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Construction Accidents in US: A Comprehensive Analysis of Seasonal and Work Type Factors

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This study examines the correlation between construction accidents and seasonal variations by analyzing OSHA accident data in the United States over the period 2015 to 2021. While previous research has explored the general relationship between weather and accidents, there is a lack of comprehensive analysis for summer accident rates. The analysis considered the number of injuries, work types, climatic conditions, and geographic distinctions between indoor and outdoor construction activities. Following an F-test, an independent sample t-test was employed to establish significant differences between indoor and outdoor accident frequencies. The seasonal impact on the outdoor construction work and certain factors contributing to increased accident risk in warmer months, which has been established by the present analysis as one-tailed and two-tailed tests. Based on the influence of heat or prolonged work hours, the seasons were classified as Winter, Spring, Summer, and Fall to identify an accident trend. The findings confirm seasonal elevated temperatures are associated with increased outdoor activity-related accidents. The data suggests that targeted safety policies, including heat stress management protocols, are crucial to mitigate the increased risk of accidents during specific seasons and in certain work environments. The results are in direct contrast to recent state laws that limit municipal power to require water breaks.

Keywords: Construction accidents, Seasonal Influence, Heat Effect, Work Type, OSHA.

Introduction & Background

In the construction industry, the number of workplace accidents has become a critical concern. There is an alarmingly high incidence of work-related injuries in the construction business (Liao, 2012). The International Labour Organization noted in 2005 that an estimated 25 to 40 percent of all workplace mishaps that occur globally are related to construction sites (Martínez Aires et al., 2010). On a worldwide scale, the construction business consistently ranks among the most hazardous, as written in (Gondia et al., 2023). An estimated one-third of the more than $250 billion in yearly costs in the United States is attributable to the direct costs of medical treatment for work-related injuries, while the remaining sum is attributable to the negative effects on economic output that result from these accidents (Page & Sheppard, 2016). The physical involvement of workers is essential to meet industry demand. Since laborers need to work in all environments, the risk of severity at construction sites is often related to temperature. It is agreed that risk and uncertainty exist throughout the entire process, from the conception of a construction project through to its completion and sometimes during the operational stage of the constructed facility, regardless of the size, nature, complexity, or geographical location of the project (Siraj & Fayek, 2019). Factors such as worker characteristics, climatic and temperature variations, and the variety of tasks performed all pose the changing risk influences on construction sites (Lee et al., 2012).

Outdoor activities such as roofing, concrete paving, and steel erecting put more than half of the construction workers in danger when they are engaged in elevated temperatures. (Acharya, Boggess, and Zhang 2018). Worker fatigue and dehydration can result in diminished concentration, thereby increasing the likelihood of accidents during seasonal shifts (Szer et al., 2021). Further, recent state laws have limited municipal power to require water breaks (Phillips, 2024). Universally, various illnesses and injuries, including sunburn, skin cancer, and heat stroke, can occur in excessively hot weather (Xiang et al., 2014).

This research focuses on recent construction accidents in the United States. The incentive for doing this research is rooted in the discovery during the literature assessment that there are few studies based on recent data in this area of study. Few studies have focused solely on the consequences of year-over-year study of accidents in the summer months, particularly July, August, and September. This study also aims to determine statistical differences between indoor and outdoor activities for various work patterns because of seasonal influences. By gradually conducting a comprehensive analysis of accident numbers and monthly trends in different years in different states, as well as understanding the different work types to identify separately indoor and outdoor activities, the research aids in determining an insightful relationship between heat effect and season changes in work activities, supporting that the summer months have a significant impact on worker injuries. The purpose of the analysis is to determine if the rate of injuries increases during the summer season.

Methodology

The data for this study was obtained from the Occupational Safety and Health Administration, using the Accident Search engine to download Investigation Summaries (OSHA 2022). Construction-related accident records between January 2015 and November 2021 were downloaded via a spreadsheet in 2022. The website has since been updated, making it difficult to replicate the initial data search. As OSHA has up to six months to complete a report, the website may provide different results over time, which also makes a search difficult to replicate (Nemmers, 2022). A series of data filtration steps were undertaken to categorize accidents across different work types, such as roofing, concrete paving, and steel erection. Carpentry work was removed due to the overall quantity of accidents and the indoor and outdoor nature of the work. Basic methodologies were employed to extract our data from the extensive dataset (Figure 1). All construction work categories commence with NAICS code 23. The accident data was categorized by occurrence date into various work types such as plumbing and mechanical, flooring, and painting, which are subsets of NAICS 23. Data from 2015 through 2021 were combined into a single dataset. This facilitated a complete analysis of the annual accident distribution by month.

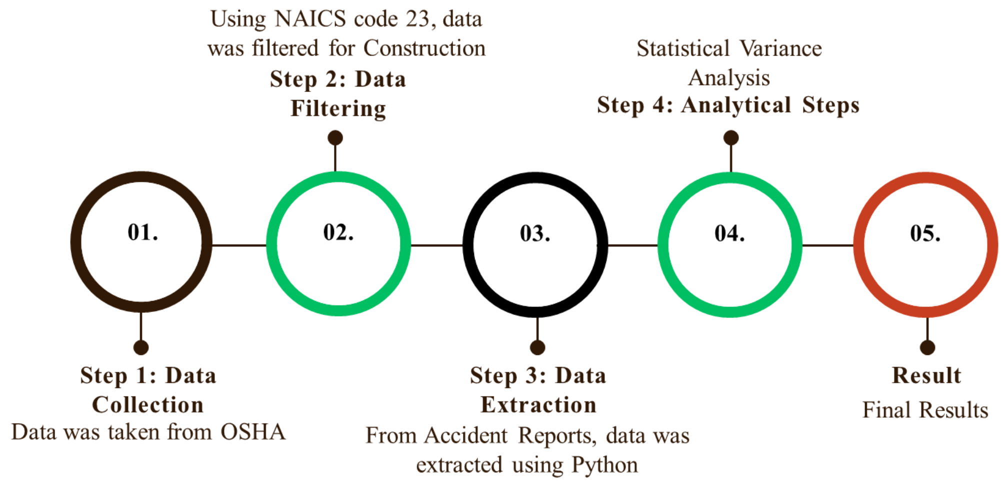

Figure 1. Framework of Study

Statistical variance analysis as well as mean comparison tests were used for 2015-2021 to determine the relation between the fluctuations of the work types and construction accidents. The accidental frequencies in indoor and outdoor construction areas were differentiated. To determine if accident rates were more variable in outdoor settings, an F-test for equality of variances was used. Significantly different variances were revealed if the F-test's p-value was less than 0.05, indicating that heat and other environmental conditions may have raised the variability of outdoor incidents. On the other hand, variances were regarded as comparable across contexts if the F-test p-value was higher than 0.05. This test was crucial in identifying whether outdoor work presented higher risks because of the environmental conditions.

$$F = \frac{{S_1}^2}{{S_2}^2}$$

The variance in outdoor accident rates is set as ${S_1}^2$ and ${S_2}^2$ represents the variance in indoor accident rates. Subsequently to the variance analysis, the mean accident rates were compared by performing a two-sample unequal variance T-test (Welch T-test). This method was considered because, based on the F test p-value, the variances were found to be significantly different ($p< 0.05$), indicating that unequal variance in accident rates was influenced by external factors in the construction environment. Where $\bar{X}1$ and $\bar{X}2$ are the means of outdoor and indoor accident rates, ${S_1}^2$ and ${S_2}^2$ are their respective variances, and n_1 and n_2 represent the sample sizes.

$$t = \frac{\{\bar{X}1 - \bar{X}2\}}{\left\{\sqrt{\left\{\frac{\{S_1^2\}}{\{n_1\}} + \frac{\{S_2^2\}}{\{n_2\}}\right\}}\right\}}$$

Degrees of freedom are calculated using the following equation. The t- test was conducted as one tail test to determine if outdoor accident rates were significantly higher than indoor rates, and alpha level of 0.05 was applied to ensure statistical significance at the 95% confidence level. This threshold minimized the risk of type 1 errors while maintaining sensitivity to detect critical differences in accident rates between indoor and outdoor environments.

$$df = \frac{\left\{\frac{\{S_1^2\}}{\{n_1\}} + \frac{\{S_2^2\}}{\{n_2\}}\right\}^2}{\frac{\{\frac{\{S_1^2\}}{\{n_1\}}\}^2}{\{n_1 - 1\}} + \frac{\{\frac{\{S_2^2\}}{\{n_2\}}\}^2}{\{n_2 - 1\}}}$$

Python was used to recheck the basic statistical operations such as counting, summing, and ranking accident counts. Vectorized computations were done to guarantee effective data processing, and straightforward visuals successfully bring attention to distributions and trends. Total number of accidents, monthly accidents for each year are computed by Python from excel sheets.

$$Total\ Accident\ in\ Year\ Y = \sum_{j=1}^{m} \sum_{i=1}^{n_j} I\left(Y_{ij} = Y\right)$$

Here, m presented the number of sheets, n_j is the number of records in sheet j, and I is an indicator that returns if the accident belongs to Year Y, and 0 Otherwise. M denotes the specific month, and I return if both year and month criteria are met.

$$Accidents\ (Y, M) = \sum_{i=1}^{n} I(Y_i = Y\ and\ Mi = M)$$

Results & Discussion

The breakdown revealed that there were 5,596 accidents that occurred in the construction industry between January 2015 and November 2021, considering indoor and outdoor activities separately. Understanding the impact of seasons, years, months, types of work, work patterns, and states commonly involved in construction accidents is essential. The investigation also examined the relationship between accident numbers and various environmental parameters, including average temperatures. Worker's ability to concentrate on the outdoor construction work is severely impaired when the temperature is too high, that increases the risk of accident (Liao, 2012).

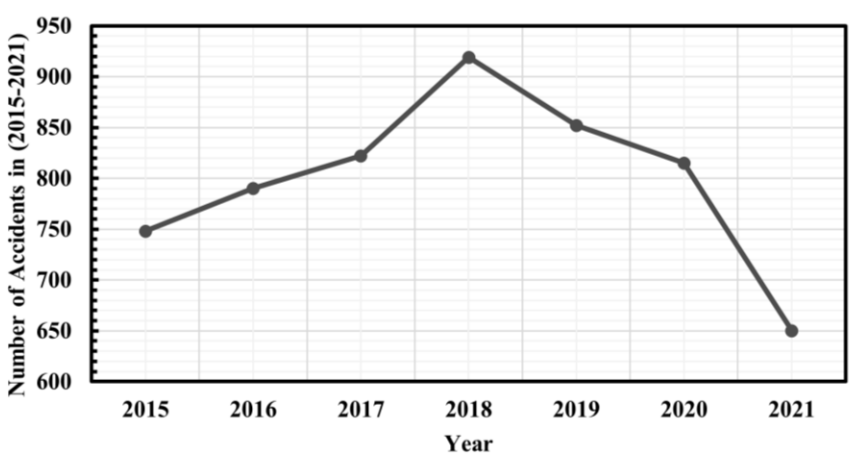

Figure 2. Total Number of Accidents Year by Year

The annual number of reported accidents for electrical, roofing, concrete paving, plumbing & mechanical, erecting steel, drywall, painting, cabinetry, and flooring from 2015 to 2021 peaks in 2018 (Figure 2). The data reveal a peak in accident occurrences in 2018, with a total of 919 cases, marking the highest recorded value within this timeframe. On average, accident numbers hover around 800 for most years, indicating a relatively stable yet concerning frequency. This pattern implies that accident rates remained consistently high before the COVID-19 pandemic, with significant incidents in 2019 and 2020. Notably, the trend suggests a substantial reduction in 2021, with the count dropping to 650, possibly reflecting the impacts of pandemic-related restrictions on transportation and workplace activities. The decline in 2021 could be attributed to decreased mobility, remote work practices, and other health protocols implemented during the pandemic, which limited work scope and potential accident scenarios.

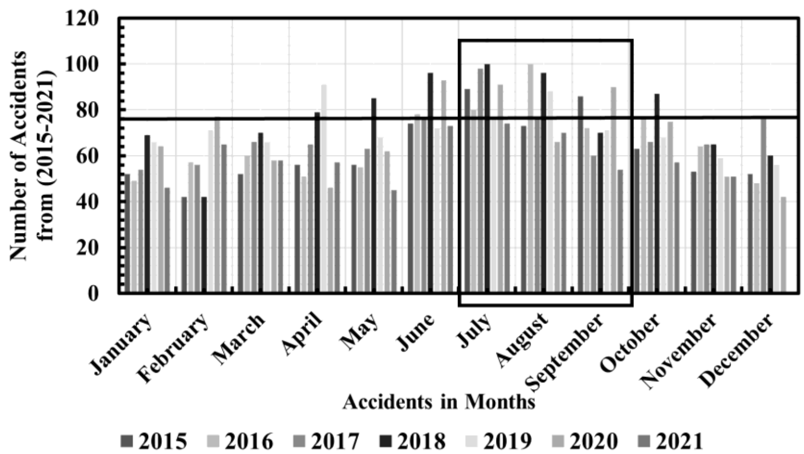

Figure 3. Total Number of Accidents by Month across Years

A further illustration that accident frequencies fluctuate across months, with noticeable peaks in specific seasons, likely influenced by environmental and operational factors (Figure 3). The correlation between warmer months and increased accident rates is visually evident in the data indicates workers are exposed to greater risks in this period. Elevated temperatures may impair physical stamina, concentration, and response times, potentially leading to more frequent safety incidents. Additionally, as these busy months often demand longer work hours and faster project completion rates, the strain on workers could further exacerbate accident occurrence.

It should be highlighted that the higher accident counts occur during the summer months (Figure 4). The seasonal grouping of data illustrates how environmental factors, such as heat, play a critical role in influencing accident rates. With an estimated 3142 instances, throughout the studied period, a recent study indicated that high temperatures considerably increased the probability of construction injuries (Gariazzo et al., 2023). The elevated accident numbers during the summer months align with periods of peak construction activity, the longest periods of sunlight, and when outdoor work is most prevalent. This seasonal surge in accidents may be attributed to heat-induced fatigue, dehydration, and reduced cognitive performance, which are common in high-temperature environments.

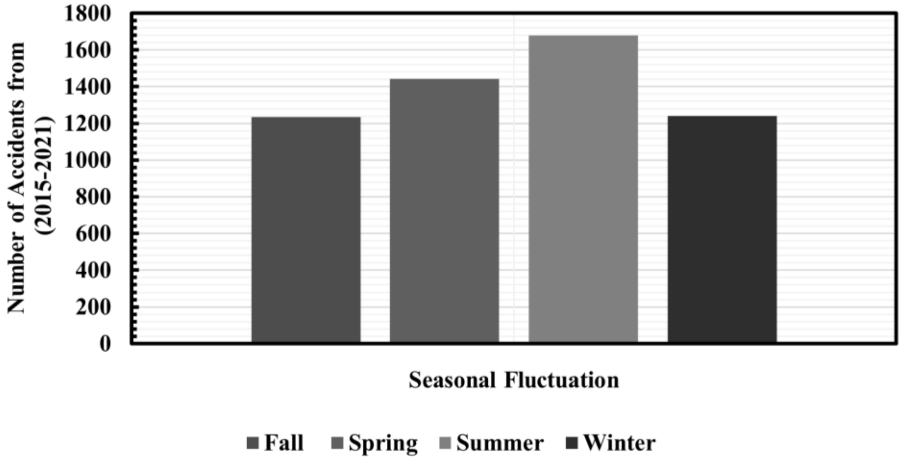

Figure 4. Accident Comparison by Seasons from 2015-2021

As illustrated in Figures 4 & 5, there is a strong association between temperature and accident rates, particularly in outdoor construction sites.

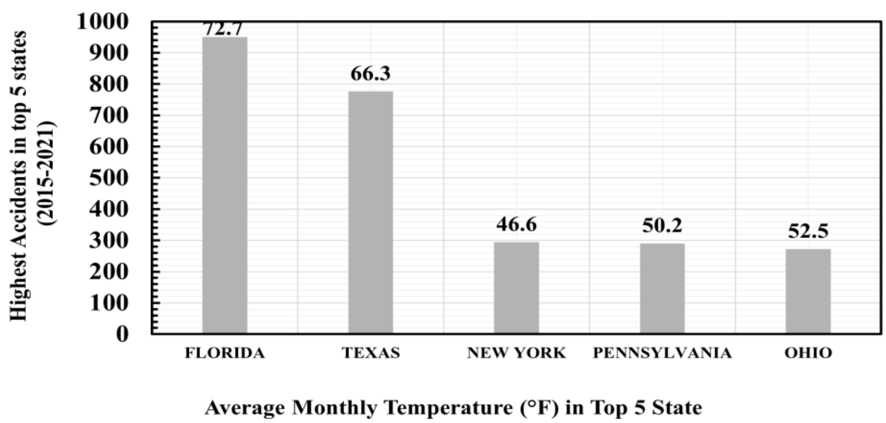

Figure 5. Top 5 States with Highest Accident Numbers based on avg temperature

The comparison across states also highlights notable differences in accident rates, with states like Florida and Texas known for their warmer climates reporting significantly higher accident numbers than cooler states such as Ohio and Pennsylvania (Figure 5). The average temperatures were taken from National Centers for Environmental Information. This observed trend supports the conclusion that environmental temperature plays a critical role in influencing accident rates, potentially due to its impact on both worker endurance and the intensity of construction activities. Higher temperatures may lead to heat-related stress, fatigue, and diminished focus, all of which can elevate the likelihood of accidents.

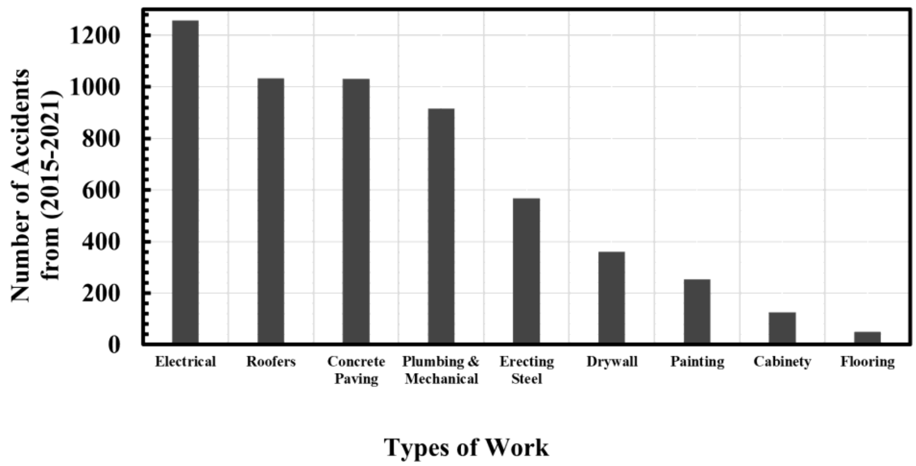

Figure 6. Top 10 Work Activities in Accidents

The results illustrate the distribution of accidents across various work types, highlighting the highest risk factors in construction (Figure 6). The analysis indicates that outdoor activities, such as roofing, concrete paving, and steel erection, are more vulnerable compared to indoor activities like painting, cabinetry, and flooring. This is likely due to the nature of tasks like roofing and concrete paving, which involve working at heights and handling heavy materials. The data clearly shows that electrical work carries the highest risk, as it involves both indoor and outdoor environments, resulting in the greatest number of accidents. This high incidence of accidents underscores the urgent need for dedicated safety protocols tailored to these higher-risk activities.

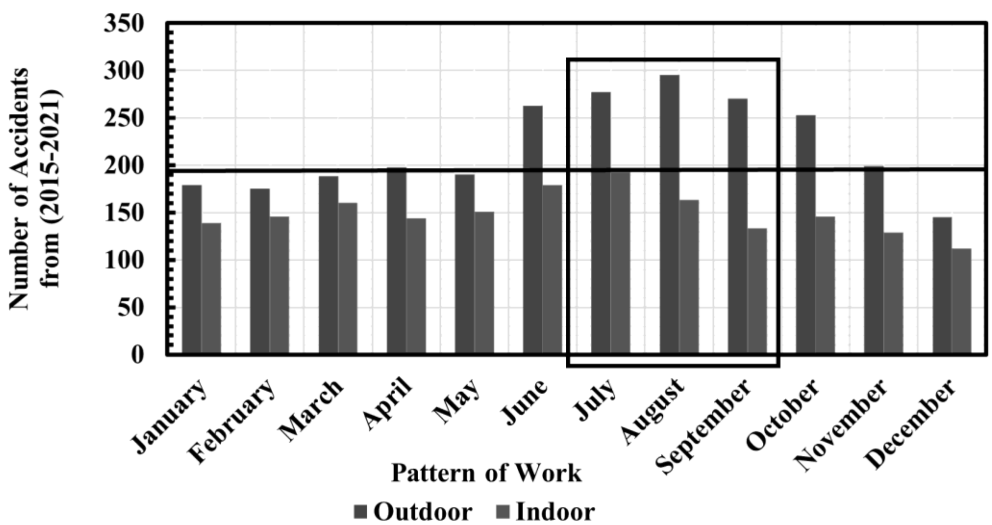

Figure 7. Indoor and Outdoor Accidents over the Months

Filters were applied to the type of work to determine indoor versus outdoor work types. Carpentry work was excluded from the students due to the number of accidents and its ability to be performed indoor or outdoor. In this analysis, differences in accidents in indoor work and outdoor work were compared using statistical tests to explore whether there are meaningful differences between indoor and outdoor construction activities in terms of their average accident rates and the variability in those rates. It is evident from (Figure 7) that outdoor accidents occur more frequently than indoor accidents throughout the year, with a sharp increase in the summer months. Indoor accidents also show an increase during the early summer.

Tests for Significance

An F-test was used to examine if there is a significant difference in the variability (variance) of accidents between indoor and outdoor construction activities. Variance reflects how much the accident rates fluctuate around the average.

Table 1

F-Test: Two-Sample for Variances

Metric	**Variable 1(Outdoor)**	**Variable 2(Indoor)**
Mean	219.3333333	149.5833333
Variance	2407.878788	483.719697
Observations	12	12
df	11	11
F	4.977839031	
P (F<=f) one-tail	0.006527162	
F Critical one	2.81793047	

The results showed that outdoor construction activities had a much higher variance (2407.88) than indoor activities (483.72). The F-test (F = 4.98, p = 0.0065) confirmed that this difference in variance is statistically significant, indicating that accident rates in outdoor work are considerably more variable than those in indoor work.

Table 2

T-Test: Two-Sample for Unequal Variances

Metric	**Variable 1(Outdoor)**	**Variable 2(Indoor)**
Mean	219.3333333	149.5833333
Variance	2407.878788	483.719697
Observance	12	12
Hypothesized Mean Difference	0	
df	15	
t stat	4.493304397	
P(T<=t) one-tail	0.000214493	
t Critical one-tail	1.753050356	
P(T<=t) two-tail	0.000428985	
T Critical two-tail	2.131449546	

Since the variances were found to be unequal, a two-sample t-test assuming unequal variances was used to determine if there is a significant difference in the average accident rates between outdoor and indoor construction. The average accident number for outdoor work was notably higher (219.33) compared to indoor work (149.58). The t-test results ($t = 4.49$, $p < 0.0005$) indicated that this difference is statistically significant, meaning that outdoor construction activities have a higher average accident rate than indoor activities.

Conclusion

The purpose of this study was to determine if accident rates increase over the summer months. This study analyzed accident trends in indoor and outdoor construction activities over the years 2015 to 2021. Accident rates peaked in 2018, with a significant decrease in 2021, possibly due to pandemic-related restrictions that impacted work activities. Monthly and seasonal trends revealed higher accident rates in warmer months, suggesting that increased outdoor work during these periods may lead to greater risks. Additionally, states with higher temperatures, such as Florida and Texas, exhibited higher accident rates than cooler states. Analysis by work type showed that outdoor tasks, including roofing, concrete paving, and electrical work, have higher accident rates and variability compared to indoor tasks. Statistical tests further confirmed that outdoor construction has significantly higher average accident rates and variability than indoor work. This outcome indicates a relationship between summer months and increased accident rates, which has not been previously found in literature.

This study has certain limitations. The analysis relied on recorded accident data, which may not capture all incidents, especially minor or unreported ones. OSHA concludes investigations up to 6 months after reporting (Nemmers, 2022) which may cause a lag in data availability. Additionally, while seasonal and environmental factors were considered, the analysis did not account for micro-climatic differences within states. Furthermore, it is not possible to detect in which season which type of work is causing more accidents, it is also not possible to know the exact temperature of the accident sites. Other contextual variables, such as regional safety regulations or variations in worker skill levels, were also beyond the scope of this study. While the differences of accident rates by construction trade was presented, it was not analyzed.

The findings suggest that weather-responsive safety strategies could mitigate risks, especially during warmer months. For example, implementing heat stress management protocols and scheduling adjustments could help accident rates in high-temperature periods. The data also points to a correlation between societal activity levels and accident frequency, where restrictive measures (such as during the COVID-19 pandemic) appeared to reduce accident rates. Future research should explore the effectiveness of specific interventions, like enhanced protective gear and training for high-risk tasks, particularly in outdoor environments. Policymakers and industry leaders are encouraged to develop targeted safety protocols based on seasonal and state-specific conditions. This could include measures like flexible work hours, cooling stations, and hydration breaks in warmer regions. These steps could significantly improve worker safety, optimize resource allocation, and reduce construction-related injuries, ultimately contributing to a safer construction industry.

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