Ambient Temperature and Adult Obesity: Evidence from U.S. County-Level Panel Data

Xiaoxi Qi[1, a*], Tianyi Tao[1, b], Kai Cheng[2, c], Xuan Liu[3, d], Longying Lai[4, e]

[1]Department of Economics, Northeastern University, Boston, MA, USA
[2]Institute for Social and Economic Research and Policy, Columbia University, New York, NY, USA
[3]Industrial Engineering and Operations Research, Columbia University, New York, NY, USA
[4]Simon Business School, University of Rochester, Rochester, NY, USA

[a*]xiaoxiq15@gmail.com
[b]taotianyi.tina@hotmail.com
[c]kc2859@columbia.edu
[d]daisy.xuan.liu@gmail.com
[e]longyinglai703@gmail.com

Abstract. Adult obesity has been extensively studied in economics and public health, yet the empirical role of ambient climate conditions remains underexplored. This paper examines the relationship between average ambient temperature and adult obesity using U.S. county-level panel data from 2006 to 2018. Using fixed-effects regressions with controls for socioeconomic, demographic, and environmental factors, the analysis exploits within-county variation over time. The results indicate that higher ambient temperatures are associated with higher adult obesity rates, even after accounting for correlated environmental conditions. The findings highlight ambient temperature as a relevant environmental correlate of obesity and underscore the importance of environmental context in public health policy discussions.

Keywords: Adult obesity, Ambient temperature, Climate change and health, County-level panel data, Environmental determinants of obesity

1 Introduction

Adult obesity remains a persistent public health challenge in the United States, with significant implications for healthcare costs, labor productivity, and long-term population health [1], [2]. Existing economic research has identified a wide range of obesity determinants, including socioeconomic status, education, demographic characteristics, and behavioral factors. Despite growing interest in environmental influences on health, however, ambient climate conditions—particularly temperature—have received limited empirical attention in the obesity literature.

This paper examines whether average ambient temperature is associated with adult obesity at the county level. Temperature may affect physical activity, outdoor mobility,

K. Othman et al. (eds.), *Proceedings of the 2026 5th International Conference on Mathematical Statistics and Economic Analysis (MSEA 2026)*, Advances in Economics, Business and Management Research 402,
https://doi.org/10.2991/978-94-6239-774-3_7

and energy expenditure, thereby shaping obesity outcomes over time. While climate variables are frequently studied in relation to labor productivity, migration, and mortality, their role in obesity remains relatively underexplored.

Using U.S. county-level panel data from 2006 to 2018 and standard fixed-effects techniques, the analysis exploits within-county variation over time to evaluate the association between ambient temperature and adult obesity. The results indicate a positive relationship between temperature and obesity under preferred specifications. Although the estimated effects are modest, they are economically meaningful when interpreted over longer horizons or across regions with substantial temperature differences.

The remainder of the paper is organized as follows. Section 2 reviews the related literature. Section 3 describes the data. Section 4 outlines the econometric framework. Section 5 presents the empirical results. Section 6 concludes.

2 Literature Review

Economic research on adult obesity has primarily emphasized individual and socioeconomic determinants, including income, education, demographic composition, food prices, and labor market conditions. Many studies document inverse relationships between income or education and obesity, although the magnitude and direction of these effects vary across populations and time periods [3], [4], [13].

A smaller literature examines environmental and spatial determinants of obesity, with mixed findings. Studies focusing on the built environment and access to green space suggest that while general green space availability does not consistently reduce obesity, forest coverage and recreational space may encourage physical activity and are sometimes associated with lower obesity prevalence [9]. These results indicate that environmental context may influence obesity indirectly through activity-related channels.

Empirical research directly linking ambient temperature to obesity remains limited. Existing studies primarily focus on physiological mechanisms, such as core body temperature, rather than ambient environmental exposure, and generally find no significant effects on obesity outcomes [10]. To the best of our knowledge, no prior economic study has examined ambient temperature as a primary explanatory variable in a panel analysis of adult obesity.

This paper contributes to the literature by incorporating ambient temperature into a standard empirical obesity framework and providing new evidence on how environmental conditions may shape obesity outcomes.

3 Data Description

This study uses U.S. county-level panel data from 2006 to 2018, with observations recorded every four years (2006, 2010, 2014, and 2018). The sample includes all U.S. counties, including Alaska and Hawaii, yielding 3,143 county-year observations, with the county-year as the unit of analysis. The four-year interval structure reflects data availability rather than an arbitrary sampling choice, as several key socioeconomic and

demographic variables are obtained from the U.S. Census Bureau's American Community Survey (ACS), which provides county-level estimates at multi-year intervals [6], [7], [17].

The county sample spans all major U.S. geographic regions, including the Northeast, Midwest, South, and West. It spans a wide range of climatic conditions, from colder northern counties to warmer southern and coastal areas, resulting in substantial variation in ambient temperatures.

The dependent variable is the adult obesity rate, defined as the percentage of adults with a body mass index (BMI) of 30 or higher. The primary explanatory variable is average annual ambient temperature, measured in degrees Fahrenheit. Climate variables, including temperature and precipitation, are obtained from the National Oceanic and Atmospheric Administration [5], [8].

The analysis controls for environmental, socioeconomic, and demographic factors correlated with obesity. Environmental controls include annual precipitation and the number of severe weather events per 100 square miles per year. Severe weather events are defined following the National Weather Service classification and include phenomena such as severe thunderstorms, tornadoes, and other hazardous weather events associated with high winds or extreme conditions [12], [18].

Socioeconomic controls include per capita personal income and the share of adults aged 25 or older with a bachelor's degree or higher. Demographic controls measure county-level racial composition, including the percentages of Black, Asian, and Hispanic residents [15], [16]. Land area per 1,000 residents is included to proxy for population density and spatial openness.

Obesity data are sourced from the Centers for Disease Control and Prevention. Demographic characteristics, education, and land area are obtained from the U.S. Census Bureau, and per capita personal income data are retrieved from the Bureau of Economic Analysis [11]. Per capita income is entered in logarithmic form in selected specifications to address skewness, and robust standard errors are used throughout the analysis.

Summary statistics indicate substantial heterogeneity across counties in obesity prevalence, climate conditions, and socioeconomic characteristics, supporting the use of a panel framework that exploits within-county variation over time.

Table 1 reports summary statistics for the main variables used in the analysis, and Table 2 presents the corresponding correlation matrix.

Table 1. Summary statistics: Weather, Obesity, Race, Education and Income Data in 2018

Variable	Mean	S.D.	Skewness	Min	P5	P25	P50	P75	P95	Max
Adult Obesity Rate (%)	31.47	4.51	-0.37	12.80	23.30	28.80	31.80	34.40	38.40	47.80
Temperature (F)	54.95	8.75	-0.05	18.70	40.70	48.40	55.10	61.70	68.50	78.60
Precipitation Rate (inches)	46.77	19.43	-0.02	2.35	13.85	32.81	49.24	62.38	72.81	186.57
Number of Severe Weather per 100 Sq-Mi	4.09	29.35	27.80	0.00	0.29	0.84	1.51	2.62	7.83	1067.19

Per Capita Personal Income in 1000s ($)	44.19	12.76	3.84	18.54	30.68	36.58	41.98	48.82	64.03	251.73
Land Area per 1000 People (mile^2)	119.30	696.66	24.66	0.01	0.98	7.92	21.02	55.17	442.44	26122.94
Hispanic (%)	7.30	8.76	2.26	0.01	0.86	2.02	3.84	8.51	28.20	49.80
Black (%)	8.76	14.13	2.34	0.01	0.15	0.65	2.22	9.76	41.04	86.61
Asian (%)	1.31	2.48	6.98	0.00	0.08	0.34	0.61	1.25	4.55	39.13
Bachelor's Degree or Higher, Age>=25 (%)	29.96	10.59	0.74	7.30	16.00	22.20	28.70	35.70	50.60	75.90
Observations	3143									

Table 2. Correlation table for 2018 Adult Obesity data

	Obesity Rate (%)	**Temp (F)**	**Precip. (in)**	**Severe Weather /100sq-mi**	**Income (1000s $)**	**Land Area /1000 (mile^2)**
Adult Obesity Rate (%)	1					
Temperature (F)	.2024236	1				
Precipitation Rate (inches)	.3143972	.4294954	1			
Number of Severe Weather per 100 Sq-Mi	-.0602744	.0100565	.0731928	1		
Per Capita Personal Income in 1000s ($)	-.4663651	-.2522647	-.1684308	.1006964	1	
Land Area per 1000 People (mile^2)	-.0845725	-.1384383	-.2259755	-.0229319	.0492912	1
Observations	3098					

*Source: U.S. Census Bureau. Centers for Disease Control & Prevention. National Oceanic and Atmospheric Administration. Bureau of Economic Analysis.

4 Hypothesis Testing and Econometric Models

This section describes the econometric framework used to examine the relationship between ambient temperature and adult obesity. The central hypothesis is that ambient temperature has a ceteris paribus association with county-level adult obesity rates, holding constant socioeconomic, demographic, and environmental factors. Consistent with the applied nature of the study, the analysis relies on standard panel data methods to exploit within-county variation over time.

4.1 Baseline Specification

Given the county-level panel structure of the data, observed at four-year intervals from 2006 to 2018, fixed-effects regressions control for time-invariant county characteris-

tics. Identification, therefore, relies on within-county changes rather than cross-sectional differences. The baseline specification is:

$$\text{Obesity}_i = \beta_1 \text{Temp}_i + \alpha_i + \varepsilon_i,$$

where Obesity_i denotes the adult obesity rate in county i, Temp_i represents average ambient temperature, α_i captures county fixed effects, and ε_i is the idiosyncratic error term.

4.2 Extended Specification

To address potential omitted-variable bias, subsequent specifications incorporate time-varying controls for environmental conditions, socioeconomic status, and demographic composition. These include precipitation, exposure to severe weather, per capita personal income, land area per 1,000 residents, racial group shares, and educational attainment. The extended specification is given below, where X_i denotes the vector of control variables. Per capita personal income is entered in logarithmic form to address skewness and to assess sensitivity to functional form:

$$\text{Obesity}_i = \beta_1 \text{Temp}_i + \text{X}_i'\gamma + \alpha_i + \varepsilon_i$$

4.3 Instrumental Variable Consideration

Ambient temperature may be correlated with unobserved behavioral factors, such as physical activity preferences. To assess sensitivity to this concern, precipitation is considered in alternative specifications either as an instrumental variable for temperature or as an independent environmental control. Although precipitation satisfies the relevance condition empirically, its exclusion restriction is potentially violated if it directly affects outdoor activity. Accordingly, instrumental-variable results are interpreted as robustness checks rather than as evidence of definitive causal identification.

4.4 Heterogeneity Analysis

To examine heterogeneity in temperature effects, the final specification includes an interaction between temperature and an indicator for counties with higher Hispanic population shares. This allows the association between temperature and obesity to vary across demographic contexts. All models are estimated using robust standard errors to account for potential heteroskedasticity.

5 Empirical results and Policy Implications

Table 3 reports the regression results across the OLS, fixed-effects, and instrumental-variable specifications described in Section 4.

Table 3. Regression results for Obesity Weather Data

	OLS	FE	FE	FE	FE	FE	FE-IV	FE	FE	FE
	Adult Obesity Rate (%)	Adult Obesity Rate (%)	Adult Obesity Rate (%)	Adult Obesity Rate (%)	Adult Obesity Rate (%)	Adult Obesity Rate (%)	Adult Obesity Rate (%)	Adult Obesity Rate (%)	Adult Obesity Rate (%)	Adult Obesity Rate (%)
Temperature (F)	-0.0213*** (0.00986)	0.531*** (0.0129)	-0.00760 (0.0133)	0.00607 (0.0221)	-0.0160 (0.0219)	0.0744*** (0.0129)	0.231* (0.123)	-0.0276 (0.0204)	0.0606*** (0.0121)	0.0495*** (0.0125)
Per Capita Personal Income in 1000s ($)	0.0223*** (0.00712)		0.0921*** (0.00471)	0.0187* (0.0109)						
Number of Severe Weather per 100 Sq-Mi	-0.0146 (0.00959)		-0.00297* (0.00163)	0.00460 (0.0137)	0.00270 (0.0135)	-0.00302** (0.00149)	0.00341 (0.0153)	-0.00563 (0.0137)	-0.00336** (0.00160)	-0.00255* (0.00145)
Land Area per 1000 People (mile^2)	0.0110*** (0.00400)		0.000183** (0.0000762)	-0.0174 (0.0202)	0.00361 (0.0172)	0.000325 (0.000258)	0.0206 (0.0440)	-0.00887 (0.0174)	0.000309 (0.000249)	0.000171 (0.000271)
Black (%)	0.116*** (0.00551)			0.203*** (0.0701)	0.181*** (0.0699)	0.185*** (0.0357)	0.206*** (0.0691)	0.168** (0.0702)	0.188*** (0.0358)	0.129*** (0.0338)
Asian (%)	-0.147*** (0.0156)			-0.0429 (0.121)	-0.0857 (0.118)	0.174*** (0.0672)	0.0197 (0.121)	-0.0983 (0.117)	0.166** (0.0666)	0.194*** (0.0656)
Hispanic (%)	-0.135*** (0.00869)			0.890*** (0.0646)	0.752*** (0.0768)	0.355*** (0.0427)	0.858*** (0.0827)	0.749*** (0.0768)	0.354*** (0.0427)	
Bachelor's Degree or Higher, Age>=25 (%)	-0.271*** (0.00892)			0.0250 (0.0242)	-0.0128 (0.0267)		-0.0137 (0.0232)	-0.0186 (0.0269)		
Log of Per Capita Personal Income					2.507*** (0.714)	2.780*** (0.266)	1.909*** (0.582)	2.377*** (0.722)	2.580*** (0.278)	3.772*** (0.206)
Precipitation Rate (inches)								0.0100* (0.00564)	0.00844** (0.00332)	0.00872*** (0.00332)
Hispanic * Temperature										0.0118** (0.00334)
Constant	37.00*** (0.607)	59.03*** (0.706)	27.31*** (0.793)	17.26*** (1.792)	11.88*** (2.231)	11.98*** (1.277)	-1.385 (6.746)	12.98*** (2.156)	13.11*** (1.249)	12.22*** (1.211)
Observations	2840	12557	10040	2840	2840	8677	2840	2840	8677	8677
Adjusted R2	0.545	0.113	0.099	0.255	0.263	0.125		0.264	0.126	0.114
F	448.2	1691.6	104.3	86.33	92.05	99.13		82.32	86.90	73.70
Within R2		0.113	0.0996	0.257	0.265	0.125	0.231	0.267	0.127	0.115

*Note: Robust standard errors are displayed in parenthesis. Significance levels: * p<0.10; ** p<0.05; *** p<0.01

Source: U.S. Census Bureau. Bureau of Economic Analysis. Centers of Disease Control & Prevention.

National Oceanic and Atmospheric Administration.

Across fixed-effects specifications, the estimated relationship between ambient temperature and adult obesity is sensitive to model specification. In parsimonious models, temperature is negative or statistically insignificant. Once precipitation is included as an independent environmental control and educational attainment—characterized by limited within-county variation—is excluded, the temperature coefficient becomes positive and statistically significant.

Under the preferred specification, a 1-degree Fahrenheit increase in average annual temperature is associated with approximately a 0.06 percentage-point increase in the adult obesity rate. Although modest, this effect is economically meaningful when interpreted over longer horizons or across regions with substantial temperature differences, suggesting that ambient temperature captures behavioral or environmental mechanisms not absorbed by standard socioeconomic controls.

The instrumental variable – precipitation – is highly sensitive to identification assumptions. While precipitation satisfies the relevance condition, its likely direct influence on outdoor physical activity raises concerns regarding the exclusion restriction. Treating precipitation as an independent control yields more stable and interpretable estimates, supporting its role as a separate environmental channel rather than a valid instrument for temperature.

The analysis also reveals heterogeneity in temperature effects. In counties with higher Hispanic population concentrations, the marginal effect of temperature on adult obesity is significantly larger, indicating that environmental conditions may interact with local demographic or occupational patterns. Overall, the evidence supports a positive association between ambient temperature and adult obesity, though the estimates should be interpreted as conditional rather than causal.

6 Conclusion

This paper examines the relationship between ambient temperature and adult obesity using U.S. county-level panel data from 2006 to 2018. While the econometric framework is standard, the study's contribution is primarily applied: it introduces ambient temperature as a previously underexplored environmental determinant of obesity. It evaluates its association using within-county variation over time.

Across fixed-effects specifications, higher ambient temperatures are associated with higher adult obesity rates once correlated environmental factors are appropriately controlled. Although modest in magnitude, the estimated effects are economically meaningful when interpreted over longer horizons or across regions with substantial temperature differences. The analysis also documents heterogeneity in temperature effects, with stronger associations observed in counties with higher Hispanic population concentrations.

Several limitations warrant caution. Unobserved behavioral factors, such as dietary choices and physical activity preferences, are not directly measured, and some determinants of obesity evolve slowly over time. Accordingly, the estimates should be interpreted as conditional associations rather than definitive causal effects.

Despite these caveats, the findings have clear implications for public health policy. Obesity prevention strategies may benefit from incorporating local climate conditions into program design, particularly in regions where higher temperatures constrain outdoor physical activity [14]. The presence of heterogeneous temperature effects further suggests the value of targeted, climate-adaptive interventions, such as indoor recreational facilities or seasonally adjusted exercise programs. More broadly, the results highlight the importance of environmental context in understanding obesity patterns

and suggest that climate conditions deserve greater attention in public health research and policy discussions.

References

1. Centers for Disease Control and Prevention, "Adult obesity causes & consequences," [Online]. Available: https://www.cdc.gov/obesity/adult/causes.html.
2. Trust for America's Health, "Adult obesity in the United States," [Online]. Available: https://www.stateofobesity.org/.
3. J. Cawley and C. Meyerhoefer, "The medical care costs of obesity: An instrumental variable approach," J. Health Econ., vol. 31, no. 1, pp. 219–230, 2012.
4. V. W. Chang and D. S. Lauderdale, "Income disparities in body mass index and obesity in the United States, 1971–2002," Arch. Intern. Med., vol. 165, no. 18, pp. 2122–2128, 2005, doi: 10.1001/archinte.165.18.2122.
5. National Oceanic and Atmospheric Administration, "Climate at a glance," [Online]. Available: https://www.ncdc.noaa.gov/cag/statewide/mapping/110/pcp/201812/12/value.
6. Centers for Disease Control and Prevention, "Data collection and reporting," Sep. 28, 2018. [Online]. Available: https://wwwn.cdc.gov/nndss/data-collection.html.
7. County Health Rankings & Roadmaps, "Adult obesity," 2025. [Online]. Available: https://www.countyhealthrankings.org/health-data/population-health-and-well-being/quality-of-life/physical-health/adult-obesity?year=2025.
8. U.S. Climate Data, "Temperature, precipitation, sunshine, snowfall," [Online]. Available: https://www.usclimatedata.com/climate/alabama/united-states/3170.
9. R. Ghimire, S. Ferreira, G. T. Green, N. C. Poudyal, H. K. Cordell, and J. R. Thapa, "Green space and adult obesity in the United States," Ecol. Econ., vol. 136, pp. 201–212, 2017.
10. M. J. Heikens, A. M. Gorbach, H. S. Eden, D. M. Savastano, K. Y. Chen, M. C. Skarulis, and J. A. Yanovski, "Core body temperature in obesity," Am. J. Clin. Nutr., vol. 93, no. 5, pp. 963–967, 2011, doi: 10.3945/ajcn.110.006270.
11. A. J. Katz, "An overview of BEA's source data and estimating methods for quarterly GDP," Bureau of Economic Analysis, U.S. Dept. of Commerce, BE-54, 2006
12. National Weather Service, "Severe weather definitions," [Online]. Available: https://www.weather.gov/bgm/severedefinitions.
13. C. L. Ogden, T. H. Fakhouri, M. D. Carroll, C. M. Hales, C. D. Fryar, X. Li, and D. S. Freedman, "Prevalence of obesity among adults, by household income and education—United States, 2011–2014," MMWR Morb. Mortal. Wkly. Rep., vol. 66, no. 50, pp. 1369–1373, 2017, doi: 10.15585/mmwr.mm6650a1.
14. Trust for America's Health, "Priority policies for reducing childhood and adult obesity," [Online]. Available: https://www.stateofobesity.org/policy/.
15. Kaiser Family Foundation, "Population distribution by race/ethnicity," Dec. 31, 2018. [Online]. Available: https://www.kff.org/other/state-indicator/distribution-by-raceethnicity.
16. Governing, "State population by race and ethnicity," [Online]. Available: https://www.governing.com/gov-data/census/state-minority-population-data-estimates.html.
17. U.S. Census Bureau, "American Community Survey data releases," Jul. 22, 2019. [Online]. Available: https://www.census.gov/programs-surveys/acs/news/data-releases.html.
18. NOAA Storm Prediction Center, "Storm Prediction Center annual report summary—2018," [Online]. Available: https://www.spc.noaa.gov/climo/online/monthly/2018_annual_summary.html.