

The Relationship Between Extreme Heat and Heat-Related Illness Hospital Visits in Maricopa County, Arizona

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ABSTRACT

Extreme heat events have become more frequent and more intense around the world. In Arizona in 2025, the total number of heat-related illness emergency department visits was 4770 individuals, and 977 individuals died from heat-related illness. Previous studies on heat, hospitalizations, and deaths consistently found that excess heat increased the risk of heat-related hospitalization. In this study, I assess whether the relationship between higher temperatures and heat-related illness hospitalizations is linear or if it increases more rapidly with more extreme heat. I obtained daily temperature and heat-related hospital visit data from the Maricopa County Heat Reports between 2020 and 2026. I fit quadratic and linear time series regressions, with the daily percentage of heat-related illness hospital visits among total hospital visits as the outcome and the daily maximum temperature as the covariate. I observed a statistically significant quadratic relationship between maximum temperature and heat-related illness hospital visits. At 110 degrees Fahrenheit (F), the quadratic time series regression predicts that 0.588% of total hospital visits will be for heat-related illnesses (95% confidence interval [CI]: 0.580% to 0.597%), and at 119 degrees F, it predicts that 1.209% of total hospital visits will be for heat-related illnesses (95% CI: 1.184% to 1.233%). The issue of extreme heat will persist due to global warming. Thus, we need to take informed actions to mitigate the negative health effects of exposure to extreme heat.

INTRODUCTION

Extreme heat events, defined as “2 or more days of hot-humid temperatures above the historical 95th percentile,” have become more frequent and more intense around the world.^{1,2} In the United States, extreme heat causes more deaths than hurricanes, floods, and tornadoes combined.² According to the Centers for Disease Control and Prevention (CDC), heat-related illnesses contributed to 12,324 heat-related hospitalizations and 2325 deaths in the United States in 2023.^{3,4} The Southwest region, in particular, experienced the greatest increase in heat-related mortality, outpacing the increase in heat severity.² In Arizona in 2025, the total number of heat-related illness emergency department visits was

4770 individuals, and 977 individuals died from heat-related illness.⁵ Of these events, 2967 hospitalizations and 614 deaths occurred in Maricopa County, the most populous county in Arizona.⁵

Excess heat increases the risk of heat exhaustion, heat stroke, acute kidney injury and failure, cardiovascular stress, and rhabdomyolysis.⁶⁻⁸ Under these conditions, the body can easily become dehydrated and lose salt through sweating, leading to heat exhaustion and strain on the cardiovascular and renal systems.^{6,9} Heat stroke occurs when the body is no longer able to regulate its temperature, allowing body temperature to rise to over 106 degrees Fahrenheit (F) in just 10 to 15 minutes.⁶

Previous studies on heat, hospitalizations, and deaths consistently found that excess heat increased the risk of heat-related hospitalization. Mock et al. (2026) studied the risk of heat-related hospitalization with regard to temperature and PM_{2.5} levels for older adults, finding a positive association between maximum temperature and the odds of heat-related hospitalization, accounting for fine particulate matter air pollution.¹⁰ Narayanan and Keellings (2025) studied 40 years of weather and mortality data and concluded that the rise in extreme-heat event days was associated with an increase in the number of heat-related deaths.² O'Lenick et al. (2025) found that "7-day cumulative associations at high temperatures" resulted in an average 1.2% increase in hospitalizations for respiratory disease among older adults, suggesting that heat exacerbates respiratory infections and diseases among the elderly.¹¹ However, it is unknown if the relationship between higher temperatures and heat-related illness hospitalizations is linear or if it increases faster with more extreme heat.

This study aims to answer this question using daily temperature and heat-related illness hospitalization data from Maricopa County, Arizona, from January 2020 to May 2026. I hypothesize that the percentage that heat-related illness hospital visits comprise of total hospital visits will be more associated with extremely high daily temperatures than with more moderate high daily temperatures.

METHODOLOGY

Data

The data were obtained from the Maricopa County Heat Reports by request from the Maricopa County Department of Public Health on May 27, 2026. It contains the daily maximum temperature, minimum temperature, and the percentage of heat-related illness hospital visits among all hospital visits. The daily data begin on January 1, 2020, and end on May 23, 2026.

To identify heat-related illnesses, Maricopa County utilizes the syndromic surveillance method, which relies on the patient's chief complaint, not on the diagnosis code given by a medical provider. The syndromic surveillance method is used by the CDC in collaboration with state, local, and territorial health departments.¹² According to the Maricopa County Department of Public Health, a heat-related illness case is counted if the patient receives a heat stroke or heat exhaustion diagnosis, or if "key phrases" are

identified “that indicate the patient was exposed to extreme environmental heat in their ‘chief complaint’ (the patient’s stated reason for visit) or ‘admission reason field’ (the provider’s noted reason for admission).”¹³ Heat-related illness symptoms are tracked before and after diagnosis. This method allows for rapid classification of cases, as a full diagnosis is not needed, which is important for Maricopa County, as this data was originally compiled for display in a near real-time public heat and health dashboard. However, this simultaneously introduces the possibility of misclassification, which is why the data is subsequently updated once additional clinical information becomes available.

Analyses

First, I assessed the relationship between date and both the daily minimum and maximum temperatures. I determined the date of the peak maximum temperature each year. Second, I assessed the relationship between date and the daily percent of hospital visits due to heat-related illness. Third, I assessed the relationship between daily maximum temperature and the daily percent of hospital visits due to heat-related illness.

Fourth, I modeled the daily percentage of hospital visits due to heat-related illness using an autoregressive integrated moving average (ARIMA) regression with maximum temperature centered at 90 °F and a quadratic term for maximum temperature as covariates. The analytic dataset included complete calendar years from January 1, 2020, through December 31, 2025; data from 2026 were excluded because it was not a full year. The ARIMA model accounts for temporal dependence in the outcome (i.e., daily percentage of hospital visits due to heat-related illness) by estimating autoregressive (AR) parameters, which model the dependence of current observations on previous observations, and moving average (MA) parameters, which model the influence of random shocks from previous days on the current observation. The optimal ARIMA model was selected automatically using the *auto.arima* algorithm in the *forecasts* package, which identifies the combination of autoregressive, differencing, and moving average terms that minimizes the corrected Akaike Information Criterion (AICc). Fifth, as a secondary analysis, I fit a similarly specified ARIMA regression with only a linear term for maximum temperature. Model fit was compared using AICc, with lower values indicating better relative fit. Model assumptions were evaluated by examining residual diagnostic plots and assessing residual autocorrelation using the autocorrelation function (ACF) and the Ljung–Box test.

Finally, I fit a series of linear regression models with daily percent of hospital visits due to heat-related illness as the outcome and the maximum temperature as the covariate, varying the highest maximum temperatures between 70 degrees F and 85 degrees F, to identify the temperature at which the slope became statistically significant (i.e., $\alpha = 0.05$). Throughout all analyses, I used R version 4.6.0 and specifically the *forecasts*, *tidyverse*, *scales*, *RColorBrewer*, *readxl*, *gt*, and *gtsummary* packages. I set the type I error rate, α , at 0.05 for all analyses.

RESULTS

Daily Temperature

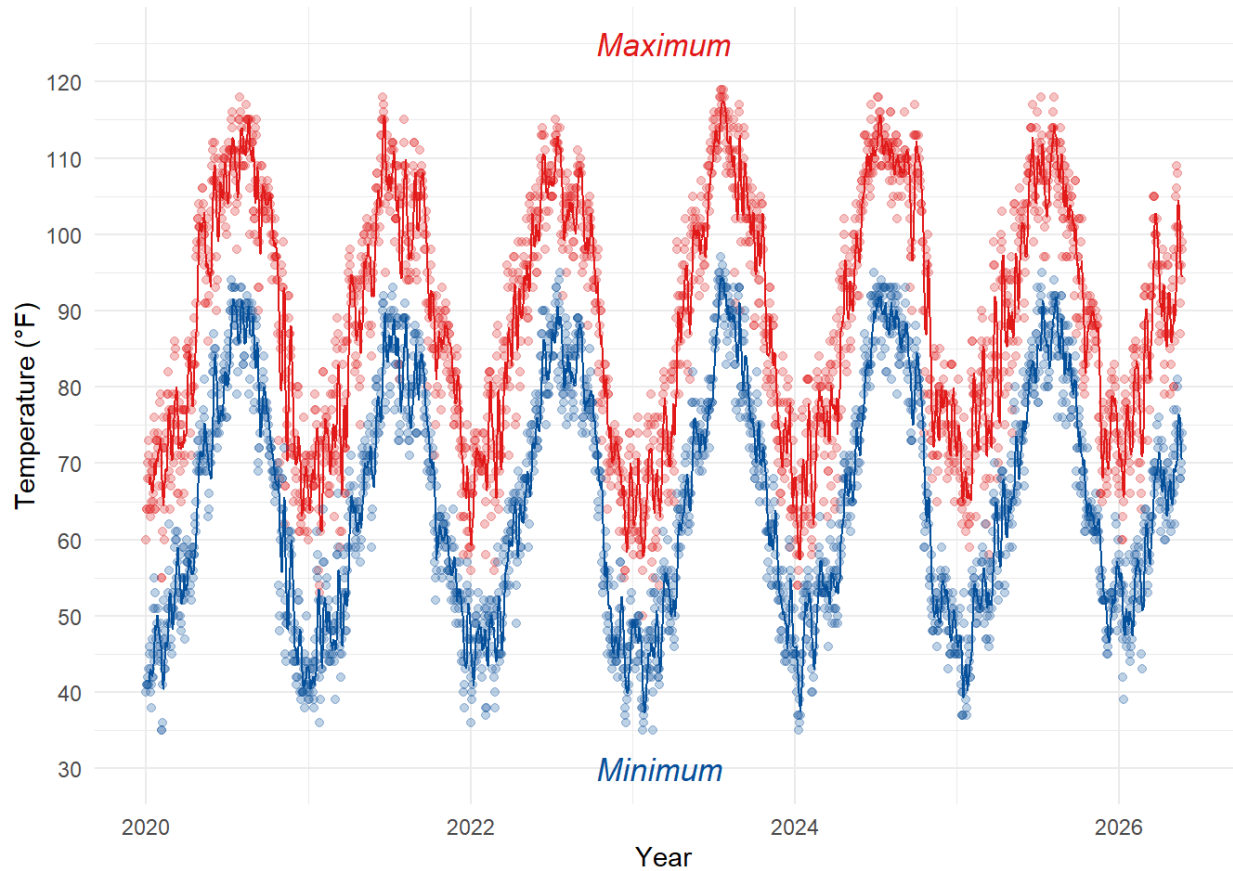


Figure 1: Daily Minimum and Maximum Temperature Over Time, Maricopa County, Arizona (2020-2026)

Between 2020 and 2025, the daily maximum temperatures peaked each year between 115 and 119 degrees F, and this peak temperature occurred between June 17 and August 7 (Figure 1). The daily minimum temperatures peaked each year between 93 and 97 degrees F, and this peak temperature occurred between June 27 and July 22 (Figure 1). The highest maximum temperature during this period was 119 degrees F and occurred three times: July 19, 20, and 25 of 2023. The highest minimum temperature during this period was 97 degrees F and occurred only once: on July 19, 2023.

Heat-Related Illness Hospital Visits

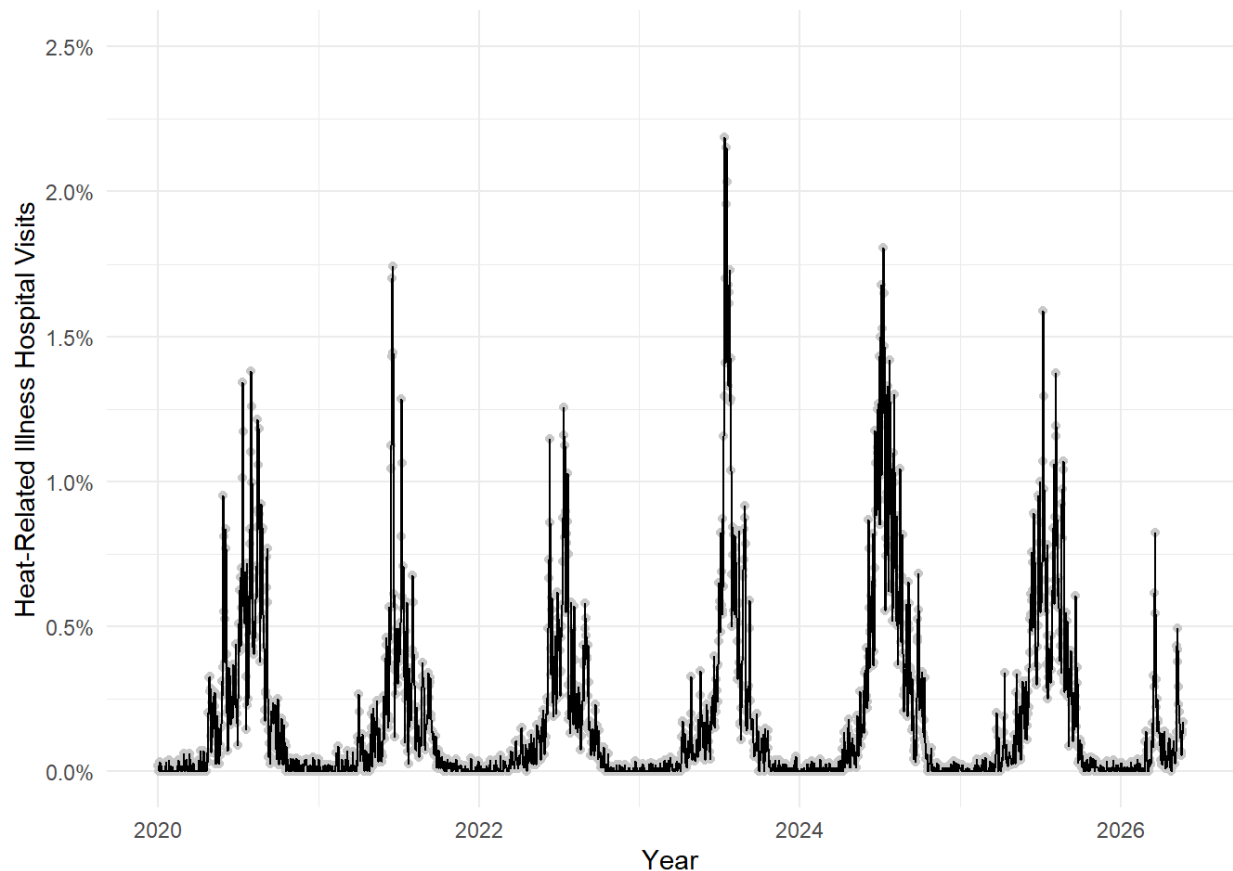


Figure 2. Daily Percentage of Heat-Related Illness Hospital Visits Among Total Hospital Visits Over Time, Maricopa County, Arizona (2020-2026)

Between 2020 and 2025, the percentage of hospital visits due to heat-related illness peaked each year between 1.380% and 2.187%, and these peak percentages occurred between June 19 and July 31 (Figure 2). The single highest percentage recorded occurred on July 15, 2023.

Heat-related illness hospital visits also occurred in other parts of the year. For example, in March, the percentage peaked at 0.823% on March 21, 2026, and in October, at 0.344% on October 6, 2024. The percentage was also equal to 0.000% (i.e., no heat-related illness hospital visits) for a little over one quarter of the timeframe, often in the non-summer months.

Maximum Temperature and Heat-Related Illness Hospital Visits

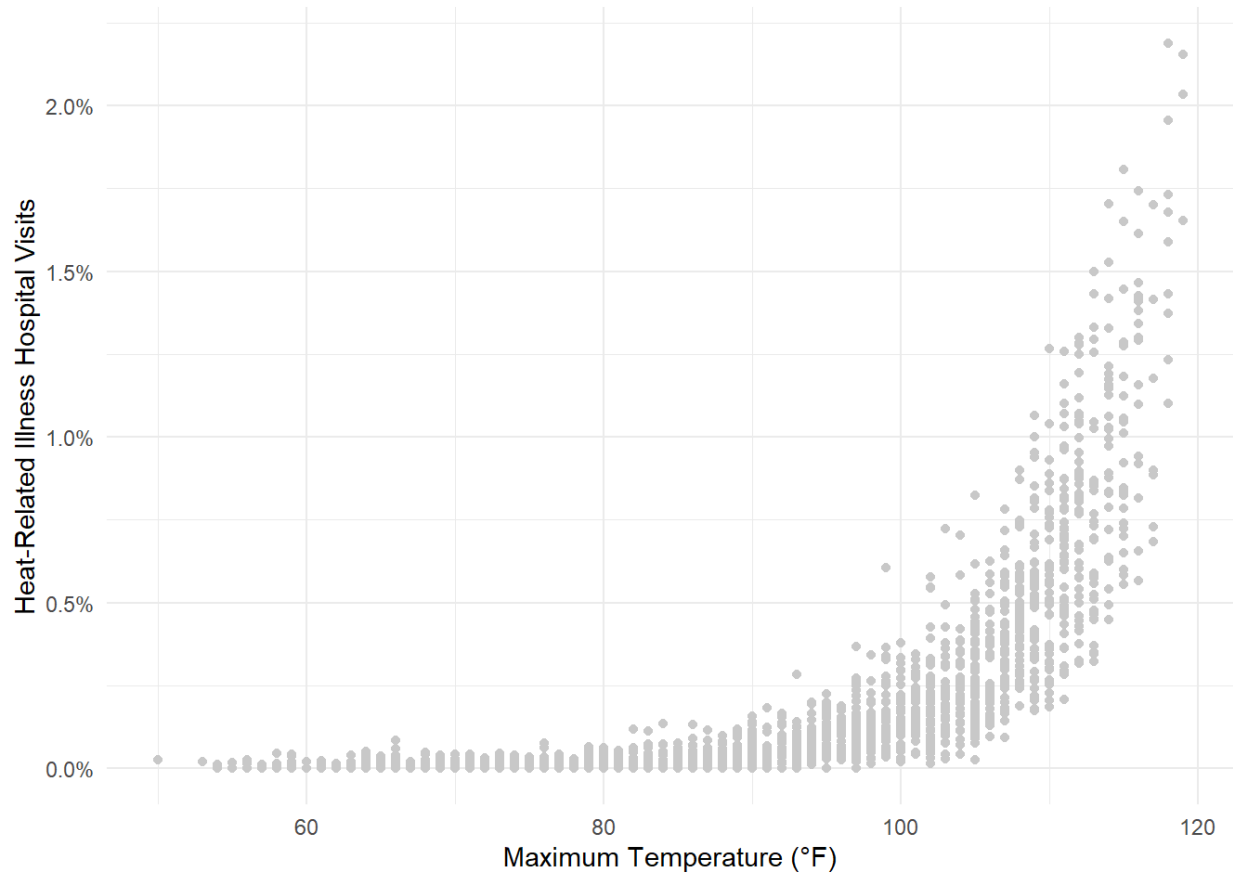


Figure 3. Daily Percentage of Heat-Related Illness Hospital Visits Among Total Hospital Visits Over Daily Maximum Temperature, Maricopa County, Arizona (2020-2026)

Characteristic	Beta	SE	95% CI
AR1	1.408	0.05746	(1.295, 1.520)
AR2	-0.3740	0.04482	(-0.4618, -0.2861)
AR3	-0.05741	0.02752	(-0.1114, -3.464 x 10 ⁻³)
MA1	-0.7823	0.05086	(-0.8820, -0.6826)
Intercept	9.125 x 10 ⁻⁴	1.813 x 10 ⁻⁵	(8.770 x 10 ⁻⁴ , 9.481 x 10 ⁻⁴)
Maximum temperature			
Linear term	1.215 x 10 ⁻⁴	2.741 x 10 ⁻⁵	(6.776 x 10 ⁻⁵ , 1.752 x 10 ⁻⁴)
Quadratic term	3.885 x 10 ⁻⁶	2.734 x 10 ⁻⁷	(3.349 x 10 ⁻⁶ , 4.421 x 10 ⁻⁶)
AICc	-25,685.04		

Abbreviation: SE = standard error, CI = Confidence Interval, AIC = corrected Akaike Information Criterion

Table 1. ARIMA Regression Results: Quadratic

Characteristic	Beta	SE	95% CI
AR1	1.582	0.04142	(1.501, 1.663)
AR2	-0.5452	0.04292	(-0.6293, -0.4611)
AR3	-0.0470	0.02359	(-0.09329, -8.329 x 10 ⁻⁴)
MA1	-0.8497	0.03397	(-0.9163, -0.7831)
Intercept	1.885 x 10 ⁻³	4.134 x 10 ⁻⁴	(1.074 x 10 ⁻³ , 2.695 x 10 ⁻³)
Maximum temperature	7.631 x 10 ⁻⁵	3.023 x 10 ⁻⁵	(1.705 x 10 ⁻⁵ , 1.356 x 10 ⁻⁴)

AICc -25,187.25

Abbreviation: SE = standard error, CI = Confidence Interval, AIC = corrected Akaike Information Criterion

Table 2. ARIMA Regression Results: Linear

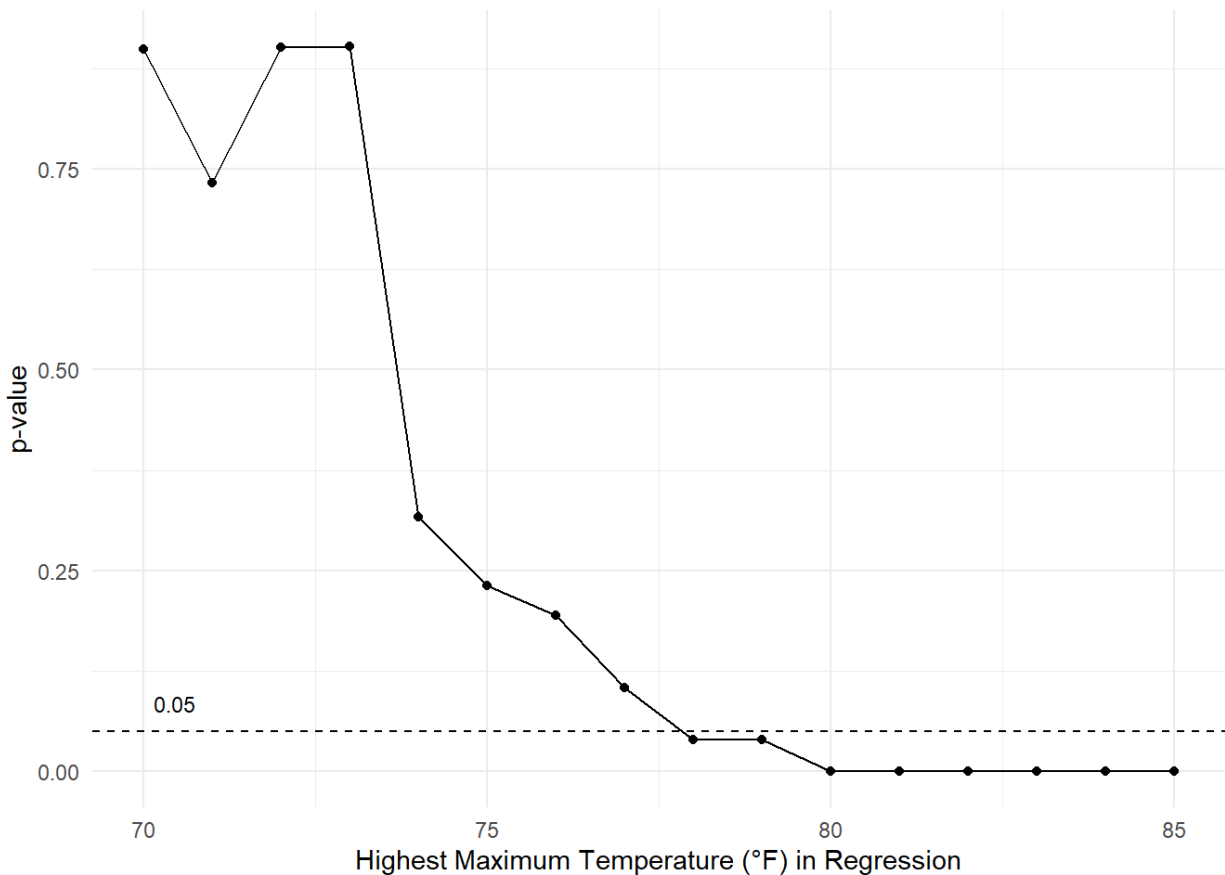


Figure 4. Significance of Slope from Linear Regression of Daily Percentage of Heat-Related Illness Hospital Visits Among Total Hospital Visits Versus Daily Maximum Temperature, Varying Highest Daily Maximum Temperature, Maricopa County, Arizona (2020-2026)

The percentage of hospital visits due to heat-related illness increased with daily maximum temperature (Figure 3). I observed a statistically significant quadratic relationship between maximum temperature and heat-related illness hospital visits in the ARIMA regression model (Table 1). For the linear term, the

estimated coefficient was 1.215×10^{-4} (95% confidence interval [CI]: 6.776×10^{-5} to 1.752×10^{-4}), and for the quadratic term, the estimated coefficient was 3.885×10^{-6} (95% CI: 3.349×10^{-6} to 4.421×10^{-6}). As a secondary analysis, I fit an ARIMA regression with only a linear term for maximum temperature and found an estimated coefficient of 7.631×10^{-5} (95% CI: 1.705×10^{-5} to 1.356×10^{-4} ; Table 2). The quadratic model provided a better fit than the linear model, as indicated by a lower AICc value (-25,685.04 vs. -25,187.25). Residual diagnostic plots suggested an adequate fit, although the Ljung–Box test detected evidence of modest residual autocorrelation ($p = 0.009$). The percentage of heat-related illness hospital visits did not increase significantly with maximum temperature for maximum temperatures under 78 degrees F (Figure 4).

Predicted Heat-Related Illness Hospital Visits

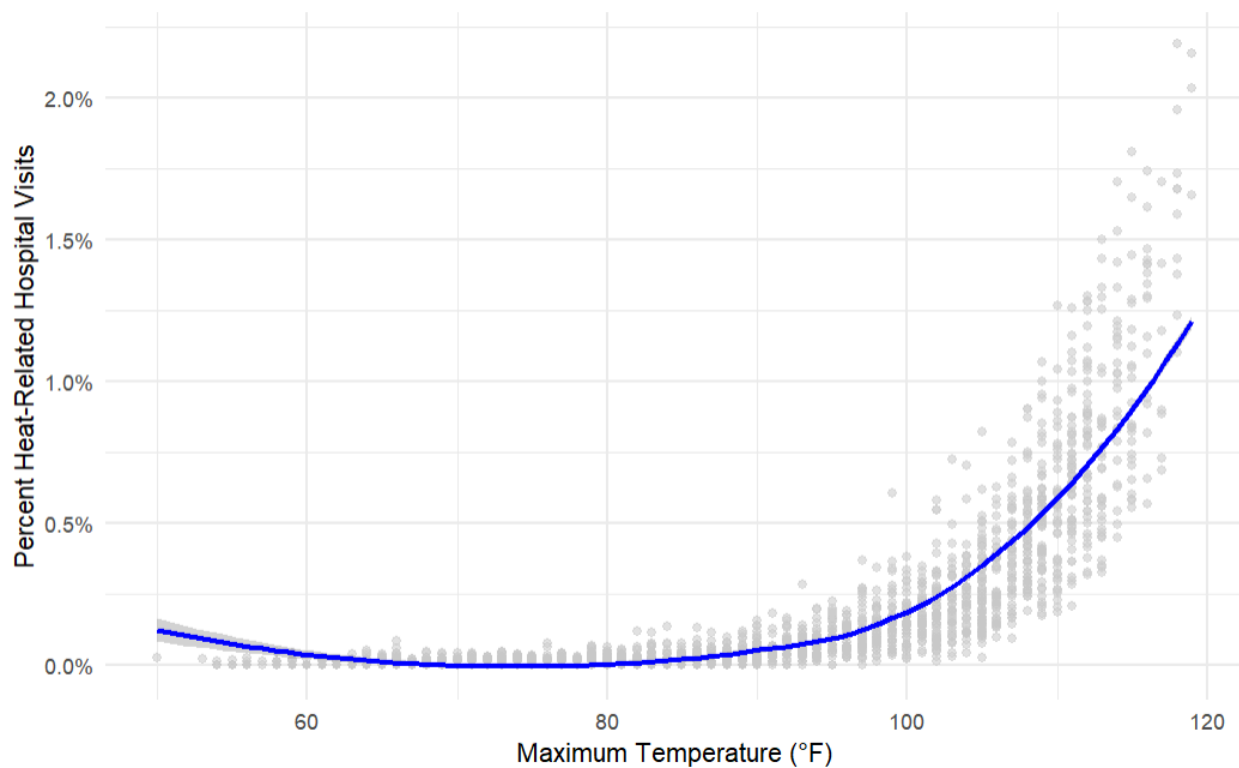


Figure 5. Predicted Heat-Related Illness Hospital Visits Among Total Hospital Visits by Maximum Temperature, Maricopa County, Arizona (2020-2026)

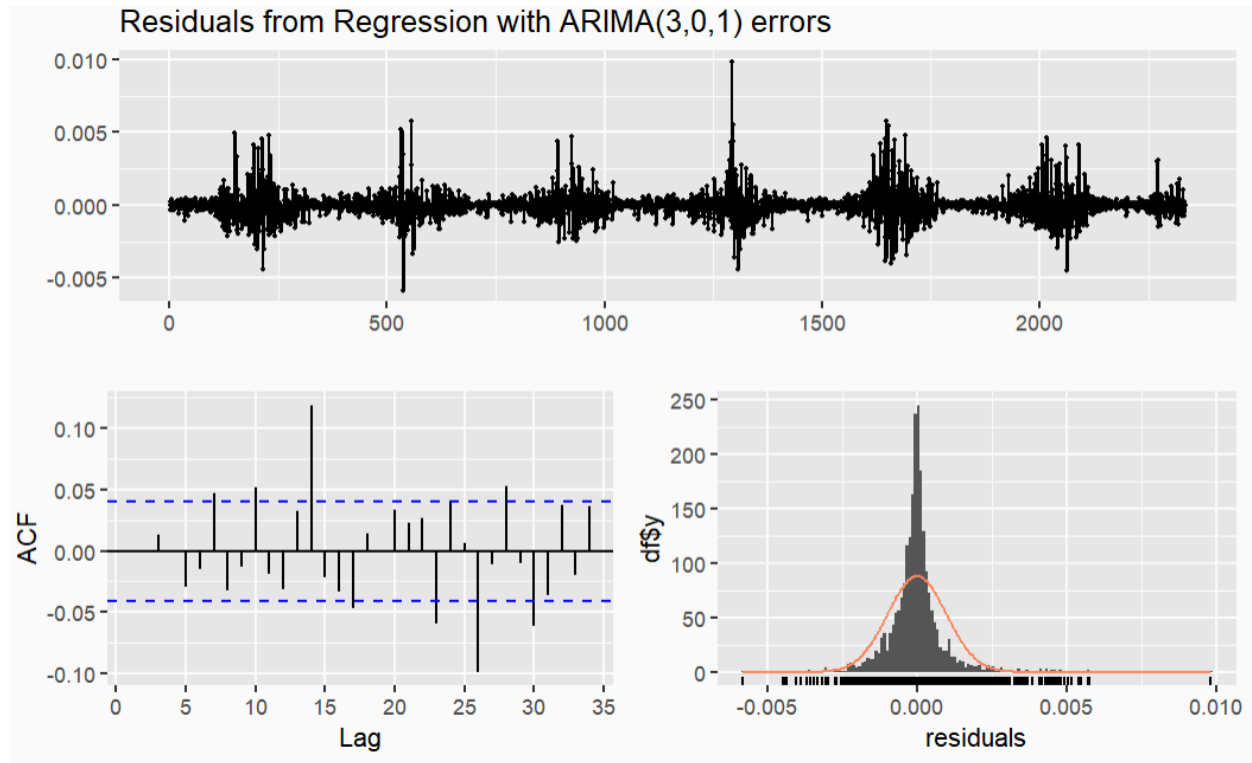


Figure 6. Diagnostic Plots for Residuals of Quadratic Time Series Regression

The proportion of heat-related illness hospital visits increased with maximum temperature. At 90 degrees F, the quadratic time series regression predicted that 0.052% of total hospital visits will be for heat-related illnesses (95% CI: 0.043% to 0.062%, Figure 5). At 100 degrees F, it predicted that 0.189% of total hospital visits will be for heat-related illnesses (95% CI: 0.181% to 0.197%). At 110 degrees F, it predicted that 0.588% of total hospital visits will be for heat-related illnesses (95% CI: 0.580% to 0.597%). Finally, at 119 degrees F, it predicted that 1.209% of total hospital visits will be for heat-related illnesses (95% CI: 1.184% to 1.233%).

The residuals were generally centered around zero over time with no strong systemic pattern, although their variability increased during several periods (Figure 6). Most residual autocorrelations fell within the 95% confidence limits, with only a few isolated lags suggesting modest remaining temporal dependence. The residual distribution was centered near zero and broadly consistent with the model assumptions, although it was somewhat more sharply peaked and heavy-tailed than a normal distribution.

DISCUSSION

In this region-based study of extreme heat and heat-related illness hospitalizations in Maricopa County, Arizona, between 2020 and 2026, I reached two central findings. First, the proportion of heat-related illness hospital visits increased faster when the daily high temperature was extremely high compared to when it was moderately high. Second, heat-related illness hospital visits were not significantly associated with daily high temperatures of 77 degrees F and below. It must be noted that this second finding reflects only the analyzed dataset and is not a clinically proven biological threshold.

A multitude of past studies have identified population subgroups most vulnerable to heat-related illness, including the elderly, males, Hispanics, non-Hispanic Blacks, migrants, and those with limited community-level resources. Hong et al. (2025) report that Hispanics and non-Hispanic Blacks experienced the highest increases in heat-related mortality between 2000 and 2023 in the United States, and a US Armed Forces study on exertional rhabdomyolysis identified non-Hispanic Black service members as one of the highest-risk groups in the military.^{14,15} Fletcher et al. (2012) also report an increased risk of hospitalization for acute renal failure among Hispanics and Blacks.⁸ Liu et al. (2026) and Ahn et al. (2026) both identified males as more vulnerable to heat-related depressive risks and impacts on respiratory health, respectively.^{16,17} Additionally, Slator et al. (2026), in a study on heat-related emergency medical services encounters, found that encounters more frequently involved males than females.¹⁸ Vaidyanathan et al. (2024) also found that more males than females visited the emergency department for heat-related illnesses in 2023.¹⁹ While finding similar overall risk between males and females, Zhou et al. (2026) found that females had a higher risk in areas with limited community-level resources.²⁰ van Selm et al. (2026) identified migrants as having an increased risk of heat-related illness due to language and cultural barriers.²¹ Numerous studies identified the elderly as especially vulnerable, with O’Lenick et al. (2025) finding disproportionate burdens among the oldest groups (i.e., older than 85 years of age) and Orlando et al. (2021) reporting that heat waves, defined as “consecutive days of high heat” by Benmarhnia et al. (2015), were correlated with increased mortality among the elderly.^{11,22,23} By comparison, Maricopa County has virtually identical percentages of these population subgroups as the entire United States, with the exception of Hispanic or Latino and non-Hispanic Black persons: 39.5% in Maricopa County versus 34.0% in the United States.^{24,25}

Previous studies have linked extreme heat exposure to numerous health conditions, including cardiovascular disease, respiratory diseases, renal damage, autoimmune diseases, rhabdomyolysis, and increased suicide risk. The 2021 Global Burden of Disease Study reports that cardiovascular diseases account for 47% of the total mortality attributed to heat in that year.²⁶ Flower et al. (2026) found evidence of increased risk of hospital admission for English patients during extreme heat for pneumonia and chronic obstructive pulmonary disease.²⁷ This finding was supported by Ahn et al. (2026), who found that higher temperatures were associated with significant increases in emergency department visits in South Korea.¹⁷ Furthermore, among the diseases Flower et al. (2026) studied, they also found the strongest evidence for an increased risk of admission for acute renal failure.²⁷ Yang et al. (2026) found that acute kidney injury was associated with higher peak core temperatures among Taiwanese farmers.²⁸ In New

York State, Fletcher et al. (2012) found an overall 9% increase in the risk of hospitalization for acute renal failure per increase of 5 degrees F.⁸ Ham et al. (2026) also discovered an association between extreme heat events and autoimmune diseases, of which the strongest association was with gastrointestinal autoimmune conditions.²⁹ Furthermore, Jayaraman et al. (2026) found that for every increase of 1 degree Celsius, the rate of suicide among young people increases by 0.75%, though this effect was only significant in the summer.³⁰ Rawson et al. (2017) also identified heat as a proven factor that increases the risk of rhabdomyolysis.³¹ These studies all point to extreme heat exacerbating or even causing a multitude of severe health complications.

With large groups of vulnerable populations and numerous health consequences, extreme heat is also placing greater strain on the healthcare system. Burke and Wilson (2026) argued that “As heat waves become increasingly frequent and intense, surges in demand for emergency care will occur against the backdrop of a delivery system struggling to accommodate even average volume.”³² This conclusion is supported by data from the Arizona Department of Health Services showing an 8 times increase in the cost of heat-related hospitalizations and a 6 times increase in the cost of emergency room visits from 2008 to 2022.⁵ A projection by Leuchter et al. (2025) predicted a national hospital bed shortage (i.e., 85% or higher hospital bed occupancy) for adult beds in 2032 and adult and pediatric beds combined in 2035 if current staffing and hospitalization rates do not change.³³ Additionally, Zeiner et al. (2026) found that a daily minimum temperature above 20.5 degrees Celsius (about 69 degrees Fahrenheit) for 2 consecutive days had the strongest association with increased dispatch activity of emergency medical services in Vienna, Austria, with more severe heatwaves producing stronger effects.³⁴ These studies suggest that intensifying extreme heat events, exacerbated by climate change, could lead to more hospitalizations for heat-related illnesses, contributing to a shortage in hospital capacity and services.

The current policy on extreme heat in Maricopa County focuses on outreach and heat relief centers. Utilizing a network of cooling centers, relief centers, and hydration stations created with the help of local businesses, nonprofits, and volunteers, water and air conditioning are provided for anyone who needs them.³⁵ This network operates from May 1st to September 30th each year, aiming to prevent heat-related illnesses and deaths among vulnerable populations during the hottest months of the year.³⁵ On the outreach side, calling 211 connects anyone with an agent who can point them to the nearest heat relief center.³⁶ Heat alerts, safety messaging, and online resources are also available from Maricopa County.^{37,38} These efforts have seen success, with the number of heat-related deaths in the county decreasing from 645 in 2023 to 608 in 2024 to 430 in 2025.³⁹

To mitigate the various health risks associated with extreme heat, van Selm et al. (2026) suggested the use of standardized heat-related illness symptom questionnaires and physiological monitoring for early detection.²¹ For the elderly, Orlando et al. (2021) found that reducing social isolation for those over 80 years of age reduced the impact that heatwaves have on their mortality.²² For patients diagnosed with exertional heat stroke, Epstein et al. (2026) recommended that “Clinical evaluation [for the patient] should continue for at least 48 hours to track organ damage and guide prognosis.”⁴⁰ These policy changes can save lives, especially as extreme heat events become more frequent and more intense.

The strengths of this study include its methods and area of focus: Phoenix, located in Maricopa County, is the fifth-largest city by population in the US and the hottest among large US cities.^{41,42} I also note several important limitations with my study. First, only one maximum temperature was given for each day, but there is variation within the county itself. For instance, according to the National Oceanic and Atmospheric Administration's National Centers for Environmental Information weather station data, the maximum temperatures on July 1st, 2026, were 89, 97, 99, 102, and 105 degrees F in Lichfield Park, Carefree, Fountain Hills, Phoenix, and Casa Grande, respectively.¹⁴ Second, the duration for which this maximum temperature was attained may also be variable. In addition, there is no specification on what time of day these hospital visits occur, which may hinder policies aimed at mitigating strain on healthcare services. This study also does not examine potential changes in healthcare-seeking behavior. Also, due to the ecological nature of this study, no inference can be drawn about specific individuals. Thus, this study cannot be used to establish individual-level risk. Additionally, this study's 6.5-year timeframe is relatively short for its assessment of long-term climate trends. Furthermore, this study only examines one modelling approach. With additional years of data in Maricopa County or other hot urban areas, future research could consider alternative modelling approaches, including generalized least-squares.

Finally, this study does not take into consideration potential confounding factors that could affect heat-related hospitalization rates, such as air pollution levels. Mock et al. (2026) discovered an interaction "between simultaneous acute temperature and PM_{2.5} exposures" among older Americans, suggesting that PM_{2.5} increases the risk of heat-related illness.¹⁰ Veneziano et al. (2026) found that extreme temperature and air pollution, especially particulate matter, NO₂, and wildfire smoke, "converge through shared biological pathways... to destabilize already fragile cardiovascular systems."⁴³ Ambient humidity and airflow affect how quickly and effectively sweat can evaporate to cool us, which could affect the risk of heat-related illness.⁴⁴ All these factors can influence the number of heat-related hospitalizations.

CONCLUSION

In conclusion, I found that the daily percentage of heat-related illness hospital visits among all hospital visits increased faster the higher the daily maximum temperature. This issue of extreme heat will persist given global warming. Thus, we need to take informed actions to mitigate the negative health effects of exposure to extreme heat. Coordinated responses among federal, state, and local government and community organizations are necessary to keep residents as safe as possible from extreme heat, especially for the most vulnerable individuals.

ACKNOWLEDGEMENTS

I thank Aaron Gettel and Melanie Rubio of the Maricopa County Department of Public Health for the provision of the temperature and heat-related illness hospital visits data, which made this analysis possible.

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