High risk, low concern: The climate perception gap in rural America

Gregory D. Kearney[1*], Satomi Imai[2], Katherine Jones[2], Lok Pokhrel[1], Xiangming Fang[1]

[1]East Carolina University, Brody School of Medicine, Department of Public Health, 600 Moye Blvd., Greenville, North Carolina, USA

[2]East Carolina University, Brody School of Medicine, Center for Health Disparities, East Carolina Heart Institute, Greenville, North Carolina, USA

*Corresponding author
Email: Kearneyg@ecu.edu

These authors contributed equally to this work.

Funding to facilitate the community health needs assessment project was provided by Eastern Area Health Center and the Foundation for Health Leadership and Innovation. There was no funding provided for the creation of this manuscript, and the views and opinions expressed are those of the authors.

Disclosures: The authors have nothing to disclose.

Abstract

Rural communities often demonstrate lower levels of concern and reduced support for climate mitigation and policies. This study examined views of climate risk and political support for climate action in Eastern North Carolina, a largely rural and agricultural region, with limited access to health care, and elevated environmental vulnerability. Understanding climate attitudes in this context is essential for developing effective and equitable engagement strategies. A Community Health Needs Assessment was administered across 36 counties that included climate risk and political support questions. Responses from 15,962 participants were analyzed and compared to modeled state and national estimates. Statistical analyses, including descriptive comparisons and multivariable regression models, were used to assess differences by sex, race, income, education, rurality, and county-level economic status. Findings revealed that rural participants were significantly less likely to express concern about climate risks, perceive imminent personal or community harm, or support increased local government action compared to national benchmarks. Higher concern was associated with female gender, non-White racial identity, and greater educational attainment. Even though many of the rural and economically distressed counties had experienced significant hurricanes and severe weather events, they reported lower perceived risk and political support. Notably, a high proportion of participants expressed uncertainty about the impacts of climate change and the role of local leaders in addressing them. These results reflect a broader "rural paradox," where high exposure to environmental threats does not always translate into high perceived risk or engagement. The study underscores the importance of place-based strategies that consider local values, resources, and vulnerabilities. Embedding climate questions within public health surveys provides a scalable method for capturing community-specific insights and informing policies that advance climate resilience, public awareness, and equitable adaptation in underserved areas.

Keywords: community engagement, mitigation, adaptation, inequality, susceptibility

Introduction

Rural areas are increasingly vulnerable to the adverse effects of climate change, facing extreme weather events than not only threaten agriculture livelihood and natural resources, but also intensifies existing socio-vulnerabilities and health disparities.[1-3] Limited economic diversity, and inadequate infrastructure in rural areas amplify these issues, highlighting environmental justice and equity concerns.[2] These factors emphasize the importance of involving rural leadership in policy making to ensure their needs and adaptive capacity are addressed effectively.

Despite positive findings from the growing body of research on the public's perception of climate change, relatively few published studies in the U.S. have focused on perspectives from rural and vulnerable communities U.S.[3,4] This gap is highlighted by initiatives such as the University of Idaho-led project, which aims to investigate how rural communities perceive climate change and adapt to its impacts, acknowledging the lack of data on these populations.[5] In 2023, approximately 74% of Americans believed that global warming is happening, while 44% reported having personally already experienced its effects.[6] This upward trend reflects heightened concern over climate change, with many Americans recognizing it as a pressing issue that affects their lives and communities. In light of increasing awareness, a little more than half (56%) of those polled thought local officials should do more to address global warming.[6] In a separate poll conducted by the Pew Research Center, a marginal decline in public participation in climate activism, with only 21% of U.S. adults engaging in climate-related activities in the past year, down from 24% two years prior.[7]

National opinion polls are highly useful, and often rely on modeling sample data for filling data gaps in large areas or where direct polling is scarce.[8] However, this approach can be

challenging when achieving a representative sample and addressing limitations, such as biases and other factors.[8,9] Local-level surveys with broad representation provides opportunities to gain deeper insight into local variations and patterns that may be overlooked by modeled data. Results from these surveys can inform targeted communication strategies that effectively resonate with local communities.[8,9]

Southeastern United States

While climate change is a global phenomenon, its impacts and effects vary regionally.[10] Climate scientists report that the southeastern United States will experience disproportionately harmful effects of climate-related challenges compared to other regions in the country.[10-12] Factors that contribute to the region's high vulnerability include its topography comprised of extensive coastal boundaries along the Atlantic and Gulf coasts, and low-lying areas that elevate climate risks from sea level rise, hurricanes, and coastal flooding. Other vulnerable risk factors include significant socioeconomic and health disparities among rural and marginalized groups living in extreme poverty, lack of access to health services and care.[10,11,13,14] Rising temperatures and frequent heat waves compound these effects and further increase the risk of heat-related illnesses, injuries, and fatalities.[15,16]

Eastern North Carolina

Eastern North Carolina (ENC) represents an ideal example of the southeastern U.S. for assessing views and opinions of climate change among rural, vulnerable communities. The eastern coastal plain region is characterized by its vast rural landscape of farmlands and forested areas encompassing approximately 11 million acres.[17] An extensive network of rivers, estuaries, and natural water bodies are integrated throughout much of the eastern and northeastern areas. These features and the near sea-level topography and coastal boarder extending into the Atlantic Ocean, make it highly susceptible to natural climate threats. Over the past 50 years alone, the

region has experienced considerable severe weather events including multiple hurricanes, sea level rise, storm surges, flooding, drought, and ecosystem and agricultural changes, thereby increasing public health risks.[18-21] Although many of these events are already occurring, climate scientists predict that with increasing global temperatures many of these natural events will occur more frequently and will be more intense.[11-13,22]

In stark contrast with affluent, populous towns with core industry, and wealthy, retirement communities dotted along the coast, many ENC rural counties grapple with deep-rooted challenges. These areas, comprised of historically marginalized communities, struggle with entrenched inter-generational poverty, pronounced health disparities, substandard housing and limited access to healthcare and services.[1,23] As global temperatures rise, the convergence of direct and indirect impacts of climate change, intertwined with existing socio-vulnerabilities intensifies threats to public health in these vulnerable rural communities.[1,18,23,24] This escalation exacerbates the strain on healthcare systems and higher costs for maintaining infrastructure.[1,12,14]

The goal of this study was to gain a better understanding of local perceptions and factors influencing climate-related harm and support for political action in eastern North Carolina. Our research interest was aligned with the mission of our medical school (Brody School of Medicine) and partnering hospital (ECU Health), for improving the health and well-being of underserved communities in rural ENC. The findings of this study offer valuable insight that can benefit healthcare providers, educators, public health professionals, and policymakers in preparing mitigation and adaptation strategies across the rural region, ultimately enhancing the resilience and health outcomes of these communities in the face of climate-related challenges.

METHODS

Data Collection, Participants and Recruitment

Data for this project was collected as part of a regional community health needs assessment survey (CHNA) conducted from May 1 through December 24, 2021. Federal laws under the Patient Protection and Affordable Care Act (ACA) and the Internal Revenue Code, require charitable and not-for-profit hospitals to conduct a CHNA every three years. The primary purpose of this assessment is for hospitals to evaluate and prioritize the health needs of their communities they serve.[25] This process necessitates collaboration with key community health stakeholders, including local health departments, and involves collecting and analyzing data from community surveys, focus groups, and secondary sources.

To ensure reliability and representativeness, counties with completed surveys of fifteen or less participants were removed. Surveys were made widely available using both digital (online) and traditional (paper-based) formats. Participant recruitment was conducted primarily by county health departments and community health groups through various advertising and promotional campaigns, including community health fairs, television and radio broadcasts, social media, and public venues. All survey data was stored in a Redcap database. There was no personal identifiable information collected from surveys, nor did the investigators interact with any survey participants. Because this study did not involve collection of personally identifiable information, or contact with human subjects, informed consent was not required and was considered "exempt" by East Carolina University Institutional Review Board (UMCIRB #21-000515, March 22, 2021).

Survey Tool

The overall structure and content of the survey were developed by representative members of the Health ENC Steering Committee. The survey encompassed a series of 23 general health and well-being questions. At the request of the researchers, an "optional module" was included at the end of the CHNA survey that included a series of validated climate change

opinion questions, adapted (with permission) from a nationally representative survey, *Climate Change in the American Mind* (conducted by the Yale Program on Climate Change Communication and the George Mason University Center for Climate Change Communication, national survey (2021; https://climatecommunication.yale.edu/visualizations-data/ycom-us/).[26] The survey design and methodology has been fully described previously and can be found elsewhere.[8]

Measures

To gain insight on ENC's perception of climate change for this project, we focused on two subscales, 1) perceived risks (i.e., worry, present and future harm), and political support (should local officials be doing to address global warming). To maintain consistency when comparing ENC survey results with the Yale modeled estimates, we kept the original wording of the parent survey questions. The response measures included, yes or no and Likert-type scale responses (i.e., 1=strongly disagree to 5 strongly agree; 1=Great amount to 5=Not at all).

Socio-demographics Indicators

Participant socio-demographic questions included gender (male, female, or other/prefer not to answer), age group (18-24 years, 25-34, 35-44, 45-54, 55-64, over 65), race (White, Black, Other, Prefer not to answer), ethnicity (Hispanic or non-Hispanic), educational level (HSD: includes less than high school diploma, +HSD: Associate's degree or vocational training, some college, Bachelor's degree, graduate or professional degrees), income (<$50,000, or ≥$50,000), occupation category (e.g., healthcare, government, education, etc..,), and Wi-fi access (yes/no).

Economic Disparities and Environmental Vulnerability Indicators

County-level classifications established by N.C. state agencies and organizations were used as proxy measures to assess community economic disparities and environmental vulnerability. For economic measures, the N.C. Department of Commerce (NC DOC), Tier

Classification System (2021) system stratifies NC's 100 counties into three distinct Tier levels (I, II, and III) based on average unemployment rate, median household income, population growth rate, and the adjusted property tax base per capita.[27] Counties designated as Tier 1, are considered the most economically distressed, while Tier 2 counties are moderately economically challenged. Tier 3 counties exhibit the strongest level of economic activity.

Environmental vulnerability measures were assessed using N.C.'s Coastal Area Management Act (CAMA) designations. Under CAMA, there are 20 counties are designated based on their risk of natural hazards such as erosion, flooding or determining whether the area possesses environmental, social, or economic values.[28]

Rural and Urban Classifications

Rural and urban classifications were determined using the U.S. Office of Management and Budget's (OMB) **Core Based Statistical Areas (CBSA)** framework. This system is widely used by federal agencies to classify counties and facilitate the collection and analysis of demographic, economic, and health-related data.[29]

Under the CBSA classification, counties are designated as metropolitan, micropolitan, or non-core based on population size and commuting patterns. Metropolitan areas consist of a central urban area with a population of 50,000 or more, along with surrounding counties that are socioeconomically integrated through commuting ties. Micropolitan areas include urban clusters with populations between 10,000 and 49,999 and their adjacent, economically linked counties. Counties not included in either metropolitan or micropolitan areas are classified as non-core and are considered the most rural, lacking significant urban centers or strong commuting connections to larger population hubs.[29]

These classifications serve as proxies for population access to essential services, including health care, transportation, education, and other primary resources. They also provide a consistent framework for comparing socio-geographic characteristics across diverse county types within the study region. The distribution of rural, micropolitan, and metropolitan counties included in the study area is presented in Figure 1, which depicts the urban–rural classification of counties in Eastern North Carolina.

Data Analysis

An unweighted participation rate was calculated by dividing the number of completed surveys in participating counties by the total number of attempted and completed surveys in those counties. To facilitate a more accurate comparison between the survey and modeled data, mean adjusted percentages for combined counties in ENC were calculated proportionally to the total population of each county. One sample t-tests were then employed to assess differences between the survey results and modeled percentages at the combined counties, state and national levels.

Likert scale categorical responses were grouped for analysis. For the question “How worried are you about global warming?" we grouped the responses into "Worried" (combining "Very" and "Somewhat worried") and "Not worried" (combining "Not very" and "Not at all worried"). For the question "How much do you think global warming will harm you personally?" responses were categorized into "Great/Moderate amount," "Little/Not at all," and "Don't know." Lastly, for the question, "When do you think global warming will start to harm people in the United States?" we dichotomized responses into "Now/in 10 years" and "25+ years/50 years/100 years/Never.”

Response percentages for socio-demographic, economic, urbanity and environmental indicators were analyzed using Chi-square tests. Logistic regression models were used to

compute adjusted odds ratios (AOR) and 95% confidence intervals (CIs) to assess the associations, controlling for age, sex, race/ethnicity, education, and income as socio-demographic variables. Respondents who preferred not to disclose information regarding sex and race/ethnicity were excluded in regression analyses, accounting for 4.6% and 7.0% of the total valid responses, respectively. Univariate and bivariate analyses were conducted using SAS statistical software (v.9.4). Statistical significance was set at an alpha level of 0.05.

RESULTS

Among 16,661 individuals who initiated the survey, 16,135 were completed in entirety, resulting in an overall completion rate of 96.8% (Figure 2). After excluding counties with fifteen or fewer completed surveys, the analysis included 15,961 responses and 36 counties (Beaufort, Bertie, Bladen, Camden, Carteret, Chowan, Craven, Cumberland, Currituck, Dare, Duplin, Edgecombe, Gates, Greene, Halifax, Harnett, Hertford, Hoke, Hyde, Johnston, Jones, Lenoir, Martin, Nash, Northampton, Onslow, Pamlico, Pasquotank, Perquimans, Pitt, Robeson, Sampson, Tyrrell, Washington, Wayne, Wilson).

As shown in **Table 1,** socio-demographics of participants were predominantly female (72.5%), between 55-64 years old (24.6%), and non-Hispanic White (61.3%). A smaller proportion identified as Non-Hispanic Black (26.3%), other racial categories (7.4%), and Hispanic ethnicity (3.3%). Educational attainment was relatively high, with 80.3% having more than a high school education. Over 57.0% percent reported annual earnings of $50,000 or more. Among the top three occupations were healthcare (27.9%), followed by government and education sectors, each accounting for nearly equal at approximately 15% of the participants. Nearly all respondents (96.0%) reported having access to Wi-Fi or the internet.

Over one-half of the participants (53.4%) represented the most economically distressed (Tier 1) counties, followed by Tier 2 (34.9%) and Tier 3 (11.6%) counties. The geographic distribution showed a slight urban predominance, with 53.4% of respondents residing in urban areas and 46.6% in rural areas. Additionally, respondents were fewer in non-core (22.0%), compared to micro (27.0%), and metro (51.0%) counties.

Table 1. Socio-Demographic, Economic, Geographical and Urbanicity Characteristics of Survey Participants: ENC Region (n=15,961))

Characteristics	n	(%)
Total	15961	100
Gender		
Male	3937	25,3
Female	11297	72.5
Other (no-binary, not listed, prefer not to answer)	352	2.3
Age Group*		
<=24 years	803	5.2
25-34	1891	12.1
35-44	2946	18.9
45-54	3312	21.3
55-64	3838	24.6
Over 65	2791	17.9
Race/Ethnicity		
White	9557	61.3
Black	4096	26.3
Other	1183	7.5
Prefer not to answer	750	4.8
Ethnicity		
Hispanic	512	3.3
Education Attainment		
HSD (includes less HSD)	3046	19.7

+HSD	12390	80.3
Income (Avg Median NC)		
<$50,000	6178	42.5
>=$50,000	8352	57.5
Occupation (Top 3)		
Healthcare	4069	27.9
Government	2257	15.5
Education	2248	15.4
Wi-fi (% Yes)	14808	96.0
Economic County Indicator		
Tier 1 (most economically distressed)	8528	53.4
Tier 2	5575	34.9
Tier 3 (least economically distressed)	1858	11.6
Geographic County Indicator		
Rural	7442	46.6
Urban	8519	53.4
Urbanicity Indicator		
Non-core (least urbanized)	3508	22.0
Micro (small urban center)	4311	27.0
Metro (most urbanized)	8142	51.0

Notes: Missing responses were not included. Wi-fi includes dial up, broadband, cellular; excludes prefer not to answer, unreliable, poor internet connections.

284

Table 2. Public Perception of Perceived Risk and Political Support of Global Warming, by Geography (n=15,96

Climate Categories and Survey Questions	ENC Region	Combin ENC Counti
		Percent (%)
Perceived Harm		
How worried are you about global warming?		
Worried (very, somewhat)	54.2	62.4
Not worried (not very, not at all)	45.8	37.6
How much do you think global warming will harm you personally?		
Great/moderate amount	50.2	46.0
Little/Not at all	32.6	43.2
Don't know	17.2	10.8
When do you think, global warming will start to harm people in the United States?		
Now/in 10 years	51.8	58.1
25+ years/50 years/100 years/Never	48.2	41.9
Political Support		
Do you think your local officials (government and politicians in your county) should be doing more or less to address global warming?		
More	55.1	59.7
Less	13.0	16.2
Don't know/not sure	31.9	24.05

Notes: Percentage are average estimates; ENC Region percent survey results (n=15,961); Combined ENC count percents are modeled estimates for 2021 generated using MRP model, as described by Howe et al. (2015). All results were statistically significant ($p < 0.001$).

Perceptions, Beliefs and Attitudes of Risk and Political Support

As shown in **Table 2**, the ENC multi-county region was significantly less "worried" (54.2%) about global warming compared to the modeled data at combined county, state, and national levels (62.4%, 64.0%, and 65.2%, respectively). When asked about global warming and personal harm, the ENC region reported a considerably higher percent (50.2%) of "concern" compared to modeled data of combined counties (46.0%), state (45.8%), and national (46.8%) levels ($p<.001$). Over 17.0% of respondents in ENC were "uncertain" about personal harm of global warming ("don't know"), significantly higher than percent of uncertainty reported in modeled data at all geographic levels ($p<0.001$).

Almost 52.0% of ENC respondents believed harm will start "now" or within the next 10 years, which was lower compared to the modeled data of perception of combined counties (58.1%), state (58.7%), and national levels (59.2%). Also, ENC respondents were more likely ($p<0.001$) to believe (48.2%) global warming would harm people in the U.S. in the distant future (25+/50+ years or never) compared to modelled results of combined counties (41.9%), N.C. (41.3%) and the U.S. (40.4%).

When asked whether local government and politicians should be doing more or less to address global warming, over 55.0 percent of the survey respondents felt that "more" should be done, which was significantly lower ($p<0.001$) compared to modeled results of combined counties (59.7%), N.C. (59.4%), and the U.S. (58.8%). A total of 13.0% of ENC participants reported that they felt their government and politicians in their county should do less to address global warming, much lower than modeled combined counties, N.C. and national percentages ($p<0.001$). For the same question, higher levels of "uncertainty" were found among ENC respondents with 31.9% reporting being unsure or "don't know" if more or less should be done,

significantly higher than the uncertainty levels at the county (24.1%), state (24.7%), and national (24.9%) modeled estimated levels ($p<0.001$).

Table 3. Socio-Economic and Geographic Characteristics Among ENC Survey Participant (n-15,961

Characteristic	n (%)	Adjusted OR (95% CI)	p-value
Gender			
Male	1321 (43.5)	1.00	
Female	5388 (53.4)	1.41 (1.30-1.54)	<0.001
Age Group			
<24 years	404 (62.4)	1.63 (1.33-2.01)	<0.001
25-34	894 (56.4))	1.08 (0.94-1.24)	0.272
35-44	1338 (52.6)	0.94 (0.83-1.06)	0.309
45-54	1327 (46.1)	0.76 (0.67-0.85)	<0.001
55-64	1656 (49.2)	0.89 (0.79-1.00)	<0.049
Over 65	1213 (50.4)	1.00	
Race/Ethnicity			
White	4060 (47.2)	1.00	
Black	1878 (57.7)	1.61 (1.47-1.76)	<0.001
Other	596 (64.1)	1.96 (1.68-2.28)	<0.001
Education			
HSD *include less HSD	1035 (44.8)	1.00	
+HSD	5753 (52.2)	1.61 (1.44-1.79)	<0.001
Income (Avg Median NC)			
< $50,000	2730 (53.5)	1.00	
>=$50,000	3770 (49.9)	0.94 (0.88-1.04)	0.261
Occupation (3 most frequently listed)			
Healthcare	1793 (48.2)	1.00	
Government	983 (49.2)	1.11 (0.99-1.25)	0.075
Education	1105 (55.3)	1.38 (1.23-1.55)	<0.001
Wi-fi/internet			
Yes	6592 (51.0)	1.06 (0.85-1.31)	0.628
No	218 (47.1)	1.00	
Economic Indicator (2022)			
Tier 1	3500 (50.0)	1.00	
Tier 2	2573 (52.4)	1.18 (1.09-1.28)	<0.001
Tier 3	822 (50.4)	1.18 (1.04-1.33)	0.008
Rural/Urban			
Rural	2994 (49.3)	1.00	
Urban	3901 (52.2)	1.10 (1.02-1.18)	0.0154
Urbanicity Indicator			
Non-core	1211 (46.1)	1.00	
Micro	1943 (51.2)	1.30 (1.17-1.45)	<0.0001
Metro	3741 (52.6)	1.32 (1.19-1.45)	<0.0001
Environmental Indicator			
CAMA	3061 (50.2)	1.02 (0.95-1.10)	0.6025
Non-CAMA	3834 (51.5)	1.00	

Note: Respondents who answered “Greatly” or “Moderate amount” to “How much do you think global warming will harm you personally?”

In chi-square analysis (**Table 3**), ENC socio-demographic, economic, urbanicity, and environmental factors were examined in relation to perceptions of being "greatly" or "moderately" to harm" from global warming. Females (53.4%) were significantly ($p<0.001$) more likely to believe that global warming would "harm them personally" compared to males (43.5%). Younger respondents, especially those under 24 years old, were the most concerned (62.4%), while middle-aged groups exhibited lowest concern (46.1%).

A majority of Black respondents (57.7%) and other racial backgrounds (64.1%) felt they would be personally harmed by global warming, compared to 47.2% of White respondents. Individuals with higher educational attainment were more likely to believe personal harm of global warming (53.5%) compared to those with a high school diploma and less (49.9%). Income levels showed a significant impact on perceptions of personal harm from global warming; higher proportion of those with lower-income (<$50,000) perceived personal harm than those with higher-income (≥$50,000), (53.53% vs. 49.9%, $p<.001$). However, when other demographic variables were controlled, there was no effect of income (AOR 0.94, $p=0.2614$).

Respondents in the educational sector (55.3%) were more likely to feel personally harmed compared to those in healthcare (48.2%) and government roles (49.2%). Regarding access to Wi-Fi or the internet, the difference between those with Wi-fi/Internet (51.0%) and those without access (47.1%) was only marginally significant ($p=0.095$); however, when other demographic variables were controlled, the difference was not statistically significant (AOR, 1.06; $p=0.6283$). ENC residents of more economically advantaged counties (Tier 2 and Tier 3) were more likely to perceive personal harm from global warming than those in Tier 1 (most distressed) counties when demographic variables were controlled for in AORs. The AORs for residents of Tier 2 and Tier 3 counties are both 1.18, indicating a higher likelihood of feeling

362 threatened by global warming compared to those in Tier 1 ($p<0.001$ for Tier 2 and $p=0.008$ for
363 Tier 3).
364
365

366

367

Table 4. Economic, Urbanicity, Environmental Indicators and Percent Reporting Global Warming and Harm to People "Now" or "In 10 years" Among ENC Survey Participant (n-15,961)

Characteristic	n (%)	Adjusted OR (95% CIs)	p-value
Economic Indicator (2022)			
Tier 1	3471 (51.5)	1.00	
Tier 2	2527 (53.1)	1.22 (1.12-1.32	<0.001
Tier 3	770 (49.2)	1.14 (1.01-1.29)	0.0348
Urbanicity Indicator			
Non-core	1217 (48.0)	1.00	
Micro	1925 (52.6)	1.30 (1.16-1.45)	<0.001
Metro	3626 (52.7)	1.25 (1.13-1.39)	<0.001
Environmental Indicator			
Non-CAMA	3741 (52.1)	1.00	
CAMA	3027 (51.3)	1.10 (1.02-1.19)	0.0194

368 Respondents from different economic tiers had varying levels of concern about the immediacy of harm from global warming

Table 5. Economic, Urbanicity, Environmental Indicators and Percent Reporting "More" Should be Done by Local Government and Politicians to Address Global Warming Among ENC Survey Participant (n-15,961)

Characteristic	n (%)	Adjusted OR (95% CIs)	p-value
Economic Indicator			
Tier 1	3642 (52.4)	1.00	
Tier 2	2691 (55.2)	1.29 (1.19-1.40)	<0.001
Tier 3	836 (51.4)	1.19 (1.06-1.34)	0.0047
Urbanicity Indicator			
Non-core	1235 (47.4)	1.00	
Micro	2035 (53.8)	1.40 (1.25-1.56)	<0.001
Metro	3899 (55.1)	1.38 (1.25-1.52)	<0.001
Environmental Indicator			
CAMA	3174 (52.3)	1.06 (0.98-1.14)	0.169
Non-CAMA	3995 (54.1)	1.00	

369

(**Table 4**). Responses in Tier 2 counties, which were "moderately distressed" were more likely (53.1%) to believe that global warming will start to harm people "now" or "within the next 10 years." The adjusted odds ratio (AOR) for this group indicated they were 22% more likely to perceive an imminent threat compared to those from the most economically distressed Tier 1 counties ($p<0.001$). Similarly, respondents from Tier 3 (most economically advantaged) counties also showed heightened concern, with an AOR of 1.14, or 14% more likely than Tier 1 residents to perceive global warming as an immediate threat ($p=0.0348$).

Perceptions among those living in micro counties (small urban centers) and metro counties (most urbanized) were more likely to believe in the near-term harm of global warming compared to those in noncore (least urbanized) counties ($p<0.001$). Respondents in Coastal Area Management Act (CAMA) counties, which are more directly affected by coastal and environmental regulations, were slightly more likely to perceive an immediate threat from global warming than those from non-CAMA counties with an AOR of 1.10, indicating a 10% higher likelihood of believing that global warming will soon start to cause harm ($p=0.0194$).

Although Tier 1 had a higher percentage (52.4%) than Tier 3 (51.4%), in chi-square analysis, the AORs for Tier 2 and Tier 3 counties were significantly higher ($p<0.001$ and $p=0.0047$, respectively) than Tier 1 counties when demographic variables were adjusted, indicating respondents in Tier 2 and Tier 3 were more likely to belief that more should be done to support increased action on global warming than those in Tier 1 (**Table 5**).

Respondents from micro and metro areas showed the highest percent of increased action by local officials (55.1% and 53.8%, respectively), when compared to those in non-core counties (47.37%) ($p<.001$).

Coastal Area Management Act (CAMA) counties indicated a 52.3% support rate for more action, compared to 54.1% from non-CAMA counties, which was significant ($p<.05$). However, when adjusting demographic variables, the AOR of 1.06 for CAMA counties over non-CAMA counties ($p=0.169$) showed no significant difference in supporting more action by local officials.

DISCUSSION

This study provides an increased understanding of the perspectives of rural and climate-vulnerable communities in eastern North Carolina. To our knowledge, this is the largest climate change opinion survey ever conducted in the state, addressing a critical research gap by uniquely capturing local perspectives in the context of a community health assessment. Our approach to include climate questions in the CHNA survey not only enriches our understanding of eastern N.C. regional attitudes, but provides insight that can assist community health organizations, health care providers, climate scientists, public health preparedness, and policymakers with planning and decision-making processes. These findings not only underscore the importance of including rural voices into the broader discourse on climate change to ensure that solutions are inclusive and responsive to the needs of the communities.[30]

Overall, findings of ENC's lower percentage of harm and less political support were not surprising and correspond with the available literature. Rural Americans often exhibit traits such as independence, self-reliance, resilience, and adaptability, stemming from their close connection with the environment, and experience dealing with weather variability.[3,31,32] The observation that ENC were less likely to support political action on climate change corresponds with their lower perceived risk at consistent with the literature. Factors including political affiliations, lack of awareness, and skepticism towards government intervention have been cited.[4,33] Climate change remains a highly polarized issue, especially in rural areas, where lower perceptions of

risk correlate with reduced climate activism and support for policy measures.[34,35] The polarization often reflects more conservative views and skepticism towards government actions. Interestingly, a study by Pechar and associates found high-level support on climate policy among rural Midwesterners voters (2020).[36] However, it was noted that the questions did not use "climate change" labeling, but instead focused on direct environmental concerns.[36] This subtle, yet important point highlights the significance of choice of wording and how individuals may conceptualize and prioritize environmental issues. This is important for effectively communicating with different audiences to resonate with people's experiences and perceptions.

Our findings that wealthier counties (Tier 2 and Tier 3) were more likely to perceive the imminent risks of global warming and support local government actions align with existing research. Wealthier individuals often have greater access to resources and means to influence climate policy.[8,37] This trend is consistent with other studies that suggest higher socioeconomic status (SES) provides access to better resources and information, likely facilitating a deeper understanding of and concern for climate issues.[37-39] In contrast, economically rural, vulnerable counties (Tier 1) exhibited lower levels of concern and less support for climate policies. This discrepancy suggests barriers such as lower educational attainment, lower SES, and limited access to information play significant roles.[14,40] This finding underscores the importance of incorporating climate equity into policy to ensure that all communities have the necessary resources and support to address climate-related challenges.

Groups expressing greater concerns about climate risk included females, as well as younger, racial/ethnic minorities and elderly individuals. This pattern is consistent with broader research, indicating that younger people, in particular, tend to have stronger emotional engagement with climate change, while the elderly may express concern for their grandchildren

and future generations.[39,41,42] These groups are often more engaged due to greater exposure to climate change education and more environmentally active social roles.[42]

Racial and ethnic disparities were also evident, with Black and other non-White groups perceiving a higher personal harm than White respondents. This likely reflects broader socio-economic vulnerabilities and a long history of marginalization, which exacerbate both the perceived and real impacts of climate change on these communities.[12,43] This finding underscores the importance of framing climate policies that address and integrate climate equity issues, ensuring that the voices of people of color in rural and underserved areas are heard and actively supported through policy measures.[44]

The influence of urbanicity on climate perceptions was notable, with respondents in urban (metropolitan and micropolitan) counties showing more concern and support for governmental action compared to those in rural, noncore areas. This aligns with the broader literature, offering that cities tend to face higher temperatures (e.g., urban heat island effect), flooding, air pollution, and heat waves, and health events, exacerbated by dense populations, built environment and infrastructure.[10]. Cities tend to have higher educational attainment, often serve as hubs for climate activism and environmental movements, contributing to higher levels of climate change awareness and concern among urban dwellers.[45,46] While not the focus of this study, political party affiliations and the rural-urban political divide cannot be ignored as an influencing factor.[7,33] Proximity to coastal areas (CAMA counties) only modestly influenced perceptions, with economic and urban factors playing more significant roles in shaping awareness and responses to climate risks.[31]

Limitations

While this study provides valuable insights, several limitations should be considered when interpreting the findings. Firstly, the study primarily focused on assessing the relationships

between survey responses and commonly defined socio-vulnerability population characteristics. However, many other factors, such as personal experiences with climate-related events, can influence an individual's views, beliefs, and perceptions of climate change. These factors were not included in this analysis. Additionally, the timing of the survey during the pandemic may have impacted various components of the survey, such as access, participation rate and responses. The use of convenience sampling and self-reported data with fixed response options introduces potential biases and limitations in depth, which may not fully capture respondents' perspectives. These challenges highlight the need for mixed method approaches to validate and deepen these findings. Future research could benefit from longitudinal designs to track shifts in perceptions over time, potentially in response to policy changes or significant climate events. Nevertheless, by incorporating climate change questions into community health needs assessment surveys, these results provide valuable insights into how socio-economic, demographic, and geographic settings impact public perceptions and policy support for climate action.

Conclusion

As climate change effects intensify, addressing socio-vulnerabilities becomes crucial for fostering resilient communities. Research highlights the importance of identifying and engaging vulnerable communities, particularly those with environmental justice concerns, to enhance resilience and adaptability to climate impacts.[47] Despite growing public concern, climate change remains a polarized topic, with rural voices often silent in the discourse. Community health surveys underscore the need to engage rural and vulnerable populations in local climate dialogues, as rural residents frequently prioritize immediate necessities over the less immediate threats posed by climate change. Integrating personal narratives into climate communication can effectively make the abstract concept of climate change more tangible and relatable, thereby

enhancing public engagement and support for climate policies.[47,48] By leveraging personal stories, we can foster a collective commitment to action, bridging the gap between awareness and tangible efforts to mitigate climate impacts.

References

1. Kearney GD. Preparing for the health impacts of a changing climate. *N C Med J*. 2020;81(5):301-306. doi:10.18043/ncm.81.5.301.

2. Atkinson CL, Atkinson AM. Impacts of climate change on rural communities: Vulnerability and adaptation in the global south. *Encyclopedia*. 2023;3(2):729. doi:10.3390/encyclopedia3020052.

3. Hales D, Hohenstein W, Bidwell MD, et al. Rural Communities. In: Melillo JM, Richmond TC, Yohe GW, eds. Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program; 2014:333-349. doi:10.7930/J01Z429C. Available from: http://nca2014.globalchange.gov/report/sectors/rural-communities

4. Bonnie R, Diamond EP, Rowe E. Understanding rural attitudes toward the environment and conservation in America. Nicholas Institute for Environmental Policy Solutions, Duke University; 2020. Available from: https://nicholasinstitute.duke.edu/publications/understanding-rural-attitudes-toward-environment-and-conservation-america. Accessed May 19, 2024.

5. Perceiving and adapting to climate change in rural America. University of Idaho News Releases. https://www.uidaho.edu/news/news-articles/news-releases/2023/080723-climatechangeperception. Updated 2023. Accessed Aug 10, 2024.

6. Leiserowitz A, Maibach E, Rosenthal S, et al. Global Warming's Six Americas, Fall 2023. Yale University and George Mason University. New Haven, CT: Yale Program on Climate Change Communication; 2023. Available from: https://climatecommunication.yale.edu/publications/global-warmings-six-americas-fall-2023/

7. Tyson A, Kennedy B. How Americans view future harms from climate change in their community and around the U.S. Pew Research Center; 2023. Available from: https://www.pewresearch.org/science/2023/10/25/views-on-future-climate-impacts-environmental-harms/. Accessed August 12, 2024.

8. Howe PD, Mildenberger M, Marlon JR, Leiserowitz A. Geographic variation in opinions on climate change at state and local scales in the USA. *Nature Climate Change*. 2015;5:596-603. doi:10.1038/nclimate2583.

9. Lauderdale BE, Bailey D, Blumenau J, Rivers D. Model-based pre-election polling for national and sub-national outcomes in the US and UK. *Int J Forecast.* 2020;36(2):399-413. doi:10.1016/j.ijforecast.2019.05.012.

10. Marvel K, Su W, Delgado R, et al. Climate trends. In: Crimmins AR, Avery CW, Easterling DR, Kunkel KE, Stewart BC, Maycock TK, eds. Fifth National Climate Assessment. U.S. Global Change Research Program; 2023. doi:10.7930/NCA5.2023.CH2. Accessed April 12, 2024.

11. Greenough G, McGeehin M, Bernard SM, Trtanj J, Riad J, Engelberg D. The potential impacts of climate variability and change on health impacts of extreme weather events in the United States. *Environ Health Perspect*. 2001;109(Suppl 2):191-198. doi:10.1289/ehp.01109s219.

12. Crimmins A, Balbus J, Gamble JL, et al. The impacts of climate change on human health in the United States: A scientific assessment. U.S. Global Change Research Program; 2016. doi:10.7930/J0R49NQX

13. Shortridge JR. An Atlas of Poverty in America: One nation, pulling apart, 1960-2003. *American Studies*. 2006;47(3/4):240-241.

14. Gamble JL, Balbus J, Berger M, et al. Populations of concern. In: The impacts of climate change on human health in the United States: A scientific assessment. U.S. Global Change Research Program; 2016:247-286. doi:10.7930/J0Q81B0T

15. World Health Organization. Climate change and human health. Updated 2015. Accessed May 7, 2016. Available from: http://www.who.int/topics/climate/en/

16. Watts N, Adger WN, Agnolucci P, et al. Health and climate change: Policy responses to protect public health. *Lancet.* 2015;386(10006):1861-1914. doi:10.1016/S0140-6736(15)60854-6.

17. North Carolina Department of Public Instruction. Geography of North Carolina. http://www.ncpublicschools.org/curriculum/socialstudies/elementary/studentsampler/20geography. Accessed November 12, 2016.

18. Patz JA, McGeehin MA, Bernard SM, et al. The potential health impacts of climate variability and change for the United States: Executive summary of the report of the health sector of the U.S. national assessment. *Environ Health Perspect*. 2000;108(4):367-376. doi:10.1289/ehp.00108367

19. Patz JA, Grabow ML, Limaye VS. When it rains, it pours: Future climate extremes and health. *Ann Glob Health*. 2014;80(4):332-344. doi:10.1016/j.aogh.2014.09.007

20. Patz JA, Engelberg D, Last J. The effects of changing weather on public health. *Annu Rev Public Health*. 2000;21:271-307. doi:10.1146/annurev.publhealth.21.1.271

21. Myers SS, Bernstein A. The coming health crisis: indirect health effects of global climate change. F1000 *Biol Rep*. 2011 Feb 1;3:3. doi: 10.3410/B3-3. PMID: 21399764; PMCID: PMC3042309.

561 22. Jensen JK. Climate change and rural communities in the U.S. Rural Policy Research
562 Institute. 2009. Available from: https://rupri.org/wp-
563 content/uploads/Climate_Change_Brief.pdf. Accessed May 19, 2023.

564 23. Devlin L, Goralnik M, Ross WG, Tart KT. Climate change and public health in North
565 Carolina: A unique state offers a unique perspective. *Environ Health Perspect*.
566 2014;122(6):146. doi:10.1289/ehp.1408542

567 24. Curriero FC, Patz JA, Rose JB, Lele S. The association between extreme precipitation and
568 waterborne disease outbreaks in the United States, 1948-1994. *Am J Public Health*.
569 2001;91(8):1194-1199. doi:10.2105/AJPH.91.8.1194

570 25. U.S. Internal Revenue Service. Requirements for 501(c)(3) hospitals under the Affordable
571 Care Act – section 501(r). Web site. Accessed Aug 10, 2024. Available from:
572 https://www.irs.gov/charities-non-profits/charitable-organizations/requirements-for-
573 501c3-hospitals-under-the-affordable-care-act-section-501r

574 26. Leiserowitz A, Maibach E, Rosenthal S, et al. Climate change in the American mind -
575 September 2021. Yale Program on Climate Change Communication; 2021. Accessed
576 April 12, 2024. Available from:
577 https://climatecommunication.yale.edu/publications/climate-change-in-the-american-
578 mind-september-2021/

579 27. North Carolina Department of Commerce. N.C. County Tier Distress Rankings. Updated
580 2023. Accessed May 19, 2023. Available from: https://www.commerce.nc.gov/grants-
581 incentives/county-distress-rankings-tiers

582 28. North Carolina Department of Environmental Quality. Coastal Area Management Act
583 (CAMA) counties. Accessed May 19, 2023. Available from:
584 https://www.deq.nc.gov/about/divisions/coastal-management/about-coastal-
585 management/cama-counties

586 29. U.S. Office of Management and Budget. 2020 standards for delineating core based statistical
587 areas. Federal Register: Daily Journal of the United States Federal Government. July 16,
588 2021. Accessed July 29, 2024. Available from:
589 https://www.federalregister.gov/documents/2021/07/16/2021-15159/2020-standards-for-
590 delineating-core-based-statistical-areas

591 30. Kotcher J, Maibach E, Montoro M, Hassol SJ. How Americans respond to information about
592 global warming's health impacts: Evidence from a national survey experiment.
593 *Geohealth*. 2018;2(9):262-275. doi:10.1029/2018GH000154

594 31. Cutter, S. L., Boruff, B., & Shirley, W. L. (2003). Social vulnerability to environmental
595 hazards. *Social Science Quarterly*, 84(2), 242-261. https://doi.org/10.1111/1540-
596 6237.8402002

32. Clark S, Harper S, Weber B. Growing up in rural America. *RSF*: The Russell Sage Foundation Journal of the Social Sciences. 2022;8(4):1-47. doi:10.7758/RSF.2022.8.4.01

33. Leiserowitz, A., Maibach, E., Rosenthal, S., Kotcher, J., Goddard, E., Carman, J., Verner, M., Ballew, M., Marlon, J., Lee, S., Myers, T., Goldberg, M., Badullovich, N., Thier, K. (2023). Climate change in the American Mind: Politics & Policy, fall 2023. Yale Program on Climate Change Communication. https://climatecommunication.yale.edu/publications/climate-change-in-the-american-mind-politics-policy-fall-2023/. Accessed Aug 15, 2024.

34. Kahan DM, Peters E, Wittlin M, et al. The polarizing impact of science literacy and numeracy on perceived climate change risks. *Nature Climate Change*. 2012;2(10):732-735. doi:10.1038/nclimate1547

35. Gregersen T, Doran R, Böhm G, Tvinnereim E, Poortinga W. Political orientation moderates the relationship between climate change beliefs and worry about climate change. *Front Psychol*. 2020;11:1573. doi:10.3389/fpsyg.2020.01573

36. Pechar Diamond E, Bonnie R, Rowe E. Rural attitudes on climate change: Lessons from National and Midwest polling and focus groups. NI Report 20-06. Durham, NC: Duke University. 2020. Available from: https://nicholasinstitute.duke.edu/sites/default/files/publications/Rural-Attitudes-on-Climate-Change-Midwest_1.pdf

37. Brulle RJ, Carmichael J, Jenkins JC. Shifting public opinion on climate change: An empirical assessment of factors influencing concern over climate change in the U.S., 2002-2010. *Clim Change*. 2012;114(2):169-188. doi:10.1007/s10584-012-0403-y

38. Leiserowitz A, Maibach E, Roser-Renouf C, Rosenthal S, Cutler M. Climate change in the American Mind: May 2017. Yale University and George Mason University. New Haven, CT: Yale Program on Climate Change Communication; 2017.

39. National Research Council. Public Participation in Environmental Assessment and Decision Making. Washington, DC: The National Academies Press; 2008. doi:10.17226/12434

40. Campbell-Lendrum D, Guillemot J, Ebi K. Climate and health vulnerability assessments: A practical approach. In: Luber G, Lemery J, eds. *Global Climate Change and Human Health*. 1st ed. USA: Jossey-Bass; 2015:363.

41. Lee TM, Markowitz EM, Howe PD, Ko C, Leiserowitz AA. Predictors of public climate change awareness and risk perception around the world. *Nature Climate Change*. 2015;5(11):1014-1020. doi:10.1038/nclimate2728

42. Hamilton LC, Hartter J, Safford TG, Stevens FR. Rural environmental concern: Effects of position, partisanship, and place. *Rural Sociol*. 2014;79(2):257-281. doi:10.1111/ruso.12023.

633 43. Akerlof KL, Delamater PL, Boules CR, Upperman CR, Mitchell CS. Vulnerable populations
634 perceive their health as at risk from climate change. *Int J Environ Res Public Health*.
635 2015;12(12):15419-15433. doi:10.3390/ijerph121214994

636 44. Lal P, Alavalapati JRR, Mercer ED. Socio-economic impacts of climate change on rural
637 United States. *Mitig Adapt Strateg Glob Change*. 2011;16(7):819–844.
638 https://link.springer.com/article/10.1007/s11027-011-9295-9. doi: 10.1007/s11027-011-
639 9295

640 45. Crowley RA, Health and Public Policy Committee of the American College of Physicians.
641 Climate change and health: A position paper of the American College of Physicians. *Ann*
642 *Intern Med.* 2016;164(9):608–610. doi: 10.7326/M15-2766

643 46. Nine cities that are leading on climate. Bloomberg Cities.
644 https://bloombergcities.jhu.edu/news/9-cities-are-leading-climate. Accessed Aug 14,
645 2024.

646 47. US EPA. Research on community resilience to climate change. https://www.epa.gov/climate-
647 research/research-community-resilience-climate-change. Updated 2022. Accessed Aug
648 15, 2024.

649 48. Gustafson A, Ballew MT, Goldberg MH, Cutler MJ, Rosenthal SA, Leiserowitz A. Personal
650 stories can shift climate change beliefs and risk perceptions: The mediating role of
651 emotion. *Commun Reports*. 2020;33(3):121-135. doi:10.1080/08934215.2020.1799049

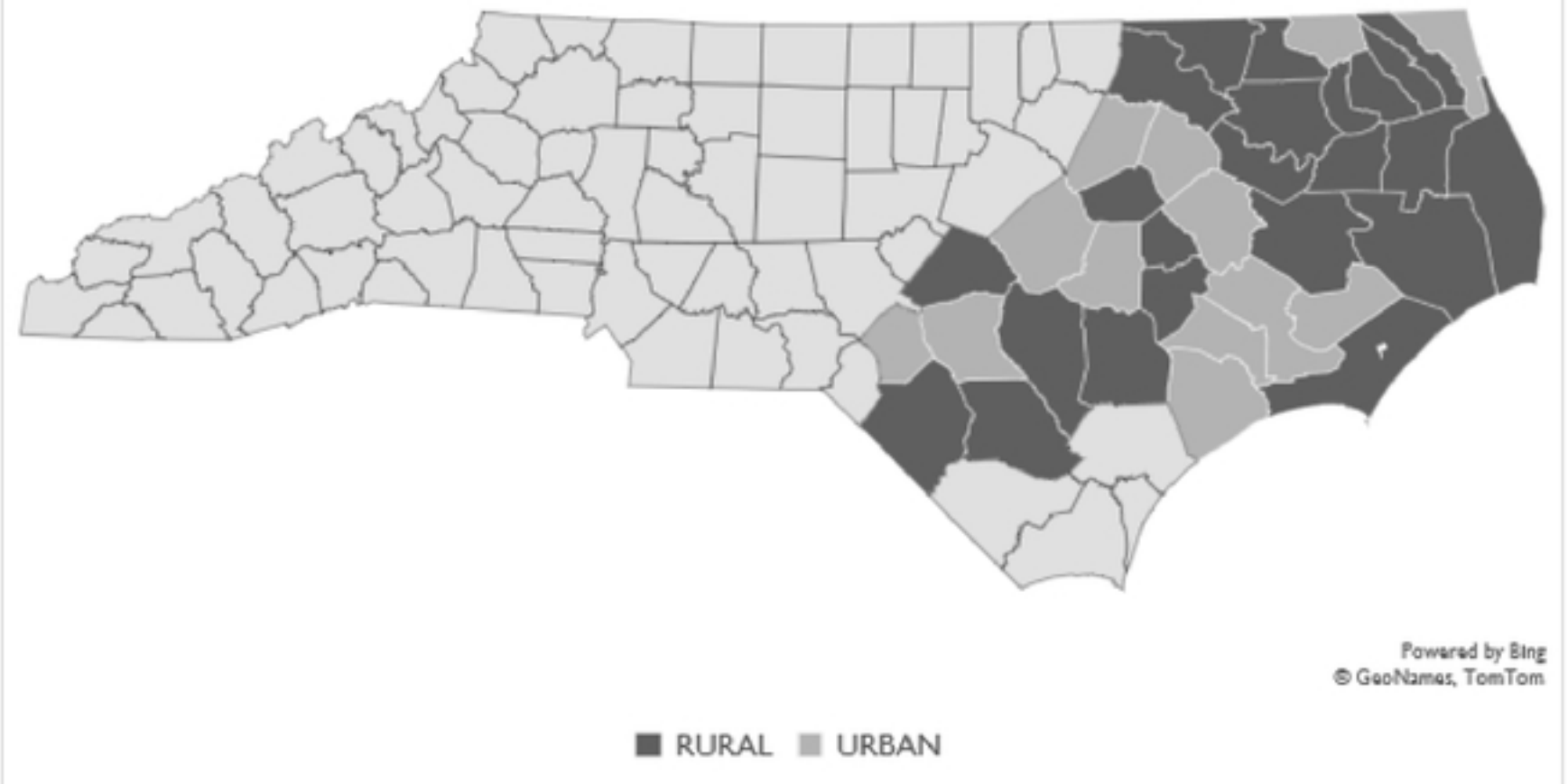

Figure 1. Eastern North Carolina, Rural and Urban Counties

Source: U.S. Office of Management and Budget (2020)[29]

FIG 1

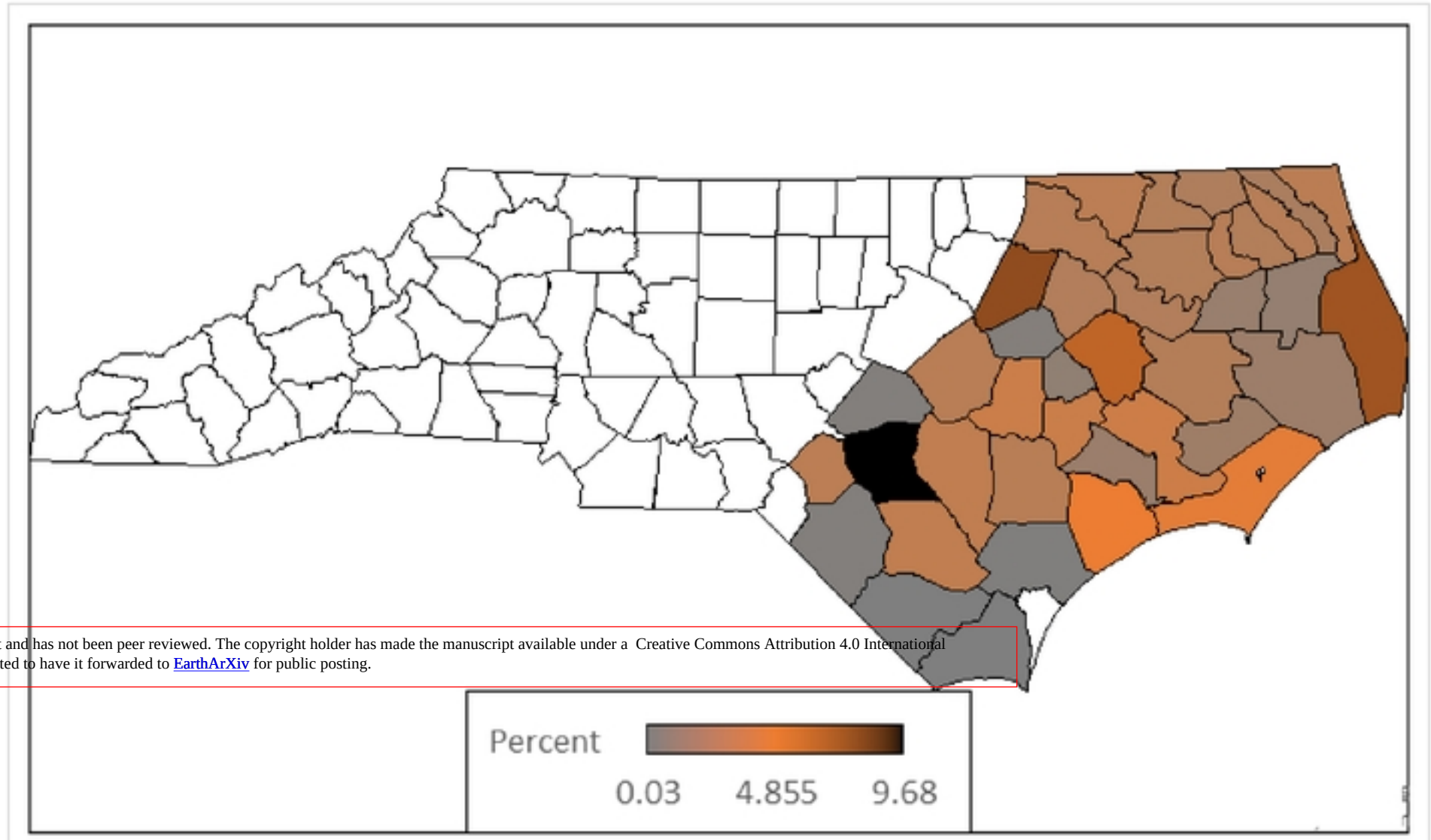

Figure 1. Percent of Survey Respondents by County (n=15,961)

FIG 2