The Implications of Heat Induced Climate Change and Lifestyle Effects in the DFW Metroplex

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Abstract

The correlation between climate change and the prevalence of extreme heat events has become firmly established with the aid of recent scientific studies. Projected climate change models anticipate an increase in the frequency and intensity of heat waves, particularly in higher latitudes, impacting inadequately adapted metropolitan areas. Already, extreme heat exposure poses a significant public health challenge, serving as the primary cause of weather-related mortality in the U.S. This research paper delves into the implications of heat-induced climate change on the lifestyles of DFW Metroplex residents. Utilizing extensive data collection methodologies, we analyze historical weather data and employ linear regression analysis to identify trends in annual surface temperature changes, monthly atmospheric carbon dioxide concentrations, shifts in mean sea levels, and the frequency of climate-related disasters in the United States. Despite challenges in medical data collection, our analysis of heat-related illnesses in Dallas, Tarrant, and Denton counties reveals a consistent upward trend from 2022 to 2023. To comprehend the local impact, we conducted a survey with the students at the University of Texas at Dallas (UTD) and interviewed the Assistant Director of the Parking and Transportation Department. Despite limitations and unforeseen challenges, this research paper highlights the urgent need for adaptive measures to mitigate the effects of climate change on public health in the DFW Metroplex.

Introduction

Since the discovery of fire, the relationship between nature and human infrastructure has been marked by conflict. Advances like torches, gas stoves, and heated skyscrapers have significantly improved human comfort, but at a cost to our climate. The continuous burning and depletion of natural resources have brought us to our current predicament. Our planet is experiencing a net loss of trees and natural processes that offer shade and help regulate carbon

levels. While technologies such as air conditioning provide relief from uncomfortable temperatures, we are simultaneously depleting the natural mechanisms that help maintain our climate. The widespread construction of concrete buildings worsens the heat and adverse weather conditions on both a large and small scale. With various adverse weather phenomena and human activities impacting the globe, people are adapting to these changes in diverse ways. In light of these factors, we argue that Heat-Induced Climate Change is increasingly affecting the well-being of DFW residents, notably students at UTD who regularly contend with the elements during their commutes to campus.

Research Question: To what extent has climate change impacted the frequency and intensity of heat-related illnesses in the DFW Metroplex, and how are residents adapting to these changes?

Null Hypothesis (H0): There is no significant impact of climate change on the frequency and intensity of heat-related illnesses in the DFW Metroplex, and residents are not adapting to any observable changes.

Alternative Hypothesis (Ha): There is a significant impact of climate change on the frequency and intensity of heat-related illnesses in the DFW Metroplex, and residents are actively adapting to these changes.

Summary of Findings

Our research uncovered complex interactions between urban infrastructure, climate fluctuations, and individual well-being in the DFW community, revealing challenges and trends. The analysis of heat-related illnesses in Dallas, Denton, and Tarrant counties highlighted a significant increase in cases in 2023, supporting our alternative hypothesis about climate change's impact on illnesses. Despite this community-wide trend, our findings show that UTD students prioritize addressing extreme cold weather over heat-related concerns, as seen in survey

responses and parking department adaptations. This underscores the diverse priorities and adaptations needed to address distinct climate scenarios in the DFW community.

Climate Change Research

In this research project, we plan to use a comprehensive data collection methodology to investigate the implications of heat-induced climate change on the lifestyles of residents in the DFW Metroplex. To evaluate climate trends and variations, we gathered historical weather data, encompassing annual surface temperature changes, monthly atmospheric carbon dioxide concentrations, shifts in mean sea levels, and the frequency of climate-related disasters in the United States. This dataset was acquired from the International Monetary Fund's Climate Data website (IMF Climate Data 2020), providing a foundation for identifying trends reflecting the impact of climate change over time. In assessing climate trends, we utilized linear regression analysis in R, inputting the dataset to analyze visual statistical significance. This process was performed for each variable collected, however, it's noteworthy that the date range for each variable varied.

For the annual surface temperature changes, the analyzed dataset comprised values exclusively for the United States, spanning from 1961 to 2022 (Figure 1). Meanwhile, for the monthly atmospheric carbon dioxide concentrations, the analyzed dataset encompassed percentages of carbon dioxide concentrations from January 1959 to May 2023. Given the monthly nature of the data, the visualization trend appears more clustered, yet remains sufficiently convenient for trend identification (Figure 2). To quantify shifts in mean sea levels, we extended our analysis to encompass global data, examining overall worldwide trends rather than focusing on individual seas. The dataset is expressed in millimeters and is derived from measurements acquired through satellite radar altimeters. These measurements are generated by gauging the time it takes for a radar pulse to complete a round-trip journey from the satellite to

the sea surface and back, and is collected multiple times throughout the year. The dataset spans from 1992 to 2022 (Figure 3). The final variable under analysis is the frequency of climate-related disasters in the United States. This dataset spans from 1980 to 2022, detailing the occurrences of various natural disasters within each respective year. It is noteworthy that the visual representation for this variable was not generated in R but was obtained from the IMF Climate Data website (Figure 4). All visuals are provided below.

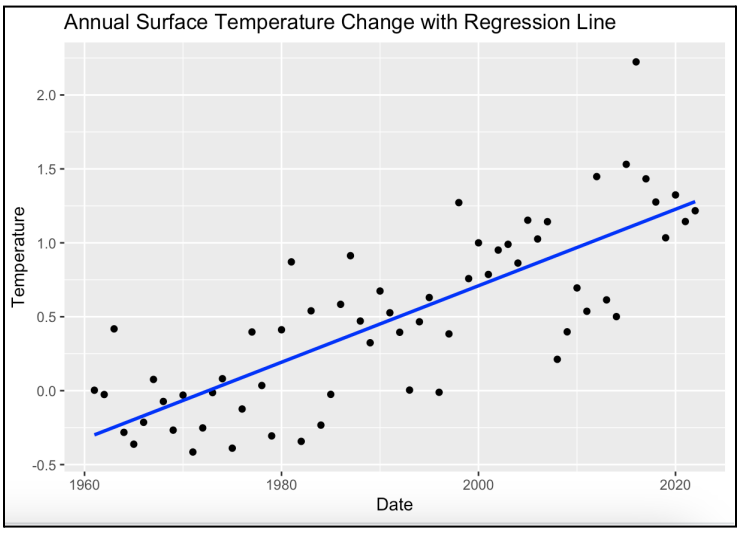

Figure 1: Annual Surface Temperature Change

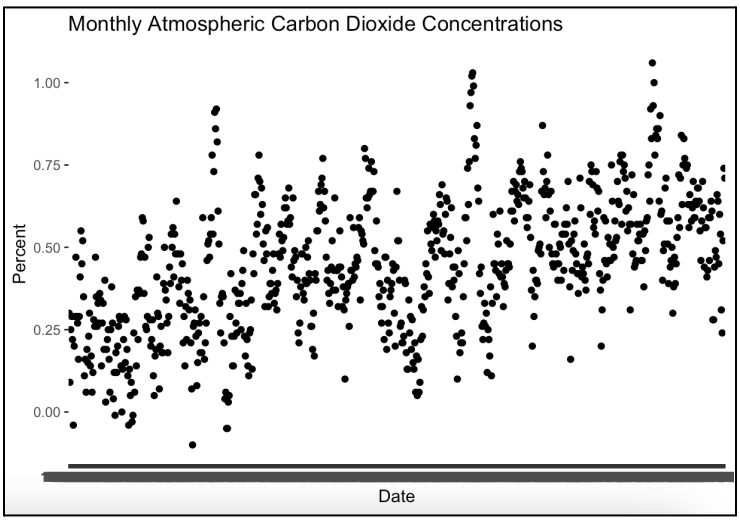

Figure 2: Monthly Atmospheric Carbon Dioxide Concentrations

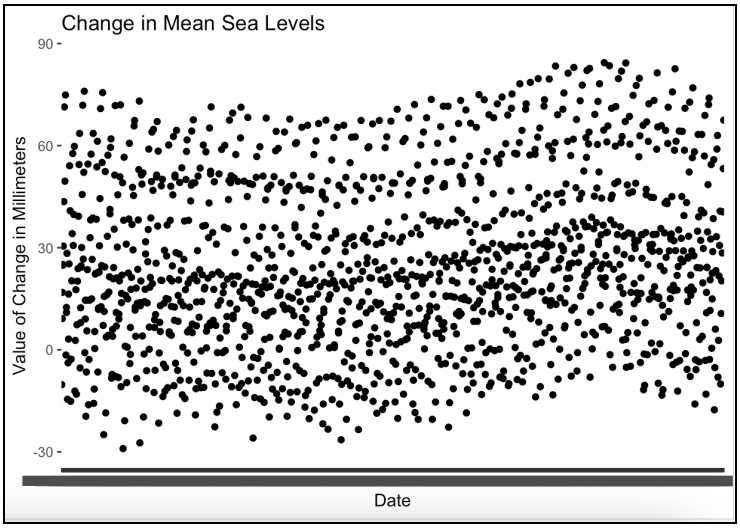

Figure 3: Change in Mean Sea Levels

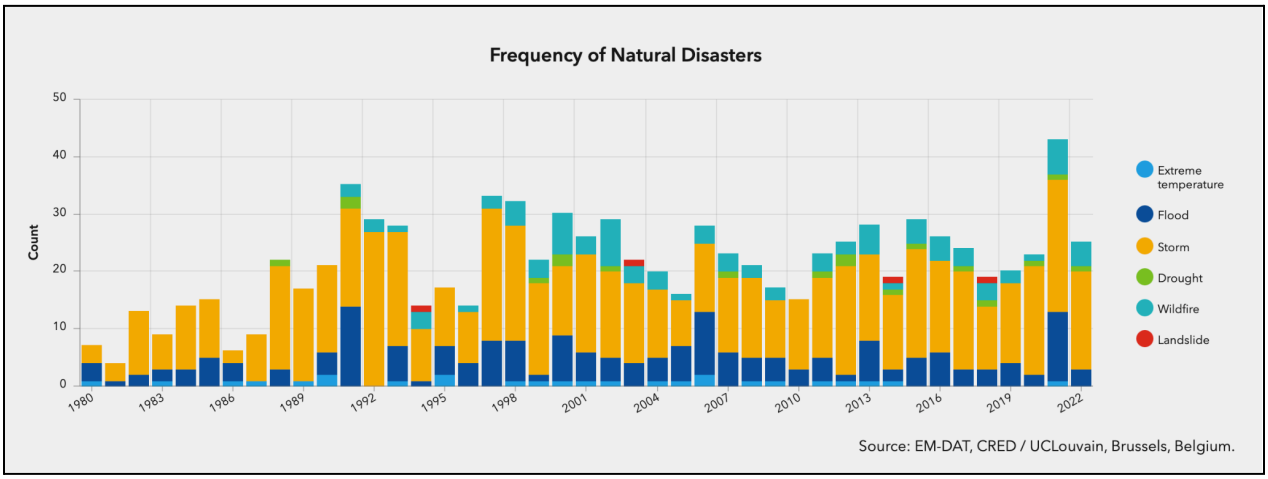

Figure 4: Frequency of Natural Disasters

From these visualizations, a clear trend emerges, illustrating the substantial impact of climate change on both a global scale and, more specifically, within the United States. The persistent positive regression line in annual surface temperature change signifies a continual rise. Furthermore, a majority of data points for carbon dioxide concentration percentage and millimeters of change in average sea levels consistently surpass the baseline value of "0". Additionally, the observed escalation in the frequency of natural disasters, including extreme temperatures, floods, and storms in the United States from 1980 to 2022, further underscores the

undeniable influence of climate change on the day-to-day lives of the average American. Armed with this overarching research on the nation as a whole, our focus then shifted to a more localized level for the purpose of our primary research—the DFW Metroplex.

Urban Heat Islands

Earth possesses natural mechanisms for regulating its environment and temperature. The ozone layer shields the planet from UV rays, and trees play a crucial role by providing shade, removing carbon from the air, and releasing water, similar to human perspiration. Trees effectively contribute to climate stability through their water moderation. However, contemporary city aesthetics often overlook natural elements, replacing greenery with sidewalks, metal structures, and skyscrapers. These materials exhibit poor performance in both absorbing and releasing heat. This situation leads to peculiar scenarios, such as people being able to bake cookies on their windshields and requiring extra salt on concrete surfaces to prevent ice formation.

In addition to these rapid temperature fluctuations, human-made infrastructures contribute to the creation of urban heat islands (UHIs), especially in densely populated areas. UHIs become problematic due to the accumulation of CO2 emissions over locations that no longer have sufficient natural means to disperse heat. Cities with high transit activity and concentrated living conditions experience heightened weather-related variations under the carbon dome magnification. These areas, comparable to saunas and parked cars left in the sun, excel at quickly accumulating and retaining heat but struggle to release it without external intervention. The Dallas-Fort Worth (DFW) area identifies as a UHI, characterized by its concrete landscapes compounded by the emissions from numerous vehicles, contributing to the dome of smog above.

Additionally, UHIs signal a twofold moisture issue known as the humidity paradox (Willet, Kate. 2020). Due to overall carbon levels and deterioration of the ozone, ice caps are

melting, fueling the rise of our oceans and an abundant amount of moisture that can help trap heat in the air. Simultaneously, dense city landscapes are making it difficult for moisture to be derived from inland, encouraging some of the more chaotic weather conditions being experienced in today's age. The collective impact of these factors amplifies the heat island effect, posing potential challenges for global residents' well-being, especially during extreme weather conditions. In light of these observations, our research aims to explore the implications of the urban heat island phenomenon and the humidity paradox on the health-related experiences of DFW residents. By examining health-related illness reports, we aim to uncover potential correlations between the urban heat island effect and public health outcomes, providing valuable insights for the community's betterment.

Medical Analysis

In our medical analysis research, we gathered data on reports of heat-related illnesses from the websites of Dallas County, Tarrant County, and Denton County. However, we encountered challenges in acquiring similar data for Collin County. While the official CDC website aggregates comprehensive data on heat-related illness and mortality, we faced limitations in utilizing it to specifically pinpoint data for the DFW Metroplex.

The collected data is reported on a weekly basis throughout the summer, and it is crucial to highlight that our specific criteria for classifying a report as a heat-related illness encompasses instances of heat exhaustion, heat cramps, and heat stroke. These criteria were carefully chosen to ensure a thorough understanding of the impact of heat-related conditions in the specified counties.

Nevertheless, our analysis was subject to several limitations. Notably, Tarrant County did not collect data on heat-related illnesses during 2020 and 2021, citing the influence of the Covid-19 pandemic. In contrast, Denton County lacked publicly available records of heat-related

illness reports before 2022. Faced with this variability in data availability, our analysis had to be confined to a comparison of the number of reported hospital visits due to heat-related illnesses for the years 2022 and 2023 across the three counties.

We compiled a spreadsheet detailing the proportion of emergency room visits attributed to heat-related illnesses for each county in the years 2022 and 2023, covering the period from the beginning of June to the end of August. This spreadsheet was then imported into R to generate plot lines, enabling a visual comparison of the proportions between the two years. The resulting visualizations are presented below.

Dallas County

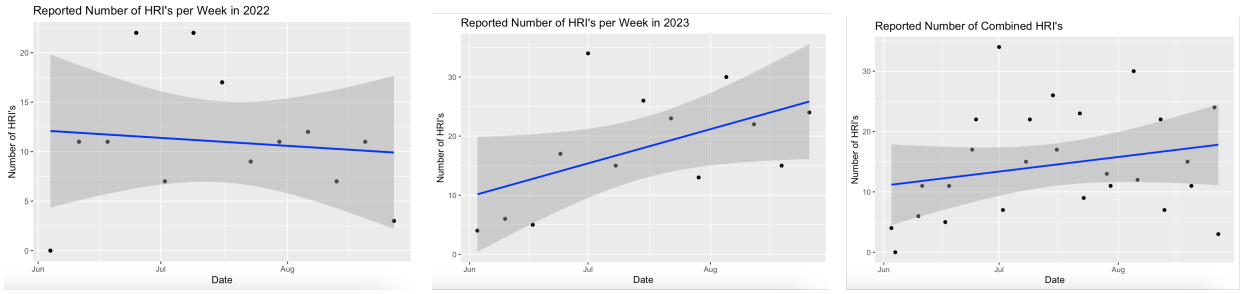

Figure 5

Denton County

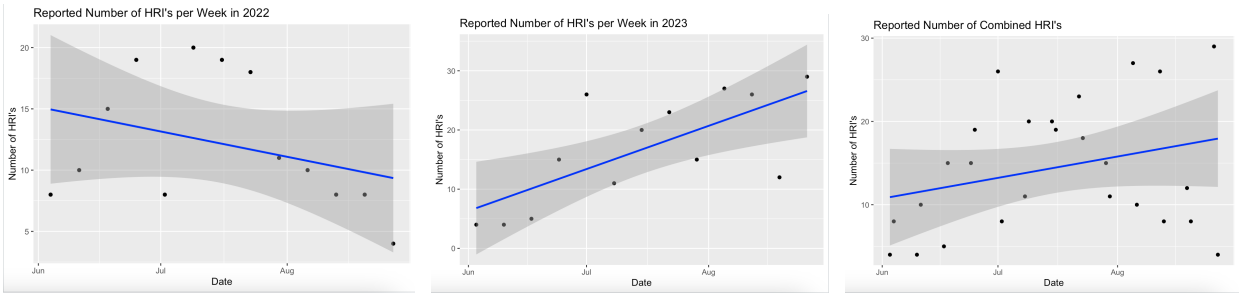

Figure 6

Tarrant County

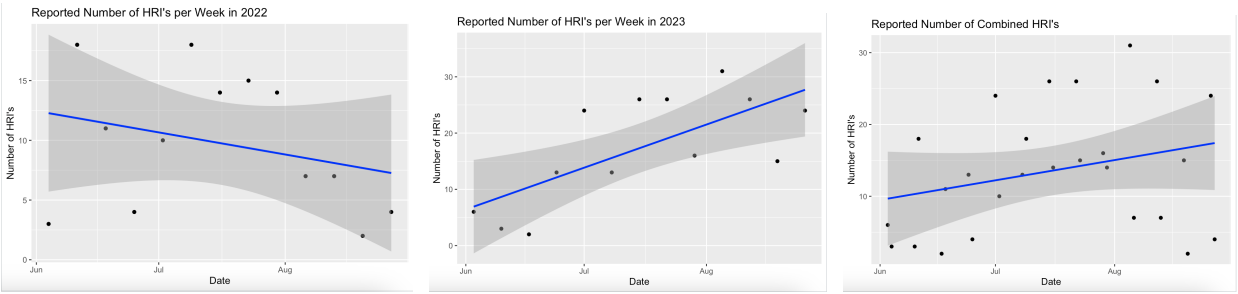

Figure 7

In these visuals, we observe a consistent downward trend in reported numbers of heat-related illnesses throughout 2022. However, there is a stark reversal in 2023, marked by a notable and rapid increase in the reported number of heat-related illnesses as the summer progressed. In the combined data images, we can identify some outlier plot points, but a general positive trend is evident. This suggests that, based on the data from the summers of 2022 and 2023 in Dallas, Denton, and Tarrant counties, there has been an increase in the number of reported heat-related illnesses. This observation prompted us to consider whether people in the DFW area are currently taking any precautions amid the rising levels of heat-related illnesses or if their lifestyles have been affected by the ongoing impact of climate change.

Collecting Parking and Transportation Department Data

To comprehend attitudes, practices, and lifestyle impacts arising from increasing temperatures on the people of DFW, we pursued both quantitative and qualitative data. For qualitative data, we interviewed Elena Grant, the Assistant Director of the Parking and Transportation Department at UTD. The aim of the interview was to gain insights into how the department is adapting to inclement weather and addressing student concerns about shuttle services, parking, and availability. The interview lasted 30 minutes, during which we asked approximately 12 questions. From the interview, we learned that significant changes in response

to inclement weather are being considered and implemented by the Parking and Transportation department, focusing on the construction and restructuring of weather-preventative infrastructure both on campus and along bus routes surrounding the campus. Safety precautions are taken during winter when there's a likelihood of ice, snow, or sleet by closing the top levels of parking structures, however the top levels remain accessible during the summer. Furthermore, the Parking and Transportation department have also installed light fixtures powered by solar panels to illuminate the area during longer winter nights and prevent road icing. The utilization of solar-powered lights proves more efficient and requires less maintenance than replacing light bulbs, offering a sustainable solution for both students and maintenance.

In a commuter school like UTD, grievances regarding parking passes and their costs are widespread. The university offers four parking permit options: Purple, Orange, Gold, and Green, yet students are unable to purchase the Purple parking pass as it is exclusively for UTD faculty. As per the UTD Parking and Transportation department website, the most affordable parking pass, Green, provides no access to parking structures on campus but allows parking in large lots around campus, priced at $169.00. In 2018, the cost of a Green parking pass was $140.00, and this price remained unchanged until the 2022-2023 academic year. Grant reports a growing trend of students opting for the next tier of parking, Gold, which includes access to parking structures and spaces in both small and large lots, and is priced at $303.00. It was priced at $257.00 from 2018 to 2021 (UTD Parking and Transportation Department). Meanwhile, an Orange parking pass today will cost you $311.00, whereas in 2018, it was priced at $257.00. As we can see, parking pass fees have increased over the course of five years, with Grant attributing the increase to economic inflation and escalating costs of construction materials like concrete and asphalt. It is important to note that, unlike other auxiliary departments and student services at UTD, parking

is entirely self-funded, with the majority of revenue coming from parking permit purchases. The electricity, fire extinguisher, parking guidance system, and cleaning upkeep of parking structures are also costly; for reference, maintenance of Parking Structure 4 costs around $22 million annually and the construction of one parking spot costs around $15,000. Since the spring of 2022, UTD has unveiled several initiatives to enhance the university's academic standing, including the Edith and Peter O'Donnell Jr. Athenaeum, which features a museum, performance hall, and plaza, along with plans for a new library and DART station (UTD Media Relations Office). While these enhancements are poised to benefit UTD for generations, they contribute to the challenge of limited parking spaces. Notably, the construction of the new Athenaeum has led to the loss of two parking lots. Grant acknowledges that campus construction and economic inflation pose significant obstacles to maintaining parking affordability for students. Despite these challenges, the department is actively adapting to the evolving landscape and aims to allocate resources to sustain current parking structures and lots at a reasonable cost.

Students who commute by bus at UTD express weather-related grievances the most, citing insufficient infrastructure at bus-stops, infrequent shuttle schedules, and a growing number of riders as key factors of discomfort. The shuttles serving UTD, operated by DART (Dallas Area Rapid Transit), play a crucial role in facilitating commutes across Dallas, Texas, and 12 neighboring cities through modern public transit services. DART is designed to ensure swift, comfortable, and cost-effective trips for public use, establishing a comprehensive transportation network that seamlessly links commuters to various destinations for living, working, and recreation.

Notably, the DART 883 bus operates on the East-Route Cityline Bush Station, making stops at 22 locations along its route, starting from the University Parkway Circle and concluding

at the Cityline/Bush Station (DART.n.d.). Grant reports that 95% of ridership on the 883 bus are UTD students, as the 883 bus runs on Renner road where many international students reside. Moreover, Grant notes that the 883 bus route boasts the highest DART ridership among all DART routes/lines. Bearing these facts in mind, DART administration has been exceptionally receptive to UTD's input and has a 50% share of the 883-bus contract with the Parking and Transportation Department. While student input is valued, legal and logistical obstacles limit UTD's ability to offer a completely seamless shuttle service. Legally, UTD lacks the authority to construct bus shelters off-campus, despite a predominantly student ridership on the 883-route. The demand for bus shelters escalates during hotter weather, not only to shield riders from direct heat but also to prevent the metal benches from heating up and becoming unusable. This concern is particularly evident at the DART bus station on Synergy Park across from the Callier Center, but adaptations have been made to address these issues at the DART station near UTD's soccer fields as mentioned previously.

Addressing the challenge of infrequent bus schedules proved to be more complex, particularly with the surge in complaints during the summer and fall of 2023, attributed to ongoing construction on Renner Road. In response, Grant highlighted that starting fall 2023, the bus has intensified its frequency on the east side of campus, reducing wait times from 30 to 15 minutes. However, this adjustment may still leave students residing on the west side of Renner Road waiting for up to 30 minutes for the bus. Emphasizing the department's primary goals for the shuttle service, Grant underscores the need to enhance both frequency and adequacy. Given that a significant portion of bus commuters are international students, the department closely monitors admissions to ensure the provision of sufficient and efficient transportation services.

Currently, the department is navigating the challenges posed by infrastructure, construction, and climate to maintain a delicate balance in delivering effective transportation services.

DART Data Analysis & Collecting Survey Data

Using the information we learned from our interview with Elena Grant as a foundation, we gathered quantitative DART ridership data and designed a survey to collect information on student behaviors and opinions related to weather, parking, and shuttle services. Our focus on analyzing this service was driven by the recognition that transit ridership plays a crucial role in mitigating the impacts of Urban Heat Island (UHI). While immediate adjustments to the city's dense infrastructure might be challenging, collectively, our students can contribute to minimizing the carbon footprint through increased mass transportation utilization. Buses, trains, and other forms of transportation facilitate the community's daily commute to and from campus, aid students in reaching their workplaces, and provide routes for local grocery shopping with stops near essential outlets. Despite its vital role in the community, DART has yet to reach the 6 million monthly ridership it achieved in 2019, prior to the COVID-19 pandemic (2019 Texas Transit Statistics). According to the Public Transportation Division of Texas 2022 transit report, DART's best monthly reported ridership was slightly over 4 million.

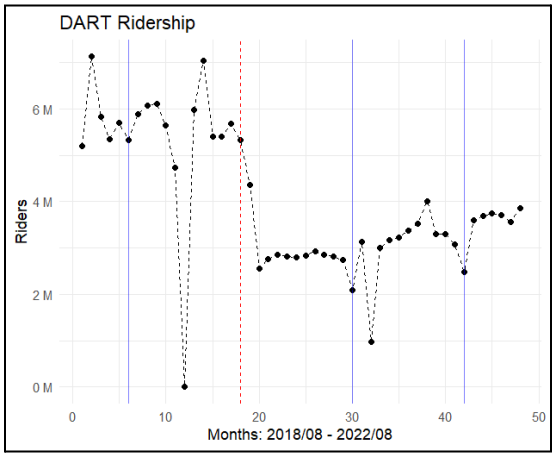

Figure 8

The line chart above illustrates DART's overall ridership since August 2018, with the red dotted line marking the year 2020 and a sharp decline in ridership (Figure 8). While the aftermath of the coronavirus has understandably heightened concerns about public health and safety, maintaining trust in public transit remains pivotal for addressing climate change. Putting pandemic hesitancy aside, our student survey assessed DART's services by evaluating functionality on a 0 to 5 Likert scale (0 representing the worst score and 5 the best). Unfortunately, our findings indicated that students did not hold a favorable view of the local transit system across various aspects covered in our five questions. Participants ranked DART on weather protection at stops, shade and visibility, onboard AC, timeliness, and seat availability. In our survey, DART performed best in terms of seat availability, receiving a score of 2.73, aligning with our observations of current ridership levels. Below this score, shade and visibility, onboard AC, and timeliness were tied at 2.21. These scores provide insight into the daily experiences of an average DART user. Many stops around UTD lack adequate shade, leaving riders exposed to the elements or requiring them to find nearby shelter with a higher risk of going unnoticed by passing buses. Despite enduring extreme temperatures and adverse weather conditions, survey participants reported instances of tardiness, which can significantly impact their academic and work schedules. This issue is further exacerbated for those in our survey who use a combination of routes alongside the 883 to reach campus. Lastly, DART's lowest score was in protection from the weather, with an average score of 1.91. While DART has some indoor shelters and roofed structures for popular stops, not all stops receive the same level of protection.

Upon analyzing the DART data, we designed a survey on transportation methods and gathered opinions on UTD's parking practices and DART behaviors. This survey was created on Qualtrics and subsequently distributed to UTD's student population, inclusive of both

undergraduate and graduate students. As graduate students at UTD, the university's student body was the most accessible for our research, and as UTD is primarily a commuter school, students typically exhibit increased concern about overall weather and traffic trends, making them an ideal target population for surveying on topics related to heat-related illnesses and other associated concerns. The survey distribution initially required IRB approval, a challenging process given our time constraints. However, we were able to get endorsement by Dr. Karl Ho to facilitate the survey distribution in a timely manner.

Our survey included 21 questions organized into two main themes: commuting patterns and traffic trends, and practices and attitudes towards inclement weather. For example, respondents were asked to select factors influencing their hesitation to commute to school, such as extreme heat, extreme cold, heavy rain and/or thunderstorms, tornadoes, foggy conditions, allergies and air quality, road visibility, other drivers' ability to drive safely, road hazards, and dysfunctional AC/heater. The survey also gathered demographic information, including age, gender, ethnicity, and academic year. Administered over a week using a QR code linked to the survey, we approached random groups of UTD students on campus during the week of November 27th, seeking their input in locations like Green Hall, the Student Union, and around the Plinth. In total, we received 33 responses, and our survey results will be detailed below.

Out of our 33 respondents, the majority were graduate students, with seniors and juniors forming the second-largest group, followed by freshmen with a slight margin, and sophomores being the least represented population (Figure 9). Approximately 57.6% of respondents were female, and 42.4% were male. Around 78.8% indicated that they reside off-campus, 15.2% reported living on campus, and 6.1% mentioned Northside as their residence. This distribution aligned with the transportation modes our participants use: over 59% drive their own cars to

school, 16% opt for walking, 11% engage in carpooling or ridesharing, less than 10% rely on DART, and approximately 5% utilize a bike, skateboard, or other non-motorized means. Among car commuters, the majority hold a Gold parking permit, with the Green parking permit being the second most popular (Figure 10). Notably, none of our participants had access to handicap parking. Over 54% of participants spend 20-30 minutes commuting without traffic, 21% reported commuting takes them 10 minutes or less (Figure 11). However, 36% reported that their commute might extend to 30-60 minutes with traffic, 27% reported that their commute was within the 20-30 minute time range with traffic, and 18% reported that their commute takes 10 minutes or less with traffic (Figure 12).

While less than 10% of respondents incorporated DART into their daily commute, all participants were surveyed about DART infrastructure, and were tasked with evaluating it by using a Likert scale. Among those 10% utilizing the DART, the 883 bus emerged as the primary commuter route for 50%, 25% utilized the 883 along with a combination of other bus routes, and another 25% incorporated both bus routes and trains. The majority (39%) of respondents disagree that DART stops offer no protection from the sun and weather, while 15% believe DART stations offer sufficient protection from the sun and weather. When asked about whether DART has good AC onboard 36% disagreed, 21% neither agreed or disagreed, and 15% agreed. We then inquired about participants' frequency of weather-related discomfort while awaiting public transportation, with 75% stating they sometimes experienced discomfort and 25% indicating they always felt discomfort.

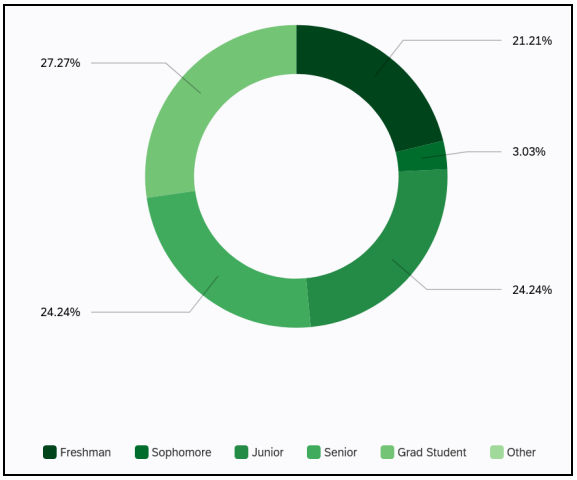

Figure 9: Survey demographics

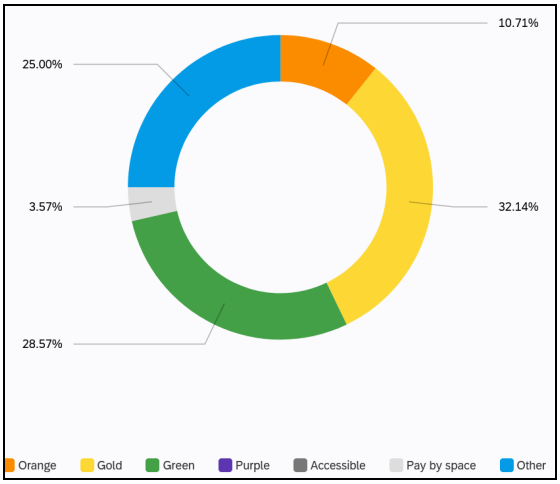

Figure 10: Parking Pass Purchases

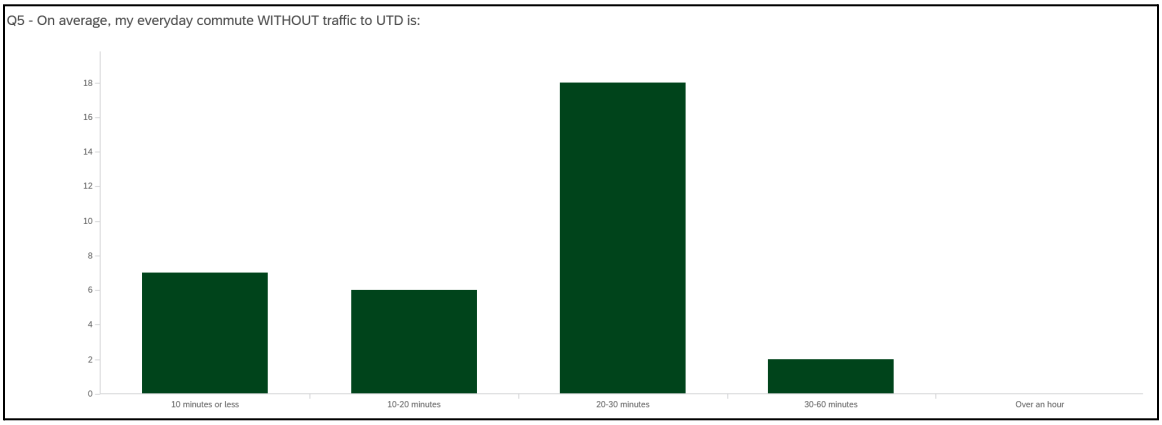

Figure 11: Commute Time Without Traffic

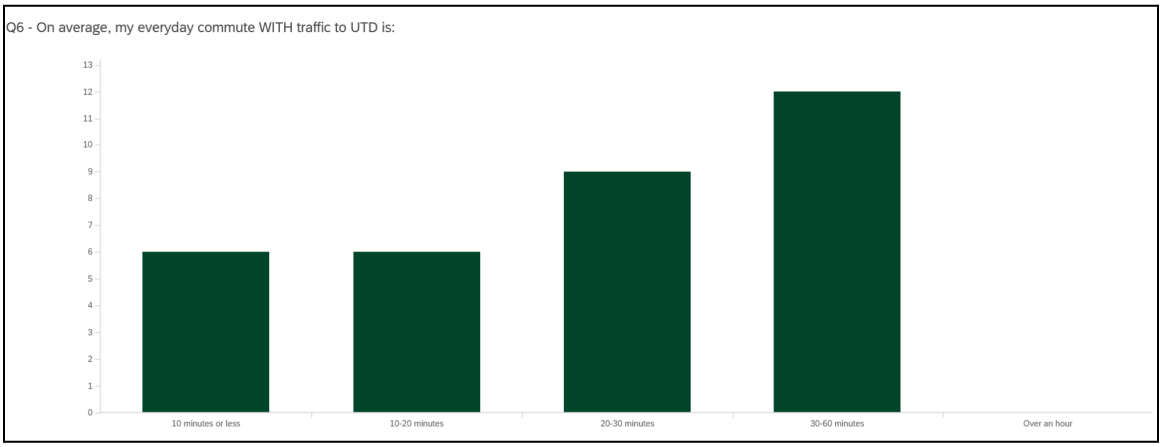

Figure 12: Commute Time With Traffic

After collecting data on our respondents' commuting methods, our attention turned to inquiries about their attitudes toward dealing with inclement weather. The most popular item that respondents used to battle the heat during their commute to campus was a water bottle (less than 40%), with sunglasses being the second most popular at approximately 23%. The majority of respondents also noted that they drink liquids during their commute (44%), 32% reported staying close to shaded areas, 15% utilized skybridges, and 9% reported taking breaks in buildings along the way. Our next question explored the respondents' opinions on UTD functions being canceled due to weather. The responses varied, with 37% wishing professors would be more considerate of the weather, 29% advocating for more frequent and earlier cancellations in adverse weather conditions, 26% expressing that cancellations are made late and often after they've commuted to campus, 4% believing functions are canceled too often for weather, and another 4% thinking functions are canceled frequently for non-harmful weather. Participants also shared their reasons for hesitating to commute to school, with extreme cold weather, tornadoes, and heavy rain/thunderstorms being the top concerns, while allergies and air quality, foggy conditions, dysfunctional AC/heater, and other car-related issues were of lower concern (Figure 13).

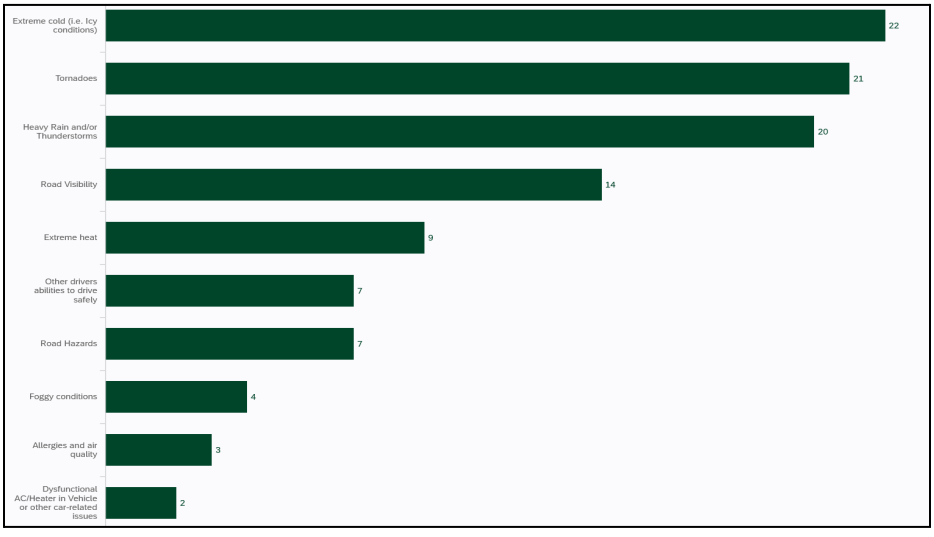

Figure 13: Most Common Concerns Pertaining To Weather

When queried about seeking medical assistance due to excessive heat, approximately 94% of participants reported having never sought medical assistance, with 3% seeking help once and another 3% seeking help more than once. However, when asked if they knew someone who had suffered from heat-related illnesses such as heat stroke or heat exhaustion, 42% responded "yes," 24% answered "maybe," and 33% answered "no." Additionally, participants were asked to express their agreement with the statement, "I pay attention to local heat advisory notifications given by the weather app on your phone," using a Likert scale. The responses were as follows: 9% strongly agreed, 42% agreed, 21% neither agreed nor disagreed, 21% disagreed, and 6% strongly disagreed.

In our exploration into the commuting habits, attitudes towards inclement weather, and health-related experiences of the DFW community, we unearthed valuable insights. As we transition into summarizing our findings, it becomes evident that the intersection of urban infrastructure, climate challenges, and individual well-being requires thoughtful consideration and collaborative efforts for sustainable improvements.

Analysis of Findings

Our research has brought to light intricate dynamics at the crossroads of urban infrastructure, climate variability, and individual well-being in the DFW community, revealing multifaceted challenges and noteworthy trends. The medical examination of heat-related illnesses in Dallas, Denton, and Tarrant counties exposed a significant surge in reported cases in 2023, pointing towards a concerning upward trajectory. This compelling evidence lead us to reject the null hypothesis and affirm our alternative hypothesis, indicating a significant impact of climate change on the frequency and intensity of heat-related illnesses in the DFW Metroplex, with residents actively adapting to these changes.

However, it is crucial to note that these community trends do not align seamlessly with the priorities and adaptations observed within the UTD student population. Despite our alternative hypothesis gaining support in the broader context of the DFW community, UTD's primary concern, as evidenced by the survey responses and adaptations implemented by the parking department, lies in addressing extreme cold weather. This highlights the complexity of climate-related challenges and the need for tailored approaches that consider the diverse priorities and adaptations required for distinct climate scenarios in the DFW community.

Conclusion

Keeping climate change, infrastructure, transit, and health considerations at the forefront is crucial for several reasons beyond the reminder of the need for sustainable energy sources. It underscores the importance of thoughtful infrastructure planning, emphasizing the potential health impacts associated with choices in construction materials, shading, and vegetation preservation. Building structures with high thermal conductivity and limited shade, coupled with the removal of humidity-moderating vegetation, can contribute to health vulnerabilities and infrastructure fragility. While UTD students may employ personal measures to alleviate heat effects, the increasing consequences of heat-related illnesses (HRI) and the additional costs for repairing materials affected by humidity and weather stress cannot be entirely mitigated at an individual level. The long-term danger lies in the forecasted longevity of these structures, which may not have been designed with comprehensive insights into the destabilizing weather patterns induced by climate change. Considering the factors contributing to urban heat islands (UHI) and their adverse effects on health, our findings indicate that UTD students are becoming more aware of their climate and adapting their behaviors accordingly. Many participants prioritize staying hydrated and seeking shaded areas to avoid discomfort. A significant portion has even chosen to

skip classes due to weather and vehicle safety concerns, expressing dissatisfaction with the timing of UTD's decisions to cancel school functions. Extreme heat emerges as a significant concern, particularly for the nearly 40% of respondents without a vehicle for protection. While awareness about the stress of heat on the body is evident, the results suggest potential room for growth, with some respondents not utilizing additional protective measures like sunscreen, hats, or umbrellas.

Expansions/Future Solutions

These studies delve into the variables that both contribute to and mitigate the formation of Urban Heat Island (UHI) and the associated risks of Heat-Related Illnesses (HRI). While building materials and transportation methods have been recognized as influential factors contributing to UHI, our project focuses on analyzing the impact of climate change as its primary driver, particularly concerning human health. An additional hypothesis suggests that UHI may have a detrimental effect on holistic wellness by potentially encouraging individuals to spend more time indoors as a means of seeking refuge from adverse weather conditions. This shift towards indoor activities could further amplify some of the observed medical cases related to heat-related illnesses.

Our project proposes actionable suggestions for transit services to consider the design of their stops, taking into account the level of exposure students face to adverse weather effects. We underscore the importance of reconsidering natural elements, such as the removal of trees in favor of roads and barren grass fields, as this alteration in the environment may contribute to the observed health impacts. The data and scientific sources we've compiled also suggest that current infrastructure activities could have exponentially more detrimental effects on future residents, as

UHI has been shown to accelerate climate polarization faster than engineers can make predictions for (Climate Impacts on Transportation).

Moreover, our findings hint at a potentially negative trend in continued ridership for Dallas Area Rapid Transit (DART), as increasing heat challenges residents' patience, making public transportation less appealing. This highlights the urgency of addressing climate-related challenges and reevaluating urban development practices to create more sustainable and health-conscious living environments.

Taking our research farther, our weather, medical, and student survey could be transformed into a dashboard that can aid in pinpointing land usage issues, as well as steps individuals can take to have better health under these conditions. Our survey revealed that while certain students were using items like sunscreen and bringing water with them during their commute, not all were engaging with the items that can help alleviate heat related stress to our bodies. This research could be potentially transformed into a GIS application that makes recommendations and further humanity’s plight against climate change.

Limitations

We encountered several limitations throughout the course of our research project. The primary constraint arose during the collection of medical data on heat-related illness emergency room visits for Dallas County, Denton County, and Tarrant County. As previously noted, Tarrant County did not collect heat-related illness data between 2020 and 2021, attributing this gap to the pandemic and the resultant absence of tracking data. Additionally, Denton County did not provide individual reports categorizing heat-related illnesses, preventing us from conducting specific research on distinct categories. For example, we were unable to compare increases in specific categories, such as heat-related fatigue or heat-related mortality, in comparison to the

previous year. Given the limitation of utilizing data solely from 2022 and 2023, our ability to analyze trends over the last decade or so is compromised, hindering our understanding of the overall increase in heat-related illnesses over time.

We encountered an additional limitation during the construction of our survey for data gathering and while conducting interviews with the parking department at UTD. When initially working to implement our survey for data collection, we sought confirmation from the IRB office regarding the use of human subjects for research. The process of obtaining IRB approval turned out to be time-consuming, taking weeks. Prior to being approved to distribute our survey and collect data, we were notified that our entire group needed to undergo hours of training. This posed a significant time constraint, as we were already facing a tight schedule to send out the survey and gather sufficient data for our research.

Ultimately, the situation presented a new challenge when we realized that obtaining IRB approval was not required; rather, the necessary approval could be secured through the endorsement of our academic professor. This realization left us feeling that we had expended time waiting for IRB approval when it was not required. By this point, we were heading into Thanksgiving break and unable to distribute our survey on campus to collect random sample data. Consequently, we had to wait until the following week, bringing us dangerously close to the deadline of our project. This time constraint forced us to rush the analysis of our collected data. Having a small sample size also reduced our ability to analyze our data by demographics.

Concurrently, we initiated contact with the parking department and found ourselves on a somewhat convoluted quest for relevant contact information. Our pursuit led us through three different managers of the parking department, none of whom responded to our emails. Eventually, we were directed to the assistant director, Elena Grant. Although we successfully

conducted an interview with her and obtained the necessary information for our project, the delayed responses and time constraints left us concerned. To mitigate potential setbacks, we proactively devised a backup plan in case we needed to proceed with our research project without relying on the information provided by the parking department, which involved incorporating supplementary questions into our initial survey, specifically focusing on various parking methodologies.

Our final limitations lie in the demographic of our survey. Firstly, our survey's sample demographic primarily consists of students, potentially introducing biases in the interpretation of the data. To address this limitation, future research could benefit from a more extensive and diverse sample size, encompassing a broader cross-section of the community beyond the student population. This would provide a more comprehensive and representative insight into the various perspectives and experiences within the DFW Metroplex. Additionally, the lack of respondents with chronic conditions within our sample introduces a limitation in the generalizability of our findings to individuals with underlying health concerns. Future research endeavors could incorporate a more diverse range of participants, including those with chronic conditions, to better capture the potential variations in experiences and responses related to heat-related illnesses. Furthermore, an interesting observation is that individuals who did not suffer from heatstroke might attribute their resilience to spending more time indoors in air-conditioned environments. This acknowledgment highlights the importance of environmental factors in mitigating the impact of extreme heat. However, this observation also introduces a potential bias, as those spending more time outdoors may be more susceptible to heat-related illnesses. Recognizing this limitation, future research could delve deeper into the role of environmental

conditions, such as the absence of shading, and behaviors in shaping individuals' susceptibility to heat-related issues.

In conclusion, our research journey was marked by various challenges that tested our adaptability and resilience. From navigating data limitations in heat-related illness reports across Dallas, Denton, and Tarrant counties to overcoming hurdles in survey implementation and interviews with the UTD parking department, we demonstrate our commitment to thorough investigation. The unanticipated complexities, such as delayed responses and the IRB approval process, prompted us to reassess our strategies and implement contingency plans. Despite these obstacles, our team persevered, utilizing creative solutions to enhance the depth of our research. As we reflect on these experiences, we recognize the invaluable lessons learned and the importance of flexibility in the face of unforeseen challenges. This project not only deepened our understanding of research methodologies but also fostered a spirit of resilience and adaptability that will undoubtedly serve us well in future endeavors.

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