MILLIMAN REPORT

Excessive heat in North Carolina

Impacts on workers compensation costs and healthcare services utilization and claims

Commissioned by the Natural Resources Defense Council

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TABLE OF CONTENTS

1. Introduction

1.1 PURPOSE OF REPORT

The Natural Resources Defense Council (NRDC), a not-for-profit international environmental advocacy group, engaged Milliman, Inc. (Milliman), a premier global consulting and actuarial firm, to study the relationship between workers compensation costs, healthcare services utilization, and excessive heat in the state of North Carolina.

1.2 BACKGROUND

Extreme heat events are the largest source of weather-related mortality in the United States [1] and have documented impacts on both workers compensation claims[2] as well as negative health outcomes[3] and increased emergency department visits.[4] Furthermore, exposure to workplace heat stress is very likely to grow with climate change as the frequency of excessive heat days increases.[5]

According to NRDC, approximately 51 million workers in the United States are employed in the six industries with the highest average number of heat-related deaths each year. Of those, approximately 9 million reside in states with permanent workplace heat standards. Where they exist, heat standards typically apply to outdoor or agricultural work so the number of workers protected by these regulations is likely much lower. In North Carolina, a state with no existing workplace heat standards, NRDC estimates that 1.7 million workers (27% of the workforce) are employed in industries with a high heat risk.[6]

In its effort to advocate for both federal and state workplace heat standards, NRDC has asked Milliman to analyze the impact of excessive heat in North Carolina on workers compensation and health insurance claims. Milliman's analysis for NRDC was developed using measures of heat index for weather stations in and around North Carolina as detailed in Section 2 below. For workers compensation, we relied on National Council on Compensation Insurance (NCCI) workers compensation payroll, claim counts, and loss data as detailed in Section 3, and for healthcare utilization we relied on Milliman's Consolidated Health Cost Guidelines™ Sources Database (CHSD), as detailed in Section 4. These sections describe the source data, methods, and results for that portion of the analysis.

1.3 KEY FINDINGS

Six key findings from this analysis are as follows:

- The sample of workers compensation data generally shows that indemnity costs are strongly or moderately correlated with the heat metric of annual hours above a heat index of 90°F and correlations are statistically significant at the selected 0.15 significance level for all heat-exposed groups combined. However, the results comparing medical costs to this heat metric are moderate or weak and not statistically significant at the 0.15 level.

[1] National Weather Service (2019). Excessive heat information. Retrieved June 23, 2023, from https://www.weather.gov/phi/heat.
[2] Heinzerling, A. et al. (October 19, 2020). Risk Factors for Occupational Heat-Related Illness Among California Workers, 2000-2017. American Journal of Industrial Medicine 63, no. 12: 1145-1154. Retrieved June 23, 2023, from https://doi.org/10.1002/ajim.23191.
[3] Ebi, K.L. et al. (August 21, 2021). Hot Weather and Heat Extremes: Health Risks. The Lancet 398, no. 10301: 698-708. Retrieved June 23, 2023, from https://doi.org/10.1016/S0140-6736(21)01208-3.
[4] Fuhrmann, C.M. et al. (August 20, 2015). Impact of Extreme Heat Events on Emergency Department Visits in North Carolina (2007–2011). Journal of Community Health 41: 146-156. Retrieved June 23, 2023, from https://doi.org/10.1007/s10900-015-0080-7.
[5] Licker, R. et al. (January 13, 2022). Quantifying the Impact of Future Extreme Heat on the Outdoor Work Sector in the United States. Elementa: Science of the Anthropocene 10, no. 1. Retrieved June 23, 2023, from https://doi.org/10.1525/elementa.2021.00048.
[6] Constible, J. (April 17, 2023). Occupational Heat Safety Standards in the United States. NRDC. Retrieved June 23, 2023, from https://www.nrdc.org/resources/occupational-heat-safety-standards-united-states.

- Two heat-exposed groups in the workers compensation study (Cartage and Trucking, and Commercial Enterprises) show strong correlations between indemnity costs and this heat metric, with statistical significance at both 0.15 and 0.10 significance levels. Especially for Cartage and Trucking, the wage-adjusted ultimate indemnity severity shows the strongest correlation and is statistically significant even at the 0.05 level. In addition, the ultimate medical severity is moderately correlated with this heat metric and statistically significant at the 0.15 level.
- For the other two heat-exposed groups in the workers compensation study (Agriculture, Construction and Erection), we could not conclude that there are strong correlations between workers compensation claim costs (indemnity or medical) and this heat metric with statistical significance at the 0.15 level based on the sample data.
- After controlling for other factors, we found that there is strong statistical evidence of a correlation between extreme heat and all-cause healthcare utilization, which can extend beyond the immediate period and affect healthcare for at least three additional months. The statistical significance is at the 0.05 level or higher based on the healthcare sample data.
- There is complex interaction between heat events and an individual's health status and socioeconomic factors. Socioeconomic factors, such as employment status, access to healthcare resources, and living conditions, play a crucial role in shaping healthcare-seeking behaviors during extreme heat events and in the aftermath.

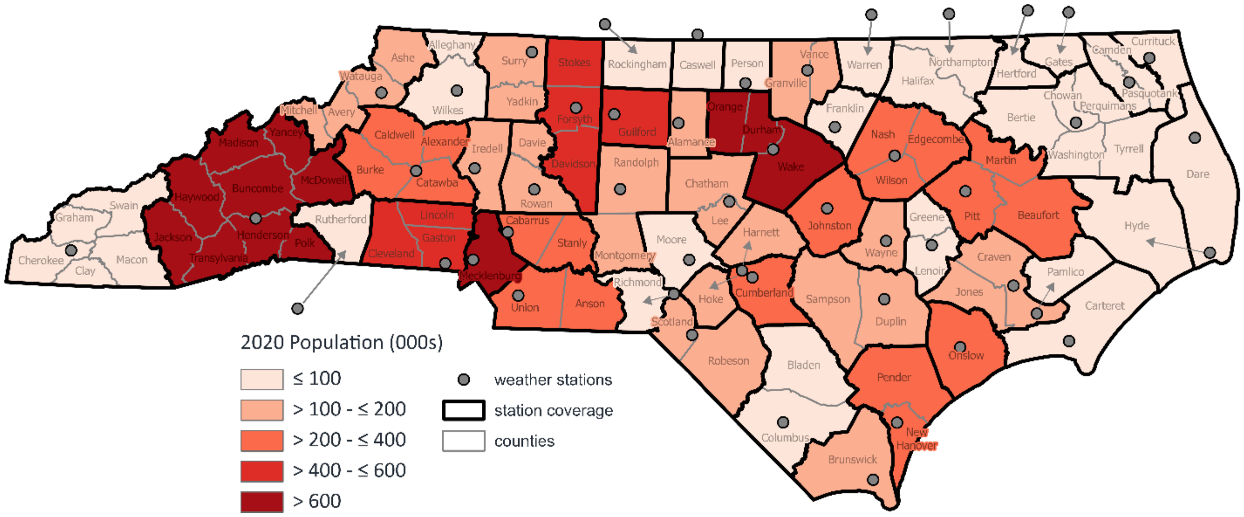
2. Heat index

2.1 DATA

We obtained weather data from the Local Climatological Data (LCD) dataset from the National Centers for Environmental Information (NCEI). The LCD dataset consists of observations from Automated Surface Observing System and Automated Weather Observing System stations. Weather stations with data available for the 2010-2019 period were included in the analysis if they reported valid data for 98% of the months within the time period considered. A month was considered valid if there were daily records available for 60% of the days in the month. Months with 30 days required 18 days of data to be considered valid and months with 31 days required 19 days. Fifty-one LCD stations were used in the final calculations (Figure 1). Additionally, we obtained 2020 population totals and coordinates for the geographic center of population for each county in North Carolina from the U.S. Census Bureau.[7]

[7] U.S. Census Bureau (2021). North Carolina 2020 Centers of Population. Retrieved June 23, 2023, from https://www2.census.gov/geo/docs/reference/cenpop2020/county/CenPop2020_Mean_CO37.txt.

FIGURE 1: DISTRIBUTION OF FINAL LOCAL CLIMATOLOGICAL DATA (LCD) STATIONS USED IN HEAT EVENT CALCULATIONS



Note: Boundaries represent single counties or combinations of counties represented by each weather station. Arrows indicate station-county relationship if the station lies outside of county coverage.

2.2 METHODS

To identify and quantify historical heat events, we first calculated the heat index (HI) for each one-hour interval of the study period. HI is calculated using temperature and relative humidity (see equations in Technical Appendix A1). These variables are reported at hourly or sub-hourly intervals depending on the reporting methods of the local weather station. Stations reporting sub-hourly data were averaged into single, hourly values of both temperature and relative humidity. Heat events were defined as one or more days during the study period where HI exceeds 90°F for one or more hours. A simple, static threshold of 90°F was recommended by NRDC because it both matches proposed workplace heat protection language and is more easily measurable, understood, and enforceable than locally defined thresholds or other measures of heat-related stress such as wet-bulb globe temperature (WBGT).

The workers compensation analysis, detailed in Section 3 below, relied on annual claims data by industry group. To support this analysis we developed annual metrics of excessive heat. For each weather station we calculated the following five statistics:

1. Number of hours exceeding a heat index of 90°F.
2. Heat event frequency: Average number of heat events.
3. Heat event duration: Average length of heat events in days.
4. Heat event season length: Length in days between the first and last heat events.
5. Heat event intensity: Average difference between heat event daily maximum HI and 90°F.

We then calculated the statewide population-weighted mean for each annual statistic:

$$W_s = \frac{\sum_{i=1}^{n}(S \times Pop_{st})}{Pop_{tot}}$$

where S is the statistic being calculated, Pop_{st} is the total population represented by a given weather station, n is the total number of weather stations, and Pop_{tot} is the total state population.

The total population represented by a given weather station is calculated as the sum of county populations with geographic population centers nearest to that weather station. Counties and the associated weather station used in our population weighting are shown in Figure 1 above.

The healthcare services analysis, detailed in Section 4, used claim-level data aggregated by month. To support this analysis, we calculated daily HI statistics as well as the start date and duration of each heat event in the study period.

2.3 RESULTS

The statewide annual statistics for the study period are shown in Figures 2 and 3. There is substantial variability across the observational period for the annual number of hours exceeding the static HI threshold (Figure 2) and annual heat event frequency, duration, season length, and intensity (Figure 3).

FIGURE 2: ANNUAL NUMBER OF HOURS EXCEEDING STATIC HEAT INDEX THRESHOLD OF 90°F

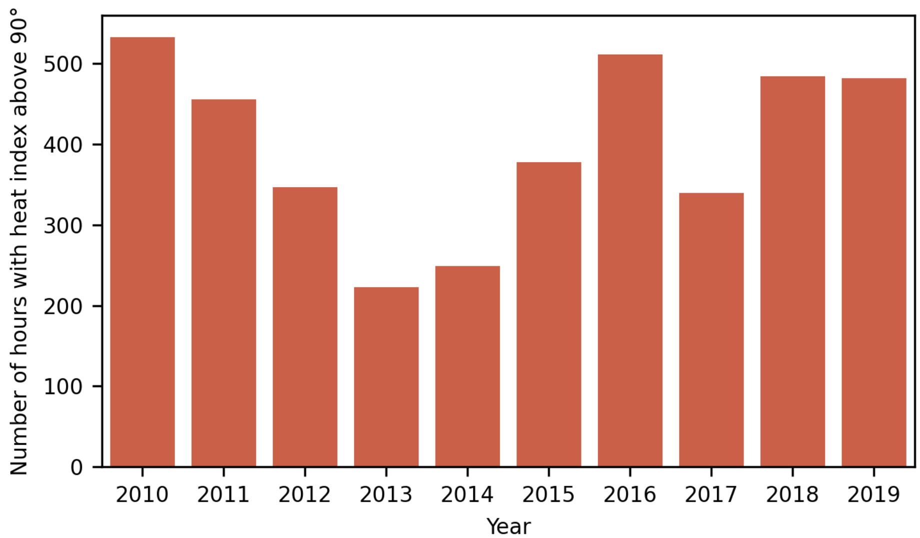
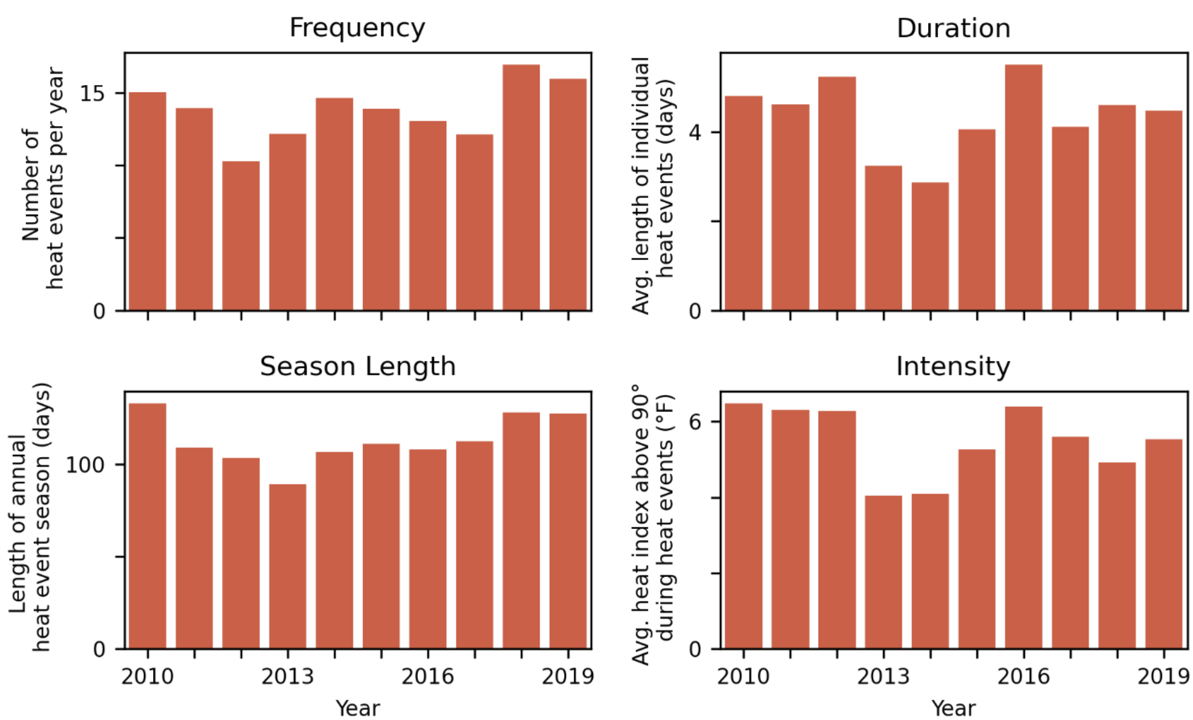


FIGURE 3: ANNUAL STATISTICS DESCRIBING HEAT EVENT FREQUENCY, DURATION, SEASON LENGTH, AND INTENSITY



3. Workers compensation

3.1 DATA

We relied on the National Council on Compensation Insurance (NCCI) Classification Experience Data in North Carolina. NCCI is the largest workers compensation rate-making and data-gathering organization in the United States. NCCI's Classification Experience Data provides summarized unit statistical plan data for payroll, premium, indemnity losses, medical losses, and claim counts for workers compensation insurance. The data report is organized by policy year, industry group, job classification code, and injury type. Specifically:

- NCCI's Classification Experience Data for policy years 2011 through 2018, evaluated as of 2021, was included in our analysis. This set of sample data generally minimizes the impacts that the COVID-19 pandemic and the uncertainty in the overall economy in 2022 (rising inflation and interest rates) might have on workers compensation claim costs. We reviewed policy year 2010 data, which was available to us in the data report, but decided to exclude it from our analysis due to the substantial negative impact that the 2007-2009 global financial crisis had on economic activity and its impact on workers compensation system costs throughout the United States.
- We used claim counts and loss amounts from workers compensation insurance experience.[8] Indemnity and medical losses were analyzed separately. Indemnity benefits consist of wage replacement and other statutory benefits provided to injured workers as compensation for their lost wages. Medical benefits reimburse claimants for their out-of-pocket medical costs and provide direct payments to providers, hospitals, pharmacies, etc. Under workers compensation insurance, indemnity benefits generally provide for two-thirds of an injured worker's lost wages (up to a limit) and medical benefits generally reimburse 100% of medical expenses. In North Carolina, there is a seven-day waiting period for indemnity benefits, but medical benefits are paid from the date of the injury (i.e., no waiting period).[9] Based on NCCI's Classification Experience Data evaluated as of 2021, the indemnity and medical portion of the losses are roughly 55% and 45%, respectively.[10]
- We combined the data on all injury types to obtain the total losses and claim counts used for this analysis.

Indemnity benefits are a function of wages and will vary due to different wage levels across heat study groups, as defined in Section 3.2 below. We used North Carolina annual wage data (years 2011 through 2018) from the Occupational Employment Statistics (OES) Survey, U.S. Bureau of Labor Statistics, to adjust indemnity losses for differences in wage levels across the heat study groups.

Heat data underlying various heat metrics is discussed in Section 2 above.

3.2 METHODS

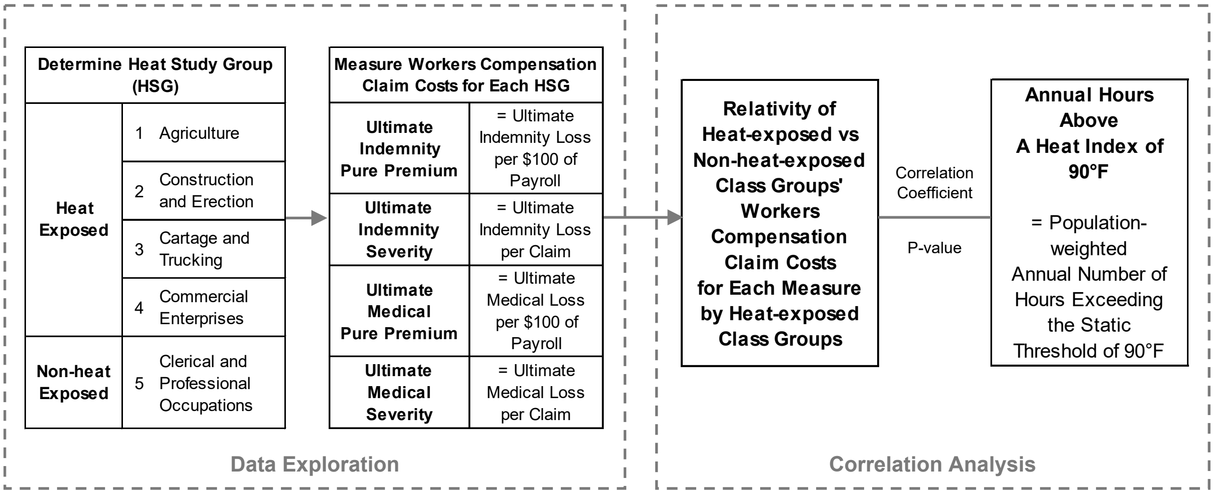
We performed a data exploration review followed by a correlation analysis to evaluate the relationship between excessive heat and workers compensation claim costs. This involved several steps, as summarized in Figure 4.

[8] Claim counts and loss amounts are on an ultimate (developed) basis due to the long-tailed nature of workers compensation insurance. The developed data provided by NCCI represents an estimated ultimate number of claims and ultimate amount of losses derived by adjusting the reported values by development factors.

[9] North Carolina Workers' Compensation Act. §97-28: Seven-day waiting period; exceptions. North Carolina Industrial Commission. Retrieved June 23, 2023, from https://www.ic.nc.gov/ncic/pages/statute/97-28.htm.

[10] Based on ultimate indemnity and medical losses for all class codes and injury types combined.

FIGURE 4: SUMMARY OF METHODS



We worked with NRDC to determine the appropriate heat study groups (HSGs) to identify the best heat-exposed and non-heat-exposed occupational classes for the analysis. NRDC is primarily interested in heat-exposed groups that represent large economic drivers in North Carolina. We selected four heat-exposed groups (HSGs 1-4) and one non-heat-exposed group (HSG 5), which is the control group. Figure 13 in the Technical Appendices shows the mapping of NCCI occupational classes to these heat study groups.

Various workers compensation claim cost measures, including ultimate indemnity pure premium (indemnity costs per $100 of payroll), ultimate indemnity severity (indemnity costs per claim), ultimate medical pure premium (medical costs per $100 of payroll), and ultimate medical severity (medical costs per claim), were calculated by policy year for each heat study group as well as for different combinations of heat study groups. As discussed in Section 3.1 above, we also adjusted the indemnity losses using an annual wage index. Ultimate indemnity pure premium and ultimate indemnity severity are shown on both an unadjusted basis and an adjusted basis.

We compared the various indicators of compensation claim costs between heat-exposed and non-heat-exposed groups by policy year using graphs. We then quantified the difference by calculating the relativity. Scatter charts were first plotted to visually examine the relationship between the claim cost relativity and the heat metric (annual hours above a heat index of 90°F). Then a more quantitative approach was used to calculate two key correlation statistics.

- The Pearson correlation coefficient (r): This statistic measures the strength of the relationship between two variables. The relationship is commonly considered to be strong, moderate, or weak when the absolute value is greater than 60%, between 40% and 60%, and below 40%, respectively.[11]
- P-value (p): This represents the probability that there is no relationship (null hypothesis). If the p-value is less than the selected significance level, correlations are considered statistically significant. It is a convention to set the significance level at 0.05, but key factors such as the sample size and power of the test should be considered when making selections.[12] Because only eight years of data were used in our analysis (i.e., sample size = 8, or degrees of freedom = 6), we set the significance level at 0.15.

Figures 5, 6, and 7 show how we analyzed the relationship between wage-adjusted ultimate indemnity severity and annual hours above a heat index of 90°F (the heat metric) for HSG 3, Cartage and Trucking.

[11] LaMorte, W. W. (April 21, 2021). PH717 Module 9 – Correlation and Regression. Boston University School of Public Health. Retrieved June 23, 2023, from https://sphweb.bumc.bu.edu/otlt/MPH-Modules/PH717-QuantCore/PH717-Module9-Correlation-Regression/PH717-Module9-Correlation-Regression4.html.

[12] Kim, J. H. (August 31, 2015). How to Choose the Level of Significance: A Pedagogical Note. La Trobe University Department of Economics and Finance. Retrieved June 23, 2023, from https://mpra.ub.uni-muenchen.de/66373/.

- For policy years 2011 to 2018, Figure 5 shows the wage-adjusted ultimate indemnity severity for HSG 3 (Cartage and Trucking) and HSG 5 (Clerical and Professional Occupations).
- Figure 6 shows the ratio (relativity) of indemnity severities and annual hours above a heat index of 90°F. The higher the ratio of the indemnity severities, the larger the difference between the indemnity severity for the heat-exposed group (in this case, HSG 3) and the indemnity severity for the non-heat-exposed group (HSG 5). The line shown on this graph is a simple least squares line between the ratios of the indemnity severities and the annual hours above a heat index of 90°F. An upward-sloping line indicates a positive relationship between the ratios for heat-to-non-heat indemnity and the heat metric—that is, indemnity severities for the heat-exposed group tend to be higher in years when the heat metric is higher.
- Columns (2) and (3) in Figure 7 are the indemnity severities in Figure 5. Column (4) is the ratio of these indemnity severities. Column (5) is the annual hours above a heat index of 90°F. The bottom of Figure 7 shows the sample size (eight years), the Pearson correlation coefficient (r) between the ratio of the indemnity severities in column (4) and the annual hours above a heat index of 90°F in column (5), 71.9%, and the p-value for the correlation coefficient, 0.04. In this case, the probability of this correlation occurring by chance is 4%, indicating there is a strong correlation between high indemnity severities and adverse heat conditions for HSG 3.

FIGURE 5: WAGE-ADJUSTED ULTIMATE INDEMNITY SEVERITY

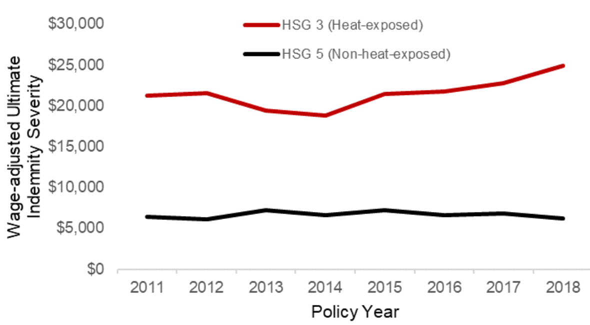


FIGURE 6: INDEMNITY SEVERITY RELATIVITY AND ANNUAL HOURS ABOVE A HEAT INDEX OF 90°F

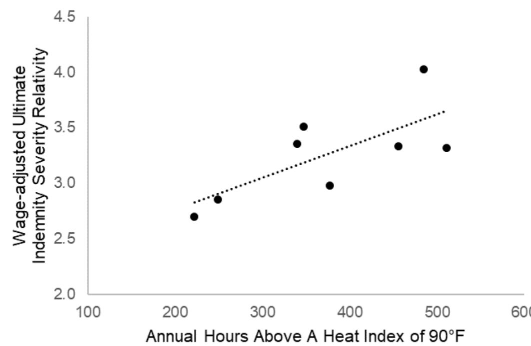


FIGURE 7: AN EXAMPLE OF ANALYZING THE RELATIONSHIP BETWEEN WAGE-ADJUSTED ULTIMATE INDEMNITY SEVERITY AND ANNUAL HOURS ABOVE A HEAT INDEX OF 90°F FOR HSG 3 CARTAGE AND TRUCKING

(1)	(2)	(3)	(4) = (2) ÷ (3)	(5)
Policy Year /	**Wage-adjusted Ultimate Indemnity Severity**			**Annual Hours Above A**
Calendar Year	**HSG 3**	**HSG 5**	**Relativity**	**Heat Index of 90°F**
2011	$21,276	$6,383	**3.33**	**455.84**
2012	21,554	6,142	**3.51**	**347.01**
2013	19,374	7,187	**2.70**	**222.38**
2014	18,758	6,567	**2.86**	**248.69**
2015	21,484	7,214	**2.98**	**377.65**
2016	21,778	6,570	**3.31**	**511.24**
2017	22,752	6,780	**3.36**	**339.38**
2018	24,925	6,186	**4.03**	**484.39**
			Sample Size	**8**
			Pearson correlation coefficient (r)	**71.9%**
			P-value (p)	**0.04**

This approach was used to analyze the workers compensation claim experience for each of the four heat-exposed groups and combinations of these groups against the annual hours above a heat index of 90°F as well as other heat metrics, including static frequency (average number of heat events per year) and static duration (average length of individual heat events in days).

3.3 RESULTS

The correlation (correlation coefficient and corresponding p-value) between the relativity of heat-exposed to non-heat-exposed groups' workers compensation claim costs and annual hours above a heat index of 90°F is shown in Figure 8 for each heat study group and claim cost measure combination. The results from the calculation described in Section 3.2 above can be seen in the row for HSG 3, Cartage and Trucking, under the column "Wage-adjusted Ultimate Indemnity Severity" and values have been highlighted with a bold box around it in Figure 8. The six compensation claim cost measures are described in Section 3.2.

In general, this sample data shows that indemnity costs are strongly or moderately correlated with annual hours above a heat index of 90°F (the first heat metric) and these correlations are statistically significant at the 0.15 level, for all heat-exposed groups combined. However, the results comparing medical costs to this heat metric are moderate or weak and not statistically significant at the 0.15 level. When looking at each individual heat study group:

- Cartage and Trucking (HSG 3) and Commercial Enterprises (HSG 5) show strong correlations between indemnity costs and this heat metric, and we can conclude that these correlations are statistically significant at both 0.15 and 0.10 significance levels. Especially for Cartage and Trucking, the wage-adjusted ultimate indemnity severity shows the strongest correlation (71.9%) with the lowest p-value (0.04) and thus is statistically significant even at the 0.05 level. In addition, the ultimate medical severity is moderately correlated (r is slightly lower than 60% with p-value of 0.13) with this heat metric and statistically significant at the 0.15 level.
- The correlation between medical costs and this heat metric is moderate for Agriculture (HSG 1), and the p-values are slightly higher than the selected significant level of 0.15. Therefore, even though a moderate correlation is seen, we could not conclude statistical significance at the 0.15 level. We have similar findings with the correlation between indemnity costs and this heat metric for Construction and Erection (HSG 2). Further research could be done with larger sample sizes (for example, more states or years could be included in the analysis).

FIGURE 8: CORRELATION BETWEEN RELATIVITY OF HEAT-EXPOSED VS. NON-HEAT-EXPOSED GROUPS' WORKERS COMPENSATION CLAIM COSTS AND ANNUAL HOURS ABOVE A HEAT INDEX OF 90°F

		Unadjusted Ultimate Indemnity Pure Premium		Wage-adjusted Ultimate Indemnity Pure Premium		Unadjusted Ultimate Indemnity Severity		Wage-adjusted Ultimate Indemnity Severity		Unadjusted Ultimate Medical Pure Premium		Unadjusted Ultimate Medical Severity	
	Heat Study Group	r	p-value	r	p-value	r	p-value	r	p-value	r	p-value	r	p-value
1	Agriculture	33.9%	0.41	17.9%	0.67	24.4%	0.56	8.2%	0.85	53.3%	0.17	52.3%	0.18
2	Construction and Erection	55.2%	0.16	55.7%	0.15	47.2%	0.24	47.3%	0.24	28.1%	0.50	31.2%	0.45
3	Cartage and Trucking	62.7%	0.10	63.9%	0.09	70.6%	0.05	71.9%	0.04	55.1%	0.16	58.0%	0.13
4	Commercial Enterprises	65.5%	0.08	66.6%	0.07	66.4%	0.07	66.6%	0.07	-11.8%	0.78	-13.7%	0.75
1-4	**All heat-exposed groups**	**61.6%**	0.10	**63.0%**	0.09	**58.9%**	0.12	**59.8%**	0.12	**36.0%**	0.38	**39.3%**	0.34

Negative Correlation			Positive Correlation		
Strong	Moderate	Weak	Weak	Moderate	Strong

The correlation between the relativity of heat-exposed versus non-heat-exposed groups' workers compensation claim costs and static frequency (the second heat metric) is shown in Figure 11 in the Technical Appendices. For all heat-exposed groups combined, indemnity severities are moderately correlated with static frequency and these correlations are statistically significant at the 0.15 level, but the results between medical costs and this heat metric are weak and not statistically significant. Agriculture (HSG 1) and Construction and Erection (HSG 2) generally show strong correlations[13] between indemnity costs and static frequency, and we can conclude that these correlations are statistically significant at the 0.15 level.

Figure 12 in the Technical Appendices shows the correlation between relativity of heat-exposed versus non-heat-exposed groups' workers compensation claim costs and static duration (the third heat metric). Overall, the correlation between the workers compensation claim costs and this heat metric are moderate or weak but not statistically significant at the 0.15 level, for all heat-exposed groups combined. Only Cartage and Trucking (HSG 3) shows a strong correlation between indemnity severities and static duration with statistical significance.

4. Healthcare services

4.1 CONCEPTUAL FRAMEWORK

Healthcare cost and utilization are driven by many factors, including an individual's health status, socioeconomic status, health insurance benefit coverage and plan design, provider efficiency and quality, advancements in managing and treating diseases, seasonality, environmental factors such as extreme heat, and other significant external drivers such as healthcare reforms, economic expansions and recessions, and, more recently, the COVID-19 pandemic. In our modeling, the cost and utilization measures are the model's dependent variables, whereas the cost and utilization drivers are the model's explanatory variables.

4.2 DATA

We combined three major sources of data to model the impact of extreme heat on healthcare utilization in North Carolina—healthcare claims administrative data, social determinants of health (SDOH) data from the Centers for Disease Control and Prevention (CDC), and the heat index data discussed in Section 2 above.

4.2.1 Healthcare Claims Data – Milliman CHSD

The Consolidated Health Cost Guidelines™ Sources Database is Milliman's proprietary longitudinal healthcare claims database, aggregated across national and regional health plans, healthcare providers, and self-insured employers, across multiple years and multiple lines of business. We selected 2017 to 2019 as the study period, to ensure relative stability of costs after the major healthcare reforms, but before the COVID-19 pandemic. We then limited the data to people residing in North Carolina with at least 10 months of medical and pharmacy coverage. In the CHSD, for purpose of de-identification, adjacent counties were reported together to form larger geographic areas, which we refer to as "super-counties" in this report. Figure 9 provides a high-level description of the population sample used (left side of the figure), as well as the socioeconomic characteristics of the geographic areas represented by the population sample (right side of the figure).

[13] Correlations between wage-adjusted indemnity costs and static frequency are moderate for Agriculture as the correlation coefficients are slightly lower than 60%.

FIGURE 9: MODEL DEVELOPMENT SAMPLE DESCRIPTIVE STATISTICS, 2017-2019 NORTH CAROLINA FROM MILLIMAN CHSD*

Coverage Type	Year	Total Member Months	Average Age	% Female
Commercial	2017	2,552,421	39.7	54.5%
	2018	2,420,146	38.9	53.8%
	2019	2,288,252	37.9	52.9%
Medicaid	2017	17,893	19.9	59.0%
	2018	16,259	20.4	59.8%
	2019	16,147	19.9	60.9%
Medicare	2017	972,780	72.5	57.8%
	2018	1,109,576	73.0	55.5%
	2019	1,364,774	73.3	55.1%

Average Values of Socioeconomic Characteristics, Geographic Areas Represented in the Model Development Data Sample, 2017-2019	
% Unemployment	3.1%
% With limited English language capabilities	1.9%
% Nonwhite minorities	33.3%
% Uninsured	11.1%
% Living in mobile homes	8.0%
% Living in crowded housing units	0.9%
% Without vehicle	2.4%
% Living in group quarters	3.3%

* Note: The average values of socioeconomic characteristics included in the above were obtained from the CDC's Social Vulnerability Index (SVI) for 2018, matched to the CHSD's geographic distribution in North Carolina by super-county.

4.2.2 Social determinants of health data – Social Vulnerability Index from the CDC

Socioeconomic factors have been found to have significant impacts on healthcare cost, utilization, and health outcomes in recent years.[14] The CDC's Social Vulnerability Index (SVI)[15] is a tool designed to assess and measure the vulnerability of communities in the presence of external stresses on human health. Such stresses include weather- or geological-related disasters, technological disasters, and disease outbreaks. The SVI also considers a range of factors such as socioeconomic status, household composition, minority status, and language proficiency to identify communities that may face challenges in preparing for, responding to, and recovering from disasters or health emergencies. The SVI is available at the county or census tract level.

4.2.3 Heat event data

We calculated the total number of heat event days in a super-county during a month using the static heat event definition described in Section 2.2 above.

4.3 METHODS

4.3.1 Healthcare cost and utilization measures

Based on existing literature and our domain knowledge, we selected a set of healthcare cost and utilization measures to model the impact of climate events; these measures were our starting set of dependent variables in modeling. They were all calculated using the North Carolina portion of the CHSD and the Milliman Health Cost Guidelines grouping methodology, and represent healthcare services from all causes, not just heat-related causes.[16]

4.3.2 Relative risk scores for measuring health status

In health services research, relative risk scores have been widely used to quantify an individual's health risks relative to the general population.[17] Relative risk scores are derived from healthcare claims data and account for factors such as age, gender/sex, and medical and prescription drug history. The relative risk scores are calculated at the individual level and then aggregated. A 1.0 relative risk score implies that the individual is expected to consume the average amount of healthcare resources as a reference population. A 1.5 relative risk score implies that the individual is expected to spend 1.5 times the average amount of healthcare resources of a reference population. For this project, we used the Medicare Centers for Medicare and Medicaid

[14] There is a large body of academic research on this topic. HHS maintains a web page of SDOH bibliography of selected recent publications, available at https://health.gov/healthypeople/priority-areas/social-determinants-health/literature-summaries.
[15] For details, please refer to https://www.atsdr.cdc.gov/placeandhealth/svi/index.html.
[16] See https://www.medinsight.milliman.com/-/media/medinsight/pdfs/medinsight-health-cost-guidelines-hcg-grouper.ashx.
[17] There is a large body of academic and industry research on relative risk scores and the methodologies and applications in health policymaking and healthcare reforms. For instance, see https://www.soa.org/4937c5/globalassets/assets/files/research/research-2016-risk-scoring-health-insurance.pdf.

Services hierarchical condition category (CMS-HCC) community relative risk scores for the Medicare portion of the population, and the U.S. Department of Health and Human Services (HHS)-HCC for the platinum metal level relative risk scores for the non-Medicare portion of the population.

Risk scores aim to predict healthcare spending accurately at the population level but can be imprecise at the individual or subgroup level. For instance, the 2020 CMS-HCC model is found to be underpredicting Medicare spending for those with “Substance Use Disorder, Mild, Except Alcohol and Cannabis” (HCC56) by about 15%, and overpredicting for those with “Diabetes with Chronic Complications” (HCC18) by 0.4%. There are many other HCCs that the model predicts perfectly, or nearly perfectly.[18] It is conceivable that imperfect risk adjustment could distort the model results by either muting or intensifying the statistical significance and magnitude of the explanatory variables.

4.3.3 Joining data by geography

We joined the healthcare cost, utilization measures, relative risk scores, extreme heat data, and health-related socioeconomic data at the super-county level.

4.3.4 Modeling

Best practices in model development balance accuracy, efficiency, complexity, suitability, and interpretability. Using machine learning, we identified the most important drivers of healthcare cost and utilization and explored the complex interactions among the different drivers (also known as “feature engineering”). We developed generalized linear models (GLMs) for cost and utilization to estimate the direction and magnitude of the significant risk drivers. These models included more than 60 explanatory variables, with zero-, one-, two-, and three-month lags to test whether extreme heat that occurred in one month would impact healthcare utilization in future months. In this process, we also tested for collinearity among the risk drivers to ensure that the models are robust.

4.4 RESULTS

The relative ranking of the explanatory variables and the direction of their impact on healthcare utilizations are summarized in Figure 10. All variables included in the figure are significant at the 0.05 level. The relative ranking of the explanatory variables is based on standardized coefficients from generalized linear models. Cells highlighted in red are in the top 10 explanatory variables for a specific utilization count. This table does not include the complete set of explanatory variables used in modeling, but only those that relate to health status, health-related socioeconomic factors, and heat events, labeled as “direct effect” in the table, as well as their two-way and three-way interactions, labeled as “interaction effect.” A positive sign means the coefficient associated with the explanatory variable is positive, meaning that, when everything else is held constant, increases in the explanatory variable will result in an increase in the utilization count in the model. A negative sign, on the other hand, means that, when everything else is held constant, increases in the explanatory variable will result in a decrease in the utilization count in the model.

[18] See the predictive ratios analysis from CMS’s Report To Congress: Risk Adjustment in Medicare Advantage (December 2021), Table 5-20a, available at https://www.cms.gov/files/document/report-congress-risk-adjustment-medicare-advantage-december-2021.pdf).

FIGURE 10: GENERALIZED LINEAR MODELS, PREDICTING HEALTHCARE UTILIZATION COUNTS
RANKING OF STANDARDIZED COEFFICIENTS OF FIXED EFFECT

			Medical Admissions		Emergency Department		Urgent Care Visits		Primary Care Visits		Specialist Visits	
			Rank	Sign	Rank	Sign	Rank	Sign	Rank	Sign	Rank	Sign
Health Status	Direct Effect	RiskScore (RS)	2	+	46	-	15	+	3	+	2	+
	Interaction effect	RS x %unemployment	58	-	3	+	11	-	6	+	40	+
		RS x %w limited English language capabilities	50	+	53	-	22	+	40	-	20	-
		RS x %identified as nonwhite	38	+	13	+	18	+	35	-	28	+
		RS x %uninsured	42	+	7	-	13	+	27	-	55	+
		RS x %living in mobile homes	44	+	41	-	24	+	55	-	44	-
		RS x %living in crowded housing units	47	-	36	-	6	+	58	+	4	-
		RS x %without vehicle	57	+	20	+	4	-	36	+	5	-
		RS x %living in group quarters	46	-	31	+	51	+	43	+	29	-
Current month's heatwave	Direct Effect	Current HW days (HW 0 Lag)	14	-	19	+	31	-	13	+	24	+
	Interaction effect	HW 0 lag x RS x %unemployment	15	+	4	-	10	+	32	-	50	+
		HW 0 lag x RS x %w limited English language capabilities	45	-	22	+	25	+	37	-	17	+
		HW 0 lag x RS x %identified as nonwhite	36	+	32	+	19	+	48	-	30	+
		HW 0 lag x RS x %uninsured	55	-	29	-	49	+	34	-	12	-
		HW 0 lag x RS x %living in mobile homes	33	-	44	-	40	+	57	-	47	+
		HW 0 lag x RS x %living in crowded housing units	18	+	51	-	7	-	42	+	6	-
		HW 0 lag x RS x %without vehicle	20	-	28	+	16	-	52	-	49	-
		HW 0 lag x RS x %living in group quarters	43	+	42	+	56	-	53	+	42	-
Previous month's heatwave	Direct Effect	Heatwave days 1 month ago (HW 1 Lag)	54	+	26	-	52	-	16	-	59	+
	Interaction effect	HW 1 lag x RS x %unemployment	27	-	11	+	5	-	44	-	32	-
		HW 1 lag x RS x %w limited English language capabilities	11	+	39	+	43	-	26	-	26	+
		HW 1 lag x RS x %identified as nonwhite	9	+	12	-	30	+	12	-	53	+
		HW 1 lag x RS x %uninsured	21	+	40	+	48	+	50	+	33	+
		HW 1 lag x RS x %living in mobile homes	8	+	17	+	41	-	9	-	15	+
		HW 1 lag x RS x %living in crowded housing units	4	-	25	+	37	+	5	+	16	-
		HW 1 lag x RS x %without vehicle	16	-	18	-	9	+	10	+	46	-
		HW 1 lag x RS x %living in group quarters	29	-	43	-	53	-	39	+	43	-
Previous 2 months' heatwave	Direct Effect	Heatwave days 2 months ago (HW 2 Lag)	19	+	34	-	14	+	21	+	25	-
	Interaction effect	HW 2 lag x RS x %unemployment	48	+	15	-	59	+	28	+	13	-
		HW 2 lag x RS x %w limited English language capabilities	5	-	27	-	26	+	46	+	58	+
		HW 2 lag x RS x %identified as nonwhite	13	-	14	+	32	-	41	+	41	+
		HW 2 lag x RS x %uninsured	24	+	10	+	28	-	30	-	51	+
		HW 2 lag x RS x %living in mobile homes	23	-	49	+	50	+	20	+	45	-
		HW 2 lag x RS x %living in crowded housing units	53	+	23	-	12	-	14	-	31	+
		HW 2 lag x RS x %without vehicle	6	+	24	+	45	+	31	-	14	+
		HW 2 lag x RS x %living in group quarters	34	-	30	-	54	+	22	-	56	-
Previous 3 months' heatwave	Direct Effect	Heatwave days 3 months ago (HW 3 Lag)	41	-	33	+	17	-	33	-	36	+
	Interaction effect	HW 3 lag x RS x %unemployment	7	+	8	+	21	+	7	-	8	+
		HW 3 lag x RS x %w limited English language capabilities	10	+	9	+	34	+	8	-	52	-
		HW 3 lag x RS x %identified as nonwhite	49	+	45	-	3	+	38	-	37	-
		HW 3 lag x RS x %uninsured	12	-	5	-	36	+	56	+	34	-
		HW 3 lag x RS x %living in mobile homes	40	-	47	-	46	+	11	-	48	+
		HW 3 lag x RS x %living in crowded housing units	17	-	37	-	8	-	4	+	57	-
		HW 3 lag x RS x %without vehicle	26	-	6	-	38	-	19	+	23	-
		HW 3 lag x RS x %living in group quarters	35	+	21	+	20	-	18	+	54	-

The direct and interaction effects associated with heat events from the current models and the previous one, two, and three months are statistically significant at the 0.05 level in all of the utilization models. This is strong statistical evidence that there is a correlation between extreme heat and utilization extending beyond the immediate period and for at least three additional months. One possible explanation is that individuals may experience health issues related to extreme heat exposure that require ongoing medical attention and care.

Looking at the direction of the indirect effects associated with heat events, we can see that the impact of heat events is not evenly distributed across the population and can be associated with either an increase or decrease of a specific healthcare utilization depending on its complex interactions with an individual's health status and socioeconomic factors. This is further supported by the observation that none of the direct heat event effects are ranked in the top 10 explanatory variables but some of the interaction effects are.

Additionally, the ranking order of the lagged explanatory variables reveals an interesting pattern. It shows that there are more three-month-lag variables in the top 10 compared to the other two sets of lags. Moreover, this pattern is observed in a larger number of utilization models. This implies that the association between heat events and utilization becomes stronger as the lag time increases. Said differently, other non-heat factors may overshadow the effect of heat events in the shorter lag periods. Even when individuals face similar levels of heat exposure and have similar demographic and health profiles, their utilization of healthcare services can vary significantly based on their socioeconomic circumstances. The examples of this variation are diverse, and the underlying patterns are complex, suggesting that factors such as employment status, language barriers, access to healthcare resources, social support, and living conditions (such as without air conditioning or in crowded housing arrangements) may play crucial roles in shaping healthcare-seeking behaviors during extreme heat events. As an example, in the medical admissions model, we found that the interactions between health status, average area unemployment rate, and heat event days have a statistically significant and positive coefficient in the zero-, one-, two-, and three-month lag models. The interpretation is that, if individuals with similar health status but living in different geographic areas with different unemployment situations are facing the same exposure to heat events, then the areas where the unemployment rate is higher would see higher medical admissions for the current month and for at least three more months.

Healthcare utilization encompasses a range of measures, such as hospital admissions, emergency department (ED) visits, medication usage, or primary care visits. Extreme heat may have varying effects on these different measures. For example, our models suggest that, everything else held constant, when heat event days increase in the current month, there is a decrease in medical admissions and urgent care visits, but an increase in ED visits, primary care physician (PCP) visits, and specialist visits (see the “Current HW days [HW 0 Lag]” row in Figure 10). This indicates the need to examine specific healthcare utilization measures individually to understand the full impact of extreme heat on healthcare systems.

Modeling the impact of climate events on cost directly is difficult because the variation in unit costs is large and could overshadow the specific impact of extreme heat. However, by using reference costs associated with different types of medical services, it may be possible to estimate an approximate cost for each additional utilization count modeled. This approach allows for an indirect estimation of the cost impact of climate events on healthcare utilization by considering the additional services required because of those events.

Please note that, if workers compensation insurance covers an individual’s medical expenses due to extreme heat, then healthcare payers would not pay such claims and such data would not enter into the claims database. While our model development data does not include medical services covered by workers compensation, they may still be of useful reference for how providers treat patients with heat-related and heat-induced illnesses.

Healthcare claims typically do not capture death information, except when death occurs during hospitalization. As such, we cannot rely on healthcare claims to estimate heat-induced deaths.

5. Limitations

USE OF REPORT

The data and exhibits in this report are provided to support the conclusions contained herein, limited to the scope of work specified by NRDC, and may not be suitable for other purposes. Milliman is available to answer any questions regarding this report or any other aspect of our review.

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DATA RELIANCE

In performing the services, we relied on data and other information obtained from National Centers for Environmental Information, U.S. Census Bureau, National Council on Compensation Insurance, Centers for Disease Control and Prevention (CDC), and other sources. Beyond the scope of work as previously described, we did not audit, verify, or review the data and other information for reasonableness and consistency. Such a review is beyond the scope of our assignment. If the underlying data or information is inaccurate or incomplete, the results of our analysis may likewise be inaccurate or incomplete. In that event, the results of our analysis may not be suitable for the intended purpose.

GENERALIZABILITY OF RESULTS

We note that the results from the Health Services section are based on a subset of the population residing in North Carolina during 2017 to 2019, and with medical and pharmacy coverage provided by commercial health insurance, Medicare, and Medicaid. We caution that the model results may not be generalizable to the subpopulations that are not included in the model development sample, especially the uninsured or under-insured populations who are more likely to be impacted by extreme heat due to lack of protection. It is conceivable that our models may not capture the full extent of the correlations between extreme heat and healthcare utilization for uninsured and under-insured North Carolinians.

VARIABILITY OF RESULTS

Any projection of future loss relativities involves estimates of future contingencies. While our analysis is based on sound actuarial principles, it is important to note that variation from the projected result is not only possible, but, in fact, probable. While the degree of such variation cannot be quantified, it could be in either direction from the projections. Such uncertainty is inherent in any set of actuarial projections.

Our estimates make no provision for extraordinary future emergence of new classes of losses or types of losses not sufficiently represented in historical databases or that are not yet quantifiable, including the potential impact of the COVID-19 pandemic.

There is substantial uncertainty regarding the impact of COVID-19 on the level and nature of business activity. Exposures, claim frequency, and claim severity will likely be affected in ways that present challenges to estimate. It is important to recognize that actual losses may emerge significantly higher or lower than the estimates in this analysis.

It is unknown how the COVID-19 pandemic may affect the availability and timeliness of medical treatment (whether or not related to COVID-19). This may affect the amount and timing of future claim payments.

The global economy experienced a dramatic increase in inflation during 2021, which continued through 2022. It is unknown whether this is a short-term shift or whether it will be sustained for years into the future, and the impact on the claims experience is as of yet unclear. Loss trend rates tend to be positively correlated with inflation, and the ultimate cost of claims is affected by the cost levels from the time claims occur through the time claim payments are made, which may be years in the future. The uncertainty with respect to future inflation levels and claim cost levels thus increases the uncertainty of the loss estimates.

UNCERTAINTY

Differences between our projections and actual amounts depend on the extent to which future experience conforms to the assumptions made for the analyses. It is certain that actual experience will not conform exactly to the assumptions used in these analyses. Actual amounts will differ from projected amounts to the extent that actual experience is better or worse than expected.

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Technical Appendices

A1. Heat index

Heat event calculations are based on the National Weather Service (NWS) definition of the heat index[19] (HI) as follows.

Eq. 1 $HI = -42.379 + 2.04901523T + 10.14333127rh - 0.22475541Trh - 0.00683783T^2 - 0.05481717rh^2 + 0.00122874T^2rh + 0.00085282Trh^2 - 0.00000199T^2rh^2$

where:

HI is the Heat Index (°F), T is air temperature (°F), and rh is relative humidity.

T is between 80 and 112°F and rh is less than 13%, the Heat Index is calculated as:

Eq. 2 $$HI_{a1} = HI - \left(\frac{13-rh}{4}\right) \times \sqrt{\left\{\frac{[17-abs(T-95)]}{17}\right\}}$$

where T is between 80 and 87°F and rh is greater than 85%, the Heat Index is calculated as:

Eq. 3 $$HI_{a2} = HI + \left[\frac{(rh-85)}{10}\right] \times \left[\frac{(87-T)}{5}\right]$$

where, finally, HI is less than 80°F, the Heat Index is calculated as:

Eq. 4 $$HI_2 = 0.5 \times \{T + 61 + [(T-68) \times 1.2] + (rh \times 0.094)\}$$

Using the equations above and following the NWS guidelines, the HI is calculated for hourly temperatures in the following order:

1. Heat index (HI_2) is first calculated using *Eq. 4*. This result is then averaged with *T*. If the average of HI_2 and *T* is < 80°, the final HI value will be calculated according to *Eq. 4*.
2. If the average of HI_2 and temperature is ≥ 80° and *T* and *rh* do not meet the criteria for adjustments outlined by *Eq. 2* and *Eq. 3*, the HI will be calculated according to *Eq. 1* (*HI*).
3. Where *T* and *rh* meet the criteria for adjusted outlined by *Eq. 2* and *Eq. 3*, *HI* will be adjusted according to the corresponding equation.

[19] National Weather Service (May 12, 2022). The Heat Index Equation. Weather Prediction Center. Retrieved June 23, 2023, from http://www.wpc.ncep.noaa.gov/html/heatindex_equation.shtml.

A2. Workers compensation

FIGURE 11: CORRELATION BETWEEN RELATIVITY OF HEAT-EXPOSED VS. NON-HEAT-EXPOSED GROUPS' WORKERS COMPENSATION CLAIM COSTS AND STATIC FREQUENCY

		Unadjusted Ultimate Indemnity Pure Premium		Wage-adjusted Ultimate Indemnity Pure Premium		Unadjusted Ultimate Indemnity Severity		Wage-adjusted Ultimate Indemnity Severity		Unadjusted Ultimate Medical Pure Premium		Unadjusted Ultimate Medical Severity	
	Heat Study Group	**r**	**p-value**	**r**	**p-value**	**r**	**p-value**	**r**	**p-value**	**r**	**p-value**	**r**	**p-value**
1	Agriculture	65.1%	0.08	58.7%	0.13	67.8%	0.06	59.1%	0.12	13.8%	0.74	20.8%	0.62
2	Construction and Erection	65.8%	0.08	67.7%	0.07	60.9%	0.11	62.1%	0.10	-2.9%	0.95	7.1%	0.87
3	Cartage and Trucking	39.5%	0.33	37.7%	0.36	34.5%	0.40	32.5%	0.43	54.1%	0.17	55.2%	0.16
4	Commercial Enterprises	50.0%	0.21	48.8%	0.22	57.8%	0.13	55.7%	0.15	-26.7%	0.52	-24.4%	0.56
1-4	**All heat-exposed groups**	**55.6%**	0.15	**54.5%**	0.16	**59.0%**	0.12	**58.1%**	0.13	**10.1%**	0.81	**18.0%**	0.67

FIGURE 12: CORRELATION BETWEEN RELATIVITY OF HEAT-EXPOSED VS. NON-HEAT-EXPOSED GROUPS' WORKERS COMPENSATION CLAIM COSTS AND STATIC DURATION

		Unadjusted Ultimate Indemnity Pure Premium		Wage-adjusted Ultimate Indemnity Pure Premium		Unadjusted Ultimate Indemnity Severity		Wage-adjusted Ultimate Indemnity Severity		Unadjusted Ultimate Medical Pure Premium		Unadjusted Ultimate Medical Severity	
	Heat Study Group	**r**	**p-value**	**r**	**p-value**	**r**	**p-value**	**r**	**p-value**	**r**	**p-value**	**r**	**p-value**
1	Agriculture	12.7%	0.76	0.7%	0.99	-1.2%	0.98	-13.0%	0.76	49.7%	0.21	44.2%	0.27
2	Construction and Erection	26.7%	0.52	26.8%	0.52	21.0%	0.62	20.9%	0.62	33.6%	0.42	32.1%	0.44
3	Cartage and Trucking	52.8%	0.18	54.7%	0.16	64.7%	0.08	66.8%	0.07	36.5%	0.37	39.9%	0.33
4	Commercial Enterprises	51.3%	0.19	53.3%	0.17	46.6%	0.24	47.9%	0.23	7.1%	0.87	3.5%	0.93
1-4	**All heat-exposed groups**	**42.3%**	0.30	**45.0%**	0.26	**36.4%**	0.38	**38.3%**	0.35	**36.8%**	0.37	**36.5%**	0.37

FIGURE 13: NCCI OCCUPATIONAL CLASSIFICATION AND HEAT STUDY GROUP MAPPING

Class Code	Class Group	Class Name	Heat Study Group	
5	10	NURSERY EMPLOYEES	1	Agriculture
8	10	GARDENING-MARKET OR TRUCK	1	Agriculture
16	10	FARM-ORCHARD	1	Agriculture
34	10	POULTRY OR EGG PRODUCER	1	Agriculture
35	10	FLORIST-CULTIVATING OR GARDENING	1	Agriculture
36	10	FARM--DAIRY & DRIVERS	1	Agriculture
37	10	FARM--FIELD CROPS & DRIVERS	1	Agriculture
79	10	FARM-BERRY OR VINEYARD	1	Agriculture
83	10	ARTIFICIAL INSEMINATION OF CATTLE--ALL OTHER EMPLOYEES & DRIVERS	1	Agriculture
106	10	TREE PRUNING, SPRAYING	1	Agriculture
113	10	FARM-FISH HATCHERY	1	Agriculture
170	10	FARM-ANIMAL RAISING-FUR BEARING	1	Agriculture
2702	10	LOGGING OR LUMBERING	1	Agriculture
2709	10	LOGGING OR TREE REMOVAL--MECHANIZED EQUIPMENT OPERATORS	1	Agriculture
2727	10	LOG HAULING	1	Agriculture
401	12	COTTON GIN OPERATION	1	Agriculture
5506	261	AIRPORT CONSTRUCTION--PAVING & DRIVERS	2	Construction & Erection
5507	261	STREET OR ROAD CONSTRUCTION-CLEARING OF RIGHT OF WAY	2	Construction & Erection
7855	262	RAILROAD CONSTRUCTION-MAINTENANCE OF WAY BY CONTRACTORS	2	Construction & Erection
6204	263	DRILLING-NOC	2	Construction & Erection
42	264	LANDSCAPE GARDENING	2	Construction & Erection
50	264	FARM MACHINERY OPERATION	2	Construction & Erection
6217	264	EXCAVATING-NOC	2	Construction & Erection
6003	265	PILE DRIVING	2	Construction & Erection
6229	266	IRRIGATION OR DRAINAGE SYSTEM CONSTR.	2	Construction & Erection
6233	266	OIL OR GAS PIPE LINE CONSTR.	2	Construction & Erection
6306	266	SEWER CONSTRUCTION-ALL OPERATIONS	2	Construction & Erection
6319	266	GAS MAINS OR CONNECTIONS CONSTR.	2	Construction & Erection
6325	266	CONDUIT CONSTR.-FOR CABLES OR WIRES	2	Construction & Erection
3365	268	WELDING OR CUTTING-NOC	2	Construction & Erection
7538	269	ELECTRIC LIGHT OR POWER LINE CONSTR.	2	Construction & Erection
5040	270	IRON OR STEEL ERECTION-IRON OR STEEL FRAMES	2	Construction & Erection
5057	270	IRON OR STEEL ERECTION-NOC	2	Construction & Erection
5059	270	IRON OR STEEL ERECTION-FRAME STRUCTURES NOT OVER 2 STORIES	2	Construction & Erection
5102	270	DOOR-FRAME OR SASH ERECTION	2	Construction & Erection
9534	270	MOBILE CRANE AND HOISTING SERVICE CONTRACTORS-NOC	2	Construction & Erection
5146	271	FURNITURE OR FIXTURES INSTALLATION-OFFICES OR STORES	2	Construction & Erection
5183	271	PLUMBING-NOC	2	Construction & Erection
5188	271	AUTOMATIC SPRINKLER INSTALLATION	2	Construction & Erection
5535	271	ALUMINUM, VINYL, OR SHEET METAL SIDING INSTALLATION & DRIVERS	2	Construction & Erection
5537	271	HEATING, VENTILATION, AIR-CONDITION & REFRIG SYSTEMS - INSTALL, SERVICE, REPAIR & DRIVERS	2	Construction & Erection
3724	272	MILLWRIGHT WORK NOC	2	Construction & Erection
3726	272	BOILER INSTALLATION OR REPAIR-STEAM	2	Construction & Erection
5160	272	ELEVATOR ERECTION OR REPAIR	2	Construction & Erection
5190	272	ELECTRICAL WIRING-IN BUILDINGS	2	Construction & Erection
7605	272	BURGLAR ALARM-INSTALLATION OR REPAIR	2	Construction & Erection
5213	273	CONCRETE CONSTRUCTION-NOC	2	Construction & Erection
5215	273	CONCRETE WORK-CONSTR. OF PRIVATE RESIDENCE	2	Construction & Erection
5221	273	CONCRETE OR CEMENT WORK-FLOOR,DRIVEWAYS,YARDS OR SIDEWALKS	2	Construction & Erection
5222	273	CONCRETE CONSTRUCTION-W/BRIDGES OR CULVERTS	2	Construction & Erection
5223	273	SWIMMING POOL CONSTRUCTION-NOT IRON OR STEEL	2	Construction & Erection
5020	274	CEILING INSTALLATION	2	Construction & Erection
5403	274	CARPENTRY-NOC	2	Construction & Erection
5437	274	CARPENTRY-INSTALLATION OF CABINET OR INTERIOR TRIM	2	Construction & Erection
5445	274	WALLBOARD INSTALLATION-IN BUILDINGS	2	Construction & Erection
5479	274	INSULATION WORK	2	Construction & Erection
5645	274	CARPENTRY-CONSTR. OF DETACHED PRIVATE RESIDENCES	2	Construction & Erection
5462	275	GLAZIERS-AWAY FROM SHOP	2	Construction & Erection
5474	275	PAINTING OR PAPER HANGING-NOC	2	Construction & Erection
5491	275	PAPER HANGING	2	Construction & Erection
5022	276	MASONRY-NOC	2	Construction & Erection
5348	276	TILE, STONE, MOSIAC OR TERRAZZO WORK	2	Construction & Erection
5551	277	ROOFING-ALL KINDS	2	Construction & Erection
5402	279	HOT HOUSE ERECTION	2	Construction & Erection
5472	279	ASBESTOS REMOVAL OPERATIONS--CONTRACTOR--PIPE AND BOILER WORK EXCLUSIVELY & DRIVERS	2	Construction & Erection
5473	279	ASBESTOS REMOVAL OPERATIONS--CONTRACTOR--NOC & DRIVERS	2	Construction & Erection
5478	279	FLOOR COVERING INSTALLATION-RESILIENT FLOORING-CARPET AND LAMINATE FLOORING	2	Construction & Erection
5606	279	CONTRACTOR-EXECUTIVE SUPERVISORS	2	Construction & Erection
5610	279	CLEANER-REMOVAL OF DEBRIS	2	Construction & Erection
6400	279	FENCE CONSTRUCTION-METAL	2	Construction & Erection
8227	279	CONTRACTORS PERMANENT YARD-FOR MAINTENANCE OR EQUIPMENT	2	Construction & Erection
9554	279	SIGN INSTALLATION MAINTENANCE, REPAIR, REMOVAL OR REPLACEMENT NOC & DRIVERS	2	Construction & Erection
7219	320	TRUCKING-NOC	3	Cartage and Trucking
7230	320	PARCEL OR PACKAGE DELIVERY	3	Cartage and Trucking
7231	320	TRUCKING-MAIL PARCEL OR PACKAGE DELIVERY	3	Cartage and Trucking
7232	320	TRUCKING: MAIL OR PACKAGE DELIVERY UNDER CONTRACT WITH US POSTAL SERVICE	3	Cartage and Trucking
7370	320	TAXICAB CO	3	Cartage and Trucking
7380	320	CHAUFFEURS & HELPERS	3	Cartage and Trucking
7382	320	BUS CO	3	Cartage and Trucking
7390	320	BEER OR ALE DEALERS	3	Cartage and Trucking
7705	320	AMBULANCE SERVICE COMPANY & EMS	3	Cartage and Trucking

8203	344	ICE DEALER	4	Commercial Enterprises
8215	344	HAY, GRAIN OR FEED DEALERS	4	Commercial Enterprises
8232	344	LUMBER YARD-NEW MATERIALS ONLY	4	Commercial Enterprises
8235	344	SASH, DOOR OR FINISHED MILLWORK DEALERS	4	Commercial Enterprises
8236	344	READY MIXED CONCRETE DEALER AND DRIVERS	4	Commercial Enterprises
8350	344	GASOLINE OR OIL DEALER	4	Commercial Enterprises
8263	345	JUNK DEALER	4	Commercial Enterprises
8265	345	IRON OR STEEL SCRAP DEALER	4	Commercial Enterprises
8500	345	METAL SCRAP DEALER	4	Commercial Enterprises
2070	346	CREAMERY & ROUTE SUPERVISORS	4	Commercial Enterprises
3821	346	AUTOMOBILE DISMANTLING	4	Commercial Enterprises
8103	346	WOOL MERCHANTS-INCL. WAREHOUSE	4	Commercial Enterprises
8204	346	BUILDING MATERIAL YARD & LOCAL MANAGERS-DEALER	4	Commercial Enterprises
8264	346	BOTTLE DEALER-USED	4	Commercial Enterprises
8864	346	SOCIAL SERVICE ORGANIZATION-ALL EMPLOYEES & SALESPERSONS, DRIVERS	4	Commercial Enterprises
2799	347	MANUFACTURED, MODULAR, OR PREFABRICATED BUILDING SETUP, HOOKUP, OR INSTALLATION AT BUILDING SITE	4	Commercial Enterprises
8002	347	AUTOMOBILE RENTAL CO	4	Commercial Enterprises
8380	347	AIR CONDITIONING SYSTEMS--AUTOMOBILE--INSTALLATION, SERVICE OR REPAIR & DRIVERS	4	Commercial Enterprises
8381	347	GASOLINE STATION-RETAIL-SELF SERVICE	4	Commercial Enterprises
8385	347	BUS CO-GARAGE EMPLOYEES	4	Commercial Enterprises
8392	347	AUTOMOBILE STORAGE GARAGE OR PARKING STATION	4	Commercial Enterprises
8393	347	AUTOMOBILE BODY REPAIR	4	Commercial Enterprises
8279	348	STABLE OR BREEDING FARM	4	Commercial Enterprises
8288	348	LIVESTOCK DEALER & SALESPERSONS	4	Commercial Enterprises
8291	349	STORAGE WAREHOUSE-COLD	4	Commercial Enterprises
8292	349	STORAGE WAREHOUSE-GENERAL MERCHANDISE-NOC	4	Commercial Enterprises
8293	349	STORAGE WAREHOUSE-FURNITURE	4	Commercial Enterprises
8723	350	INSURANCE COMPANIES, INCLUDING CLERICAL & SALESPERSONS	5	Clerical and Professional Occupations
8799	350	MAILING OR ADDRESSING COMPANY OR LETTER SERVICE SHOP--CLERICAL STAFF	5	Clerical and Professional Occupations
8803	350	AUDITORS, ACCOUNTANT OR FACTORY COST OR OFFICE SYSTEMATIZER-TRAVELIN	5	Clerical and Professional Occupations
8810	350	CLERICAL OFFICE EMPLOYEES	5	Clerical and Professional Occupations
8820	350	ATTORNEY-ALL EMPLOYEES & CLERICAL MESSENGERS	5	Clerical and Professional Occupations
8855	350	BANKS AND TRUST COMPANIES-ALL EMPLOYEES, SALESPERSONS, DRIVERS & CLERICAL	5	Clerical and Professional Occupations
8856	350	BANKS AND TRUST COMPANIES-ALL EMPLOYEES, SALESPERSONS, DRIVERS & CLERICAL	5	Clerical and Professional Occupations
8871	350	CLERICAL TELECOMMUTER EMPLOYEES	5	Clerical and Professional Occupations
8901	350	TELEPHONE OR TELEGRAPH CO OFFICE OR EXCHANGE EE'S	5	Clerical and Professional Occupations

For more information about Milliman and the Milliman Climate Resilience Initiative, please visit us at:

milliman.com/mcri

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