least one of the general categories of coping strategies.

As presented, our results reveal that households with children younger than age 5 years are more likely to engage in all of the strategies: use temperature strategies, forgo expenses, seek payment assistance, and use bill strategies. Households with health-compromised members are more likely to seek a broader range of coping strategies as well. Specifically, if a household has a member with a medical disability, it more typically seeks payment assistance, and households with members who rely on an electronic medical device, a demographic that is particularly vulnerable to a lack of power, engage in all of the strategies, including using risky temperature behaviors, which, of course, could particularly compromise the health of the household. We also find racial disparities, with Black and Hispanic households more likely than White households to use bill strategies, such as bill balancing or debt accrual, and Hispanic households more likely than White households to forgo expenses, but neither is more or less likely to undertake temperature strategies. Lastly, when we stratify the sample by income, the results reveal that lower income levels correlate with seeking payment assistance, forgoing expenses, and using bill strategies.

Beyond the sociodemographic characteristics, Fig. 3 reveals that those living in deficient housing conditions—mold in the home, poor insulation, drafty air, holes in the wall, bad plumbing, exposed electric sockets, broken air conditioning, or nonworking stove or refrigerator—are more likely to engage in all four general categories of coping strategies. Finally, there is significant seasonal variation, likely due to weather conditions. *SI Appendix*, Table S1 reveals that in the colder months, households are more likely to engage in all of the coping strategies, whereas in the warmer months, respondents used less warmth-seeking behavior and more bill balancing.

We also tested the specific coping techniques under the payment assistance and bill strategies categories (i.e., those in green in Fig. 1). Select results are presented in Fig. 4, with a model specification that matches the models presented in Fig. 3; full model results are found in *SI Appendix*, Table S2. Here, we find three groups that are more likely to engage in all six coping strategies: (1) households that have at least one member who relies on an electronic medical device, (2) households with young children, and (3) those who live in deficient housing conditions. Consistent with Harrington et al. (27) and Gibbon and Singler (24), households with small children and with members who are medically compromised, either disabled or rely on an electronic medical device, are more likely to accrue debt; yet we also find that several other vulnerable populations are more likely to take on utility debt as a coping strategy, including those who have experienced energy insecurity in the past, Black and Hispanic households, those who live in deficient housing conditions, and those at the lowest income level.

We additionally find that households that have a member with a disability as well as Black households are both more likely to seek out government assistance, while Hispanic households and respondents with less than a high school education are more likely to engage in bill balancing. Those in the lowest income strata and those who are 100 to 150% of the FPL are associated with seeking government assistance and tapping their informal networks, while those under 100% FPL are also more likely to balance their bills.

Determinants of Multiple Coping Strategies. The results presented thus far suggest that households often engage in more than one coping strategy, and often at the same time, as reaffirmed by other scholars (11, 13, 20, 26). A natural extension is an examination of which sociodemographic or household factors correlate with the use of a greater number of strategies. To do so, we ran a Poisson model in which the outcome measure is a count variable that ranges from zero (no coping strategies) to four (all four main coping strategy types, as presented in blue in Fig. 1). Fig. 5 presents the marginal effect size of key variables, and the full set of results are presented in *SI Appendix*, Table S3. Here, we see that previous incidence of energy insecurity, sociodemographic variables, and deficient housing conditions are correlated with a greater number of strategies used in the home. Previous inability to pay one's energy bill has the largest effect size, followed by a previous disconnection experience. On average, those with small children in the household or with medical conditions use more coping strategies. Similarly, we

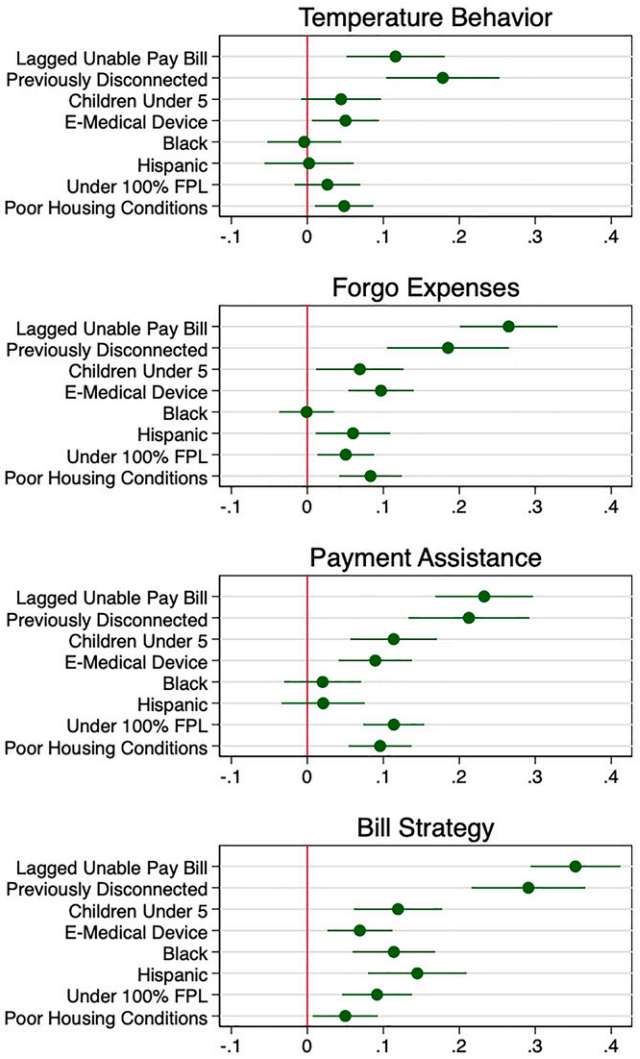

Fig. 3. Linear probability model regression results, with 95% CIs for selected variables with dependent variables: risky temperature behavior, forgo expenses, seek payment assistance, and engage in a bill strategy (n = 5,187). The omitted race category is White. The omitted income category is household within 150 to 200% of the FPL. Additional control variables include members in the house are older than 65 years, other race, respondent has a high school education or less, household is within 100 to 150% of the FPL, respondent is employed, home ownership/renter type, type of home, state fixed effects, and wave fixed effects.

find that households of color and lower-income households also typically use more strategies. These behaviors are more pronounced in the winter months than in the summer months.

Fig. 5 provides insights as to who is more likely to engage in a greater number of coping strategies, but it does not reveal how households may pair specific strategies together. In Table 1, we extrapolate the number of low-income households that engage in any given pairing of the four general coping strategies over the course of the year. Once again, we calculate these values by multiplying the 2018 ACS estimate of all US households within 200% of the FPL (28) by the percentage of households in the sample that reported using these coping strategies over the course of the year. The most common pairings, with more than 2 million households each, are between forgoing expenses and bill strategies as well as risky temperature behavior and bill strategies. The least common is the pairing of payment assistance and bill strategies; however, more than 190,000 households still engaged in these two financial strategies simultaneously during the course of the year to pay energy bills.

We test the robustness of these results through several techniques. First, we modify the construction of the energy-insecurity variables by making them both single time period lags and a measure of occurrence anytime in the past year, respectively. Second, we consider the possibility that the unbalanced nature of our panel introduced bias if observations are missing not at random. Third, we expand the count variable in the final regression to include all coping strategy measures, not just the higher order categories. In this set of regressions, we include behavior strategies and forgoing expenses, and then separate out each individual measure of payment assistance and bill strategies, for a total of eight measures. Finally, we replace the state fixed effects with regional fixed effects because regional variables may help account for climate and weather patterns. We estimate these models with both standard regional classifications (e.g., West, South, Northeast, and Midwest) and climate regions using the classification from Karl and Koss (29), which are also used by the National Oceanic and Atmospheric Administration.

All robustness checks are available in *SI Appendix*, Tables S4–S7. Model results are remarkably stable with the variation in energy insecurity measures (*SI Appendix*, Table S4) and with the alternative count variable (*SI Appendix*, Table S6). The balanced panel results (*SI Appendix*, Table S5) are also quite similar to the main results in terms of statistical significance, although with a few differences in which a variable falls out of the conventional statistical significance thresholds. Specifically, those with household members who rely on medical devices are not associated with risky temperature behavior or payment assistance. While these minor differences between the main results and the balanced panel results are important to weigh when assessing the overall validity of the findings, none of these suggest significant model specification problems, nor do they undermine the main findings of the analysis. The final set of models, in *SI Appendix*, Table S7, which controls for region, is entirely consistent with the main results.

Discussion

In this analysis, we address two tiered questions. First, descriptively, what are the primary ways in which households cope with energy insecurity and how prevalent is each strategy? Second, who engages in these strategies among the US low-income population? To answer these questions, we analyze data from an original, nationally representative, multiwave survey of low-income households that was administered during the first year of the COVID-19 pandemic. We find that households do not solely engage in financial coping techniques, such as debt accrual, paying their bills at strategic intervals, or applying for government assistance, as is typical for other forms of material hardship. In fact, households pursue additional, arguably quite risky, energy-specific behaviors. For example, to pay their energy bills, households will forgo purchasing groceries, delay going to the doctor, or compensate for colder indoor temperatures through risky warmth-seeking behaviors. Our results reveal that all of these practices are not only common among low-income American households but also many households engage in several of these approaches simultaneously.

We also find variation across sociodemographic groups. Most important, we find that households with vulnerable residents, such as young children or medically compromised individuals, cope through several concurrent techniques. Both types of households use both behavioral strategies, such as engaging in potentially risky efforts to remain warm, and financial strategies, such as taking on utility debt, strategically shifting their

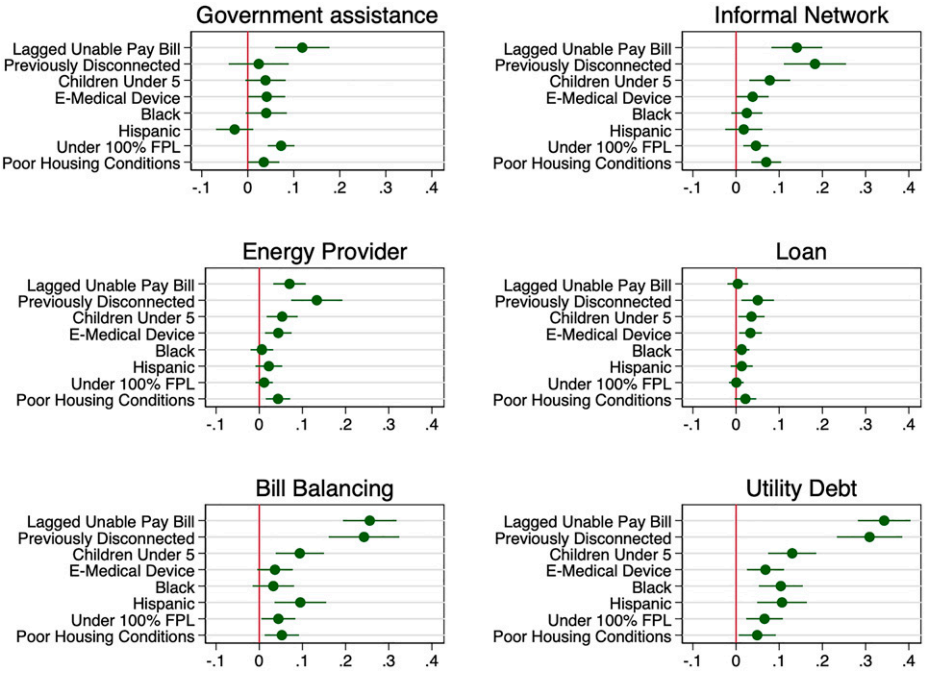

Fig. 4. Linear probability model regression results, with 95% CIs for selected variables with dependent variables government assistance, informal network assistance, energy provider assistance, loan, bill balancing, and utility debt (n = 5,187). The omitted race category is White. The omitted income category is household within 150 to 200% of the FPL. Additional control variables include members in the house are older than 65 years, "other" race, respondent has a high school education or less, household is within 100 to 150% of the FPL, respondent is employed, home ownership/renter type, type of home, state fixed effects, and wave fixed effects.

bill payments, or seeking payment assistance from both formal and informal networks. This suggests that these households need to do everything within their abilities, including the most risky strategies, to avoid a life-threatening utility disconnection.

The results of this analysis suggest several opportunities for public policy action. First, one of the leading predictors of engaging in any, or a combination of, coping strategies is the condition of one's home. Approximately 17.8% of survey respondents, or an estimated 3.4 million low-income households (28), reported that their dwelling suffered from at least one deficient housing condition. Our empirical analysis further suggests that when a household has dilapidated or inefficient dwelling conditions, such as a broken heating, ventilation, and air conditioning system or holes in the wall, they more frequently use all possible coping strategies. Helping these households repair equipment, upgrade appliances, and update the physical structures in which they live would improve energy efficiency and lower home energy bills, and thereby alleviate the need to engage in risky coping behaviors. Thus, the government can expand programs such as the Weatherization Assistance Program (WAP)—a federally funded program

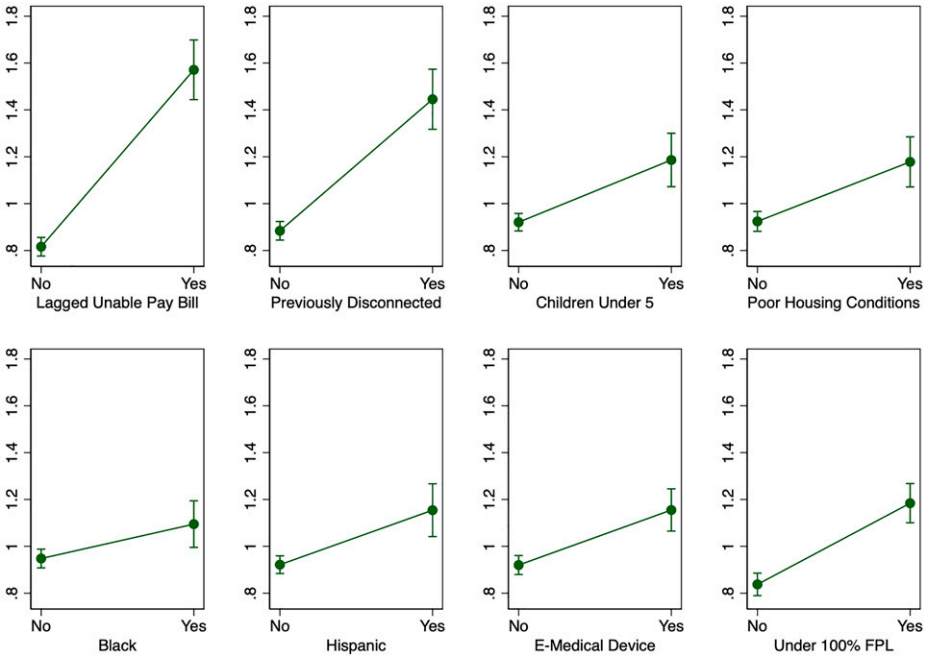

Fig. 5. Marginal effects from Poisson regression with dependent variable as a count of coping strategies.

Table 1. Estimates of households that engaged in coping strategy pairings

	Risky temperature behavior (%)	Forgo expenses (%)	Payment assistance (%)
Forgo expenses	1,429,578 (7.5)		
Payment assistance	1,848,921 (9.7)	1,753,615 (9.2)	
Bill strategy	2,153,897 (11.3)	2,287,325 (12.0)	190,610 (1.0)

Each cell contains 2 values: (1) an estimate of the No. of US households within 200% of the FPL that would engage in each coping strategy pairing and (2) the proportions of the survey sample that reported engaging in any given pairing over the course of the year are in parentheses.

that helps low-income households update their dwellings each year through energy efficiency upgrades and renewable energy installations—and, with insights from this analysis, target households with residents who are particularly vulnerable, such as those with young children or with individuals who rely on electronic medical devices. Even though millions of homes need repairs and efficiency upgrades, WAP currently only helps 35,000 low-income households each year (30). To ensure more robust participation in WAP, the government can also increase annual appropriations and clearly communicate the value of weatherization, evaluate success based on established energy poverty metrics (6), and collaborate with local community groups and members to ensure the information is shared with energy-insecure households (31).

Second, the federal government can also allocate more funds to the Low-Income Home Energy Assistance Program (LIHEAP), a federally funded energy bill assistance program. We found that applying for government payment assistance is significantly less common than several other far riskier coping techniques, such as temperature-seeking behavior, forgoing expenses on food and health care, and using bill strategies. This is not surprising because currently, due to limited Congressional appropriations, LIHEAP serves 20 to 25% of the eligible population, is only offered once per year to each eligible applicant, and has a limited program year (32). We also found that households engage in more coping strategies at the end of the year, or in the colder winter months, than other times of year, even though nearly 50% of LIHEAP funds are expended on helping households heat their homes. Based on this analysis, demand for bill assistance outstrips supply and outreach efforts to energy-insecure households are likely insufficient. Therefore, Congress should consider appropriating more money toward LIHEAP. In the absence of increased funding, LIHEAP administrators should continue to target outreach efforts to the populations that are the most likely to engage in risky financial and physical behaviors identified in this article, including households with young children, those with medically compromised members, and those who live in deficient housing conditions.

Third, state institutions can protect their constituents from utility disconnection by applying temperature-based, date-based, or targeted protections for vulnerable populations (33).[†] Many states offer such protections, but there remain opportunities for expanding the scope, scale, and duration of coverage, especially in the particularly hot and cold months, when households seek dangerous coping strategies. Based on the results in this analysis, states could specifically and swiftly encourage utilities to provide disconnection protections for households with medically compromised individuals as well as households with young children. While only five states provide protections for households with young children, nearly all states currently have a disconnection policy to protect those with medical conditions. However, the stringency of the medical protections varies across states and often requires one or more notes from a physician (33), which may be a hurdle for some applicants to obtain, especially if they are unable to afford timely medical care. Therefore, states could reconsider the breadth of these protections for their vulnerable constituencies as well as consider easing the burdens households with particularly vulnerable members must overcome to benefit from these policies.

Our results highlight the vulnerability that millions of low-income families face, many of whom are putting their financial and physical well-being at risk to maintain indoor thermal comfort, pay their energy bills, and ultimately avoid utility disconnection. We collected these data during a public health crisis, during which stay-at-home orders were enacted. The orders resulted in people spending more time at home (i.e., consuming more residential energy) than before the pandemic. Although the timing of the data collection may limit the generalizability of the findings to future conditions, there is also reason to believe that other such factors may lead to worse conditions in coming years. For example, utilities will need to invest in low-carbon capacity and infrastructure, which will likely increase energy costs and related household bills (34). In addition, climate change will continue to produce more erratic and extreme temperatures, leading to more energy demand—heat in the winter and air conditioning in the summer—as well as more weather-related emergencies (35). These factors are likely to converge, which will expand the energy-insecure population and the need for already vulnerable individuals and families to use at least one potentially risky coping strategy to pay monthly energy bills. As such, it is imperative that we recognize the prevalence of the domestic energy insecurity problem, the risks associated with household coping behavior, and the need for targeted policy interventions to help alleviate this especially dire form of material hardship.

Table 2. Distribution of respondents by region and climate region

	Sample, %
Regional distribution	
West	21.3
Northeast	15.8
Midwest	21.0
South	44.8
Climate region distribution	
Northeast	17.7
Upper Midwest	6.5
Ohio Valley	16.9
Southeast	21.3
Rockies and Plains	1.7
Southeast	14.9
Southwest	5.2
Northwest	3.5
West	11.6
Alaska	0.1
Hawaii	0.5

[†]Note that we included these protections in the present analysis insofar as they are captured in the state fixed effects term.

Table 3. Variable names, definitions, and descriptive statistics

Variable name	Operational definition	Type of variable	Mean	Linearized SE	95% CI
Dependent variables					
Risky temperature behavior	Respondent reports engaging in any of the following: using the stove for space heat, using a space heater, burning trash in the home for heat, using the fireplace for heat, or using the dryer vent for heat	Binary	0.2597	0.0101	0.2398–0.2796
Forgoes expenses	Respondent reports the need to forgo expenses on food or medical care to pay for energy	Binary	0.1697	0.0092	0.1516–0.1877
Seeks payment assistance	Respondent reports seeking payment assistance to help pay energy bill	Binary	0.2270	0.0109	0.2057–0.2484
Engages in bill strategy	Respondent reports engaging in a bill strategy, either balancing payments across bills or acquiring utility debt	Binary	0.3170	0.0126	0.2922–0.3417
Seeks government assistance	Respondent reports seeking government assistance through WAP, LIHEAP, or another local government program	Binary	0.1146	0.0077	0.0995–0.1298
Seeks payment assistance from informal network	Respondent reports seeking payment assistance from friends, family, a faith organization, or a nonprofit	Binary	0.1036	0.0075	0.0889–0.1181
Seeks payment assistance from utility provider	Respondent reports seeking payment assistance from their utility through a payment plan or other utility support	Binary	0.0579	0.0057	0.0466–0.0692
Takes out a loan	Respondent reports taking out a loan or payday lending to pay an energy bill	Binary	0.0193	0.0033	0.0127–0.0258
Engages in bill balancing	Respondent reports engaging in bill balancing	Binary	0.1835	0.0108	0.1624–0.2046
Takes on utility debt	Respondent reports taking on utility debt	Binary	0.2719	0.0118	0.2487–0.2950
No. of coping strategies	No. of the following strategies used by the household: risky temperature behavior, forgoes expenses, seeks payment assistance, engages in bill strategy (ranges from 0 to 4)	Ordinal	0.9764	0.0310	0.9156–1.0370
Independent variables					
Lagged, struggled to pay energy bill, t-1	Respondent reported difficulty paying energy bill in the previous wave	Binary	0.1418	0.0098	0.1225–0.1611
Previously disconnected	Respondent reported being disconnected at some previous time period, either in a previous wave or any time the year before the first data administration in May 2020	Binary	0.0675	0.0090	0.0499–0.0851
Children in house are younger than 5 y	There is at least 1 child living in the house who is younger than 5 y old	Binary	0.1517	0.0105	0.1310–0.1724
Member(s) of household are older than 65 y	There is at least 1 individual living in the house who is older than 65 y	Binary	0.3292	0.0121	0.3054–0.3529
Member(s) of household have a disability	There is at least 1 individual living in the house who has a medical disability	Binary	0.4042	0.0129	0.3790–0.4295
Member(s) of household rely on electronic medical device	There is at least 1 individual living in the house who relies on an electronic medical device	Binary	0.1799	0.0100	0.1603–0.1996
Black household	Household is of Black racial composition	Binary	0.1698	0.0110	0.1482–0.1914
Hispanic household	Household is of Hispanic racial composition	Binary	0.1972	0.0144	0.1689–0.2255
Household identifies as other race	Households is of other racial composition	Binary	0.0909	0.0081	0.0748–0.1069
White household (omitted)	Households is of other White racial composition	Binary	0.5414	0.0150	0.5120–0.5707
Household respondent has high school education or less	Respondent reports having only a high school diploma or less	Binary	0.5529	0.0138	0.5258–0.5801
Household is within 100 to 150% of FPL	Respondent reports that household is within 100 to 150% of the FPL, based on income categories provided by the authors in the survey instrument	Binary	0.2966	0.0112	0.2746–0.3185
Household is under 100% of the FPL	Respondent reports that household is under 100% of the FPL, based on income categories provided by the authors in the survey instrument	Binary	0.3999	0.0131	0.3742–0.4255
Household is 150 to 200% of the FPL (omitted)	Respondent reports that household is within 150 to 200% of the FPL , based on income categories provided by the authors in the survey instrument	Binary	0.2122	0.0094	0.1937–0.2307
Household respondent is employed	Respondent reports being employed at time of the survey	Binary	0.3164	0.0132	0.2906–0.3423
Broken or inefficient house conditions reported	At least 1 of the following house conditions is present: mold in the home, poor insulation, drafty air, holes in the wall, bad plumbing, exposed electric sockets, broken AC, or nonworking stove or refrigerator	Binary	0.1778	0.0074	0.1633–0.1922
The respondent(s) rent their residence	Respondent rents their residence	Binary	0.5021	0.0142	0.4743–0.5299
The respondent(s) claim “other” for home ownership type	Respondent neither rents nor owns their residence	Binary	0.0740	0.0072	0.0599–0.0882
The respondent(s) own their residence (omitted)	Respondent owns their residence	Binary	0.5509	0.0146	0.5223–0.5796
Home is a trailer	Dwelling is a trailer	Binary	0.1147	0.0094	0.0962–0.1332
Home is an apartment or condominium	Dwelling is an apartment or condominium	Binary	0.3334	0.0140	0.3059–0.3608
Home type is “other”	Dwelling type is reported as “other”	Binary	0.0027	0.0008	0.0012–0.0043
Home type is single-family home (omitted)	Dwelling is a detached or attached single-family home	Binary	0.4242	0.0059	0.4126–0.4358
Summer (wave 2)	Data gathered in the second wave	Binary	0.4255	0.0060	0.4138–0.4372
Fall/Winter (wave 3)	Data gathered in the third wave	Binary	0.3164	0.0043	0.3079–0.3249
Winter/Spring (wave 4)	Data gathered in the fourth wave	Binary	0.2605	0.0052	0.2504–0.2707
Previously struggled to pay bill	Respondent reported difficulty paying energy bill either in any previous wave or any time the year before the first data administration in May 2020	Binary	0.2505	0.1290	0.2252–0.2758
Lagged, disconnected, t-1	Respondent reported being disconnected from their utility provider in the previous wave	Binary	0.0365	0.0060	0.0247–0.0483

Materials and Methods

Survey Design and Sampling. This study was approved by the Indiana University Human Subjects & Institutional Review Board as exempt status. We produced the data for this analysis via an original survey designed by the authors and administered by YouGov, a private polling firm. To build the sample, we surveyed a representative group of respondents of those within 200% of the FPL. This threshold is a common percentage for analyses of low-income households (see, for example, ref. 36). In addition, federal energy assistance programs such as LIHEAP tend to use 150% of the FPL as the eligibility threshold; therefore, our sample allows us to analyze differences across households that are under and over this specific threshold.

YouGov generates a random and representative sample through a two-step process. First, the firm draws a random sample from the full population of all households within 200% of the FPL. Next, the firm uses a matching algorithm to select matching households from their proprietary panel of approximately 2 million US participants. Scholars have widely validated YouGov's sampling techniques (37–39). For the present analysis, we generated demographic survey weights to ensure that the sample is fully representative of the population of low-income households and applied these weights in all regressions. YouGov awards points per completed survey, which translates into financial compensation.

We administered the survey at four separate points in time, roughly coinciding with different seasons, over the course of the year from mid-2020 to mid-2021. In the first wave, which we administered in May 2020, we asked questions about baseline conditions of energy insecurity, both in the month of May and over the past year, the year that predated the COVID-19 pandemic. In the present analysis, we only use this wave to construct lagged energy insecurity variables.[‡] Beginning in wave two, which we administered in August 2020, we asked questions that pertained to several months at a time. In our August survey, we covered the months of June, July, and August. We administered wave three in January 2021, which pertained to the months of September through January, and wave four in late May and early June of 2021, which pertained to the months of February through June. This analysis focuses only on waves two through four.

The decline in sample size across waves of the survey was anticipated, given our expectations about attrition. We also set approximate quotas for each wave to achieve nationally representative samples, and the survey was closed when these quotas were met, in the interest of keeping the surveys open for as short of a duration of time as possible. This approach allowed us to document one person's response, for example, completed on the first day that the instrument was open, as in the same time period as another's, who completed it on the last day that it was open. If we left the instrument open for too long, then the first respondent may have experienced completely different circumstances (e.g., policy, coronavirus, personal circumstances) than the second respondent, but we would still claim them both as occurring in the same wave. To avoid this problem, we set threshold for responses with YouGov ahead of time and closed the survey once we met those thresholds.

Thus, there are individuals who dropped from the sample not due to nonresponse but due to us closing the survey. As a result, it is impossible for us to identify who dropped from the sample due to attrition and who dropped due to the survey closing. To analyze whether anyone was discontinued in the study not at random, however, we present basic descriptive statistics in *SI Appendix*, Tables S8 and S9. First, for any sociodemographic variable that is likely to remain constant over the waves, we present means and SDs by subsample: those who stopped after the second wave, those who stopped after the third wave, and those who made it through all of the waves. Second, for any variable that was likely to change over time, which includes housing, energy insecurity, and coping strategy variables, we estimate means and SDs within waves. Here, we compare those who stopped after the second wave with those who went on to complete subsequent waves, all at wave two values; we then compare those who stopped after the third wave with those who went on to complete the final wave, all at wave three values. The results show that there are no large differences for any variable, either across subsample or within wave. All means are well within the SDs of one another.

The final unbalanced sample is 2,247 in wave two (summer), 1,670 in wave three (fall/winter), and 1,378 in wave four (winter/spring). With some nonresponse to survey questions, the final sample size in the regressions is 5,187. We presented the weighted distribution of respondents across regions and climate regions in Table 2.

We administered the survey online and it lasted ∼10 to 15 min. The survey included questions on respondents' personal and household characteristics, housing conditions, heating and cooling behavior, rates of energy insecurity, and various coping strategies. In each of the waves, we asked respondents to reflect on the past several months to identify whether, at any point over that time period, they experienced an inability to pay their energy bill or a utility disconnection.

Variables. In this analysis, we used these various measures to test the relationship between household sociodemographic variables and household conditions, respectively, and various coping strategies. All of the dependent variables included in Figs. 2 to 4 are binary, coded as a "1" if a respondent reported that their household performed that action in a given wave, and "0" otherwise. The two energy insecurity independent variables are coded as follows: the first is a single-wave lag if the respondent reported having difficulty paying their energy bill in the last wave; the second is a comprehensive measure of a previous utility disconnection, in the event that a respondent reported in any previous time period that they were disconnected, including the prewave-one time period of the year before the pandemic. We present the variables that we include in the analyses, the way that we operationalized them, and their descriptive statistics in Table 3.

The timing of the data collection also coincided with several policies that aimed to reduce hardship for all Americans due to the COVID-19 pandemic. For example, the distribution of the Child Tax Credit began during wave two, summer 2020, and the second and third round of stimulus checks, $600 and $1400, respectively, were dispersed during wave three, fall/winter 2020. The timing and provision of these payments likely explains why the overall proportion of the sample population that forwent expenses reduces over the duration of the analysis. In addition, during this time, state- and utility-level policies were implemented to protect households from being disconnected if they were unable to pay their utility bills. While this collection of policies may have had an impact on household coping strategies, we do not include them as covariates in the present analysis. The stimulus and tax credit affect all eligible families the same across space and time. By contrast, the utility disconnection policies do vary over space and time; however, these protections are monthly and at times daily protections, which cannot cleanly be aggregated to the wave level at which we collected the data and present our results. In addition and importantly, it is likely that any variation in coping strategies caused by these policies will be soaked up by the state and wave fixed effects that we include in all of the models, allowing the specification to provide unbiased correlations between the sociodemographic indicators and household coping strategies.

Regression Analysis. We use a linear probability model to produce the results presented in Figs. 3 and 4 and a Poisson model for Fig. 5. For each regression, we use the full suite of covariates with survey weights. The full reporting of modeling results is contained in *SI Appendix*.

Data, Materials, and Software Availability. Anonymized replication data and statistical code data have been deposited in the Harvard Dataverse (https://doi.org/10.7910/DVN/XKGOCW) (40).

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[‡]Wave one was different than the other waves in several ways. First, wave one only covered 1 month of time, while the others covered several months. Second, wave one occurred during the heart of the stay-at-home orders and mass shutdowns. Thus, including this wave of data in a substantive way could further limit the external validity of the findings.

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