By Eva Laura Siegel, Kathryn Lane, Ariel Yuan, Lauren A. Smalls-Mantey, Jennifer Laird, Carolyn Olson, and Diana Hernández

DOI: 10.1377/hlthaff.2023.01052
HEALTH AFFAIRS 43,
NO. 2 (2024): 260–268
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Energy Insecurity Indicators Associated With Increased Odds Of Respiratory, Mental Health, And Cardiovascular Conditions

Eva Laura Siegel, Columbia University, New York, New York.

Kathryn Lane, New York City Department of Health and Mental Hygiene, New York, New York.

Ariel Yuan, New York City Department of Health and Mental Hygiene.

Lauren A. Smalls-Mantey, New York City Department of Health and Mental Hygiene.

Jennifer Laird, Lehman College–City University of New York, New York, New York.

Carolyn Olson, New York City Department of Health and Mental Hygiene.

Diana Hernández (dh2494@cumc.columbia.edu), Columbia University.

ABSTRACT **Energy insecurity, defined as the inability to meet household energy needs, has multiple economic, physical, and coping dimensions that affect health. We conducted the first citywide representative survey of energy insecurity and health in a sample of 1,950 New York City residents in 2022. We compiled ten indicators that characterize energy insecurity as experienced in New York City housing settings and then examined associations between number and types of indicators and health conditions. Nearly 30 percent of residents experienced three or more indicators, with significantly higher levels among Black non-Latino/a and Latino/a residents compared with White non-Latino/a residents, renters compared with owners, recent immigrants compared with those living in the United States for longer, and those in households with children compared with those with no children. Residents with three or more indicators of energy insecurity had higher odds of respiratory, mental health, and cardiovascular conditions and electric medical device dependence than residents with no indicators. Our study demonstrates that broadening the understanding of energy insecurity with context-specific metrics can help guide interventions and policies that address disparities relevant to health and energy equity.**

Energy insecurity, the inability to meet household energy needs, has economic, behavioral, and physical dimensions.[1] Energy insecurity and its associations with health are increasingly important to document as climate change increases energy needs and governments enact and implement clean energy policies.[2–5] Known detrimental impacts of energy insecurity on health and well-being include poor sleep and mental health and respiratory ailments resulting from the use of a stove or oven for heat.[6] In high-risk populations, dangerous temperatures at home stemming from energy insecurity may result in hypothermia, heat stress, dehydration, and even death.[7,8]

The issue of energy insecurity has long been understudied, and there remains a need for large-scale, comprehensive studies of how it affects population health. The nationally representative Residential Energy Consumption Survey collects data on household energy use every four to five years, including indicators such as receiving a service disconnection notice, keeping the home at an unhealthy temperature, and reducing or forgoing spending for basic needs to pay for utilities.[9] However, it does not inquire about household debt or health status, nor does it capture the full range of coping behaviors that people experiencing energy insecurity may employ.[10,11]

John Cook and colleagues administered a brief energy insecurity indicator focused on heating

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and service disconnections in a hospital-based study conducted during 2001–06 and found that household energy insecurity was associated with household and child food insecurity, increased hospitalizations, and poorer-rated health in children; severe household energy insecurity was also associated with developmental concerns in children.[12] Similarly, in a 2015 community-based survey, Diana Hernández and Eva Siegel found that positive responses to the brief energy insecurity indicator were associated with poor respiratory, sleep, and mental health outcomes among adults in northern Manhattan.[6] At the national level, Diana Hernández and Jennifer Laird analyzed 2015 Residential Energy Consumption Survey data and found that the escalating risk for disconnections leads to health-compromising coping strategies, including trade-offs with food and medicine and keeping homes at an unhealthy temperature,[13] showing that energy insecurity is an embodied hardship.[14]

A more comprehensive array of indicators can aid in capturing the energy insecurity experience and assess differences in energy insecurity exposures and outcomes among subpopulations. The goal of the current study was not to develop or test an energy insecurity measure for potential use in other settings but, instead, to present a compilation of ten energy insecurity indicators that extends prior conceptual and empirical work to better reflect the multidimensional nature of energy insecurity. Informed by scholarship that established the energy insecurity conceptual framework, including how it affects health,[1,15] these indicators encompass economic dynamics such as difficulty paying, arrearages, and the threat and experience of disconnections; physical conditions including exposure to extreme heat and cold; and coping responses such as reducing energy consumption to save money on utility bills and relying on a stove or oven for heat. Previous studies have examined only a subset of these indicators (that is, disconnections, energy-limiting behavior, energy burden, or high energy use intensity), mostly in an isolated fashion,[11,13,16–19] or they missed key elements such as warm weather burdens and debt.[6,12]

Our representative survey of energy and health employed this multifaceted set of energy insecurity indicators to increase understanding of how energy insecurity manifests and to explore health correlates across chronic illness conditions, disease states, and mental health status in New York City.

Study Data And Methods

SURVEY From February 28 to April 1, 2022, the New York City Department of Health and Mental Hygiene fielded the New York City Household Energy and Health Survey in a sample of New York City adults. The survey instrument was developed using a core set of indicators, initially created by Hernández,[20] based on a national study of energy insecurity, which included qualitative interviews and a survey, that has influenced recent research in the field.[19] In partnership with the Bureau of Environmental Surveillance and Policy and the Bureau of Epidemiology Services at the New York City Department of Health and Mental Hygiene, survey questions were adapted, further codeveloped, and user tested. The New York City Household Energy and Health Survey was self-administered online or with an interviewer over the telephone in the respondent's language of choice: English, Spanish, Simplified or Traditional Chinese (Mandarin or Cantonese), or Russian. A stratified random sample of 6,405 adults was selected from the NYC Health Panel (formerly called Healthy NYC), a probability-based survey panel of 13,000 adults ages eighteen and older that was designed to be representative of New York City adults.[21] Of the 6,405 sampled panelists, 1,950 completed the survey (1,787 online and 163 by phone), for a participation rate of 30.4 percent. The final data set was weighted to account for probability of selection and nonresponse (see the online appendix for further details, including the unweighted sample numbers by category).[22]

PRIMARY OUTCOME VARIABLES Participants were asked whether they or anyone in their household had ever been diagnosed with certain health conditions or a group of conditions. Mental health conditions were specified as anxiety, depression, or other. Respiratory conditions were included as asthma or chronic obstructive pulmonary disease. We also inquired about other chronic conditions: cardiovascular disease, chronic kidney disease, diabetes, and hypertension (high blood pressure). In addition, we asked whether anyone in the household regularly used any electric medical devices at home (for example, a dialysis machine or asthma nebulizer).

ENERGY INSECURITY MEASUREMENT Our primary independent variable was the number of positive energy insecurity indicators, measured using our ten-indicator instrument, which comprised six new indicators alongside four previously used ones. Incorporating the four-indicator instrument used in prior studies,[6,12] we asked whether participants had received a shut-off notice in the past six months, used a stove or oven for heat during the most recent heating season, went without heat or cooling because of inability to pay in the prior heating or cooling season, or experienced a shut-off of

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utility service because of nonpayment in the past twelve months. Building on this base to describe energy insecurity in New York City across a wider range of dimensions, we also asked whether, during the past twelve months, participants experienced being extremely cold at home, being uncomfortably hot at home, reducing energy use because of concerns about not being able to afford the bill, or having difficulty paying the energy bill. We further inquired whether participants used air conditioning less often because of the cost of bills during the past summer or owed $100 or more on electricity, gas, or combined electricity and gas bills at the time of the survey (see EI indicator questions in the appendix for details).[22]

For our analysis, we compared residents who experienced three or more energy insecurity indicators with those who experienced two, one, or no indicators. This decision was based on the distributions of energy insecurity indicators in this sample and the patterning of those distributions across several health and social axes (see appendix exhibit S2 for details).[22]

DEMOGRAPHIC VARIABLES We used the following demographic variables available from the NYC Health Panel data set: age group (adjusted to time of survey completion), sex assigned at birth, race and ethnicity, educational attainment, place of birth, length of residence in the US, and household language. We inquired about employment status and household poverty in the New York City Household Energy and Health Survey.

STATISTICAL ANALYSIS We conducted analyses using SAS, version 9.4, and SUDAAN, version 11.0.4, and we used survey weights in all analyses. We calculated the prevalence of each energy insecurity indicator and the prevalence of multiple indicators. We calculated descriptive statistics including weighted prevalence, mean, 95% confidence intervals, and relative standard error, and we conducted t-tests to test for significant differences between groups of at least 0.05. We modeled adjusted logistic regressions with PROC SURVEYLOGISTIC to examine associations between self-reported health conditions (categorized as ever diagnosed or not) as the outcome and a categorical energy insecurity variable (zero, one, two, and three or more indicators of energy insecurity) as the predictor. We adjusted models for age group, sex assigned at birth, self-reported race and ethnicity, education level, presence of children in the home younger than age eighteen, presence of household members age sixty or older, household income as a percentage of the federal poverty level, and employment status (see appendix exhibits S3–S6 for details).[22]

In this study, a consistent pattern of unequal sociodemographic distribution of energy insecurity indicators emerges.

LIMITATIONS This work includes several important limitations. All demographic and health characteristics were self-reported, potentially introducing measurement error. Educational attainment was collected during panel registration and may have since changed. Because respondents were not necessarily heads of households, they might not have had full knowledge of utility bills, debt, and coping strategies employed. This study was only representative of survey participants (noninstitutionalized New York City adults), and findings should not be generalized to other contexts. Even within New York City, this sample should not be considered representative or descriptive of the experience of the energy insecurity of adults living in nursing homes, jails, homeless shelters, and other congregate settings. The prevalence of energy insecurity indicators in New York City may also have been underestimated because of a temporary moratorium on utility shut-offs during the COVID-19 pandemic: Terminations for nonpayment of bills were paused through December 2021 for all residential customers and until September 2022 for low-income customers participating in an energy assistance program. Moreover, several income support programs, such as enhanced unemployment benefits and utility debt forgiveness,[23] may have served as economic buffers during the pandemic.

Study Results

PREVALENCE OF ENERGY INSECURITY INDICATORS

More than one in four New York City residents experienced thermal discomfort at indoor temperatures that were too cold (30 percent) or too hot (28 percent) in 2022 (exhibit 1). Twenty-one percent had difficulty paying utility bills. Of those, 66 percent were in debt for energy costs (data not shown), and 14 percent of all New York

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City residents owed $100 or more in utility bills (exhibit 1). Receipt of a service disconnection notice for electricity or gas because of debt or nonpayment and any service shutoffs for heat, electricity, and gas were experienced by 8 percent and 3 percent of residents, respectively. Thirty-nine percent of residents reduced their energy use because of cost. Some coped with energy bills by reducing use for cooling or heating, with 14 percent using air conditioning half the time, less than half the time, or never when it was hot and 7 percent not using heat in cold weather because of run cost. Twenty-one percent coped with being too cold at home by using a stove or oven for heat.

EXHIBIT 1

Weighted prevalence of energy insecurity indicators among New York City residents, 2022

Energy insecurity dimensions and associated indicators	Weighted prevalence[a] (%)	95% CI
Physical conditions		
Home too cold	29.5	26.1, 33.1
Home too hot	27.5	24.3, 30.9
Economic dynamics		
Difficulty paying bill	21.2	18.5, 24.2
Utility debt $100 or higher	14.0	11.6, 16.7
Disconnection notice	8.2	6.4, 10.5
Service shut offs	3.2	2.0, 5.1
Coping responses		
No or reduced air conditioning during hot weather because of run cost	14.3	12.1, 16.9
No heat because of run cost	6.7	5.1, 8.6
Reduced energy use because of cost	38.7	35.3, 42.3
Stove or oven used for heat	21.3	18.3, 24.7

SOURCE New York City Household Energy and Health Survey, March 2022. **NOTE** Weighted estimates based on responses of $N = 1{,}950$ survey participants. [a]Percent of individuals.

PREVALENCE AND DEMOGRAPHIC VARIABILITY BY NUMBER OF ENERGY INSECURITY INDICATORS Thirty-one percent of New York City residents experienced none of the ten energy insecurity indicators, 22 percent experienced one indicator, 18 percent experienced two indicators, and 28 percent experienced three or more indicators (exhibit 2). The prevalence of three or more indicators was significantly higher among Black non-Latino/a and Latino/a residents (40 percent and 33 percent, respectively) compared with White non-Latino/a residents (18 percent). People with a household income less than 200 percent the federal poverty level and those in households with children were also more likely to experience three or more indicators of energy insecurity (38 percent and 37 percent, respectively) compared to those with an income of 200 percent of poverty or more and those in households without children (19 percent and 24 percent, respectively). Renters had a higher prevalence of three or more indicators of energy insecurity (31 percent) compared with owners (23 percent). Foreign-born New York City residents had a higher prevalence of three or more indicators of energy insecurity (38 percent) than that of their US- and US territory–born counterparts (22 percent and 21 percent, respectively), as did recent immigrants compared with those residing in the US for longer. Residents with a college degree or higher were less likely to experience three or more indicators compared to those with lower educational attainment, and households with members age sixty or older were less likely to experience three or more indicators compared to those without an older adult.

ASSOCIATIONS BETWEEN ENERGY INSECURITY AND HEALTH CONDITIONS In adjusted models, we observed increased odds of mental health conditions, respiratory conditions, cardiovascular disease, and use of electric medical devices among residents with one, two, or three or more indicators of energy insecurity compared to those with zero indicators (exhibit 3). Among those with three or more indicators of energy insecurity, the adjusted odds ratio of mental health conditions was 3.9, the adjusted odds ratio of respiratory conditions was 2.2, and the adjusted odds ratio of cardiovascular disease was 2.5 compared to those with zero indicators. The adjusted odds ratio of using electric medical devices was 3.4 among those with three or more indicators of energy insecurity compared to those with none. The other three conditions (chronic kidney disease, diabetes, and hypertension) were not consistently associated with energy insecurity indicators.

Discussion

In 2022 we conducted the first citywide survey to characterize energy insecurity and its correlates with health and social vulnerability in New York City, laying the groundwork for new avenues of exploration connecting energy insecurity and health. The citywide prevalence of three or more indicators of energy insecurity in this study (28 percent) was similar to the prevalence of energy insecurity reported at the community scale locally (27 percent), based on indicators from Cook and colleagues,[6,12] and nationally, using Residential Energy Consumption Survey indicators (27 percent).[9,24]

Early research in this field called for more comprehensive measures of the impact of energy insecurity on quality of life and mental health.[25] Using our expanded, ten-indicator instrument, we found that experiencing three or more indicators of energy insecurity correlated with men-

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EXHIBIT 2

Weighted prevalence of energy insecurity indicators, by number of indicators, among New York City residents, overall and by demographic characteristics, 2022

	No. of indicators (out of 10)			
	0	1	2	3+
Overall, %	31.1	22.3	18.1	28.4
Age (years), %				
18–24 (ref)	15.3[a]	26.3[a]	23.5[a]	35.0[a]
25–44	30.5***	19.3	19.8	30.3
45–64	30.3***	22.9	16.9	29.9
65+	39.1****	26.8	14.5	19.6*
Sex assigned at birth, %				
Male (ref)	33.0	24.1	15.5	27.5
Female	29.8	21.0	19.9	29.3
Race and ethnicity, %				
White non-Latino/a (ref)	40.0	26.8	15.7	17.6
Black Latino/a	23.4****	21.8	14.6	40.2****
Latino/a	24.8****	20.4*	21.8*	32.9***
Asian or Pacific Islander non-Latino/a	33.4	20.6	18.4	27.5
Other or multiracial non-Latino/a	45.9[a]	16.7[a]	18.3[a]	19.0[a]
Education,[b] %				
High school diploma or less (ref)	27.0	20.3	19.9	32.8
Some college	26.7	20.8	18.9	33.5
College degree or more	38.6***	25.6*	15.5	20.3***
Household income, %				
Less than 200% FPL (ref)	25.4	18.9	18.1	37.6
200% FPL or more	37.3****	26.5**	17.1	19.2****
Housing tenure				
Owned by resident or family (ref), %	40.1	21.6	15.3	23.0
Rented or occupied without payment of rent, %	26.9****	22.6	19.4	31.0**
Household size (mean no.)	2.6	2.9	3.0	3.3
Household members, by age, %				
With members <18 (ref)	25.6	20.0	17.4	36.9
Without members <18	34.0**	23.5	18.5	24.0***
With members >60 (ref)	33.7	25.0	18.4	23.0
Without members >60	29.1	20.2*	18.0	32.8***
Place of birth,[c] %				
US-born (ref)	35.8	24.1	17.9	22.1
US territory–born	37.0[a]	18.0[a]	24.1[a]	20.9[a]
Foreign-born	24.0****	19.9	17.7	38.4****
Length of residence in US,[d] %				
Less than 5 years (ref)	22.3[a]	—[e]	—[e]	64.4[a]
5–10 years	28.7[a]	30.7[a]**	18.1[a]	22.6[a]***
More than 10 years	23.8	18.8**	17.4**	40.0*

SOURCE New York City Household Energy and Health Survey (selected demographic characteristics obtained from respondents' enrollment in the NYC Health Panel), March 2022. **NOTES** Weighted estimates based on responses of $N = 1{,}950$ survey participants. Weighted prevalence is percent of individuals. FPL is federal poverty level. [a]Estimate must be interpreted with caution: relative standard error is greater than 30 percent, 95% confidence interval half-width is greater than 10, or sample size is too small. [b]Education estimates based on responses of survey participants ages 25 and older. [c]Place of birth is applicable to the person participating in the survey. [d]Based on responses of survey participants not born in the US or in US territories. [e]Suppressed value: estimate is not given because potentially unreliable. *$p < 0.10$ **$p < 0.05$ ***$p < 0.01$ ****$p < 0.001$

tal health, respiratory, and cardiovascular conditions and with the use of electric medical devices. The sensitivity of the respiratory tract to temperature and air quality[26,27] may explain the association between energy insecurity indicators and respiratory conditions. Moreover, we found that having three or more indicators of energy insecurity was strongly associated with mental health conditions, as reported elsewhere.[28] The energy insecurity–mental health association can be explained by the physical and psychological disturbances produced by inhospitable temperatures and by the anxiety and stress associated with debt and economic trade-offs. The accumulation of energy insecurity–related burdens (that is, an extremely cold home, difficulty paying util-

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EXHIBIT 3

Association of self-reported health conditions and electric medical device use among New York City residents with number of energy insecurity indicators, 2022

	No. of indicators (out of 10)					
	1		2		3+	
	aOR	95% CI	aOR	95% CI	aOR	95% CI
Mental health conditions	1.4	0.9, 2.2	1.5	1.0, 2.3	3.9	2.4, 6.3
Respiratory conditions	1.7	1.1, 2.7	0.7	0.4, 1.3	2.2	1.3, 3.6
Cardiovascular disease	2.0	1.2, 3.5	1.5	0.8, 2.9	2.5	1.3, 4.8
Chronic kidney disease	1.2	0.4, 3.5	1.9	0.7, 5.2	1.6	0.6, 4.3
Diabetes	1.2	0.7, 1.9	0.8	0.4, 1.5	1.3	0.8, 2.2
Hypertension	1.3	0.8, 2.1	0.8	0.5, 1.3	1.7	1.0, 2.7
Use of electric medical device	2.4	1.3, 4.6	2.4	1.3, 4.5	3.4	1.9, 6.0

SOURCE New York City Household Energy and Health Survey, March 2022. **NOTES** Weighted estimates based on responses of $N = 1{,}950$ survey participants. Logistic regression models adjusted for age group, sex assigned at birth, self-reported race and ethnicity, education level, presence of children in the home younger than age 18, presence of household members age 60 or older, household income as percentage of the federal poverty level, and employment status. Health condition questions asked about diagnosis or electric medical equipment use for the respondent and the members of the respondent's household. Adjusted odds ratios (aORs) are compared to those with zero indicators of energy insecurity.

ity bills, and disconnection threats) requires a more intensive response[13] and high-effort coping strategies,[29] which can be stressful to manage[10] and can magnify risks for cardiovascular disease.[30]

The links between energy insecurity and health identified in this study may have been magnified by additional factors, including the synergistic effects of the COVID-19 pandemic.[31] A recent study found that people with a disability were disproportionately affected by energy insecurity during the COVID-19 pandemic,[32] and our findings suggest that people living with some chronic diseases are also more likely to experience energy insecurity. The present study did not find that older New York City adults were more likely to experience energy insecurity; however, according to AARP, older adults are particularly susceptible to the intersecting issues of thermal comfort, health, and safety.[33] Our findings do, however, expand on prior research linking power outages to electric medical devices and socioeconomic disparities,[34] indicating the need for enhanced safeguards, such as bill assistance and resilient power access.[35]

ENERGY INSECURITY, HOUSING, AND HEALTH

Energy insecurity and its linked health risks are known to be exacerbated by poor-quality housing, marked by inefficiencies, outages due to faulty systems, and high prevalence of asthma triggers such as indoor air pollution and mold.[1,15] In this study, as in previous research,[3,6] a consistent pattern of unequal sociodemographic distribution of energy insecurity indicators emerges, with low-income, Black non-Latino/a, and Latino/a residents disproportionately affected. The implications of these disparities are relevant from a health equity perspective, given that the burden of disease inequitably falls on many of the same populations.[36]

Historic redlining policies and widespread disinvestment in urban centers, along with other strategies to maintain wealth and health disparities across generations, have effectively created concentrations of poverty, poor health, and inadequate housing in specific areas.[36–40] Racial segregation along with financial, language, and education barriers are often associated with poorly maintained housing, especially in rental properties, so the resultant higher risks of energy insecurity observed in these communities is, unfortunately, unsurprising.[41]

Energy insecurity in New York City is distinctive, given that many residents live in large, multiunit buildings where heating is not controlled by the occupants. Many residents also do not pay for heat directly, and although housing ordinances require landlords to provide heat for renters during the winter,[42] heating may remain unsatisfactory. Cold apartments may force residents to find alternatives such as using a stove or oven for heat, as 21 percent of participants in our study did. Heating of buildings may also be excessive, making apartments stiflingly hot; therefore, survey responses may reflect exposure to this form of extreme heat. In contrast, residents (regardless of owner or renter status) largely control the use and cost of air conditioning and other methods of cooling, which we saw reflected in the higher prevalence of forgoing cooling (versus forgoing heating) because of cost.

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THE USE OF ENERGY INSECURITY INDICATORS TO INFORM POLICY Indicators that document residents' lived experience of indoor temperatures that are too hot or too cold are important in understanding energy insecurity and can draw attention to issues that are modifiable through policy. For example, our survey indicates that nearly 9 percent of New York City residents lacked air conditioning (data not shown), and among those with air conditioning, 14 percent reduced its use during hot weather (using it about half the time or less during very hot weather), most often because of cost. The underuse of cooling devices because of costs has been found in another recent New York City–based study,[43] as well as in Arizona.[44] Enduring extreme indoor heat to save on energy costs poses preventable health risks that will increase with climate change, as air conditioner use can be a matter of life and death.[7] Equipping housing units with cooling options and subsidizing cooling costs during hot weather are policy interventions that can be implemented even on small scales.

The use of an expanded set of energy insecurity indicators allows for identifying key mechanisms of this phenomenon, as well as documenting both positive impacts and unintended consequences of policy and programmatic interventions. As New York City works to institute residential cooling regulations by 2030,[45] measuring energy insecurity indicators related to extreme heat and cost barriers to cooling can support the design and evaluation of related policies. For example, concerns regarding cost shifting onto low-income populations were previously identified by the New York City government with the implementation of residential building electrification policies, such as the 2019 Local Law 97,[46] which sets carbon emission standards and enforcement timelines for large buildings. Routine energy insecurity surveillance can help determine whether cooling access policies result in the unintended consequence of cost shifting onto residents who cannot afford them, thereby exacerbating energy insecurity.

ACADEMIC-GOVERNMENT PARTNERSHIPS Our academic-government collaboration was an outgrowth of efforts to advance the New York City Department of Health and Mental Hygiene's ongoing work to prevent negative health impacts from heat. The partners initially developed an evaluation of a citywide air conditioner distribution program, which indicated that energy costs were a major barrier to cooling at home.[43] The partners wanted to better understand the citywide burden of energy insecurity and how it manifests in New York City to support the implementation and evaluation of major climate policies.

The current, joint endeavor demonstrates the potential of health departments to support energy insecurity measurement.

The current, joint endeavor demonstrates the potential of health departments to support energy insecurity measurement and the value of academic-government partnerships in informing policy development and tracking impacts. Researchers at academic institutions can conduct exploratory and complementary research, working in concert with public health agencies to share approaches, leverage available data and established data collection mechanisms, and develop instruments and targeted metrics.

In recent years, municipal health departments have promoted air conditioning as life-sustaining medical equipment for high-risk populations,[7] measured heat vulnerability,[47–49] estimated air conditioning and cooling access at the population scale,[50] and evaluated the impact of cooling interventions,[43] in some cases with academic partners. Regular energy insecurity surveillance can be implemented more widely by leveraging public health infrastructure at the local, state, and federal levels in partnership with academic institutions to assess policy efforts.[5] For instance, surveillance is imperative to understanding the health impacts of residential cooling in response to climate change and other energy-related policies such as the Inflation Reduction Act of 2022.

FUTURE DIRECTIONS We aimed to demonstrate the use of a broad set of energy insecurity indicators that reflects both qualitative and quantitative emerging evidence on this complex phenomenon. The ten-indicator energy insecurity instrument, although useful as a basis for surveys in other populations, might not be fully applicable to the lived experience of energy insecurity across contexts. Differences in infrastructure, resources, and responses are to be expected across geographic locations, genera-

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tions, and individuals (for example, the definitions of "uncomfortably hot" and "extremely cold" likely vary depending on local climate and individual traits).[51]

We selected these ten indicators to describe energy insecurity in a large, highly diverse city across a range of dimensions, not to develop a universally applicable energy insecurity instrument. The individual indicators are not weighted, so although having multiple indicators likely indicates a higher risk for energy insecurity–related consequences, each indicator might not be equally impactful. The development and validation of other locally appropriate sets of energy insecurity indicators can build on our findings, considering which indicators and in what combination would be suitable for various modalities (that is, surveys, clinical screens). For example, energy insecurity indicators related to power outages and fuel shortages may be important in some settings, although less relevant in New York City. Ultimately, an instrument that assesses the level of severity based on thresholds, weights, or specific combinations of energy insecurity indicators could be developed and validated across contexts, so that community-specific expressions of energy insecurity are adequately and consistently captured.

Conclusion

As the policy community responds to climate change and the clean energy transition, our study demonstrates that broadening the understanding of energy insecurity with context-specific metrics can help guide interventions and policies that address disparities relevant to health and energy equity. ■

The New York City Health Panel is supported by multiple grants from the Centers for Disease Control and Prevention (CDC), including Epidemiology and Laboratory Capacity for Prevention and Control of Emerging Infectious Diseases Supplemental Covid-19 Cares, Epidemiology and Laboratory Capacity for Prevention and Control of Emerging Infectious Diseases Supplemental Covid-19 PPPHCE, ELC COVID Enhancing Detection Expansion Supplemental, Immunization & VFC COVID-3 Cycle Vaccination Supplemental, CDC COVID-19 Crisis Response Workforce Supplemental, and CDC Public Health Infrastructure. This research was supported by the Alfred P. Sloan Foundation; the JPB Foundation; the Robert Wood Johnson Foundation; and the National Institute of Environmental Health Sciences, National Institutes of Health, through Grant No. 5P30ES009089-18 (Andrea Baccarelli, principal investigator). The authors thank the NYC Health Panel participants and the Division of Epidemiology at the New York City Department of Health and Mental Hygiene for making this work possible. This is an open access article distributed in accordance with the terms of the Creative Commons Attribution (CC BY-NC-ND 4.0) license, which permits others to distribute this work provided the original work is properly cited, not altered, and not used for commercial purposes. See https://creativecommons.org/licenses/by-nc-nd/4.0/. To access the authors' disclosures, click on the Details tab of the article online.

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