# The Impact of Walkable Cities in Texas on the Mental Health of Residents

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EPPS 6356 Data Visualization

12/04/2024

## Abstract

Our study aims to examine the relationship between walkability index across three large Texas cities and the average depression rates for residents of those cities. Using existing data from the CDC and the EPA's National Walkability Index, we were able to extract relevant data and use various data visualizations to meaningfully showcase the observed association. Through our review and representation of the data, we can see evidence of a negative association between a Texas city's average walkability index and the average depression rates experienced by its residents. The limitations and lack of accessible mental health data highlight the need for further research on this topic that focuses in more detail on walkability measures and definitions, other measures of mental health outcomes, and controls for other socioeconomic factors that are likely impacting mental health outcomes for Texas city residents.

## Introduction

In the United States today, 83% of the population lives in urban areas, as compared to 64% urban population in 1950. By 2050, it is projected that 89% of the U.S. population as well as 68% of the world population will be living in urban areas. Given these statistics, it is fundamental for us to develop a better understanding of how urban environments can influence humans' daily lives and thus their mental health and wellbeing. City design is characterized by a number of factors, all of which can play a role in how humans experience the built environment; these factors can include housing type and density, street design, greenspace, public transportation, community facilities and amenities, density, walkability, and more (Rohe, 1985). Because of the relevance in our daily lives and how it is more easily noticeable and experienced, we were compelled to focus on walkability for our research interests. As Dallas residents, we have first-hand lived experience in how the lack of walkability is present and controls the way in which we adapt our lifestyle and mobility, and we know this to be true for residents of other major Texas cities as well. The lack of walkability is an essential aspect of urban design that characterizes Texas as a state as well as its major cities; for the most part, if residents don't have a personal vehicle or other access to one, mobility is limited to relying on public transit or other modes of transportation. There is extensive research on why walkability is impactful on daily life and wellbeing; namely, the "environmental conditions that people may experience, such as the stress of travel, noise, the perception of danger or insecurity in the street, the lack of natural light or little contact with nature and the lack of physical activity, affect moods and emotions in general" (Zumelzu and Herrmann-Lunecke, 2021, p.4). For these reasons, we chose walkability to be our independent variable to be studied in relation to its impact on mental health.

The purpose of this study is to contribute to research of how the walkability of cities affects residents' mental health. We aimed to primarily focus on metropolitan areas in Texas and compare the walkability indices of multiple major cities in the state - Dallas-Fort Worth, Austin, and Houston. We can analyze these patterns and trends to find correlations between walkability and the mental health of city residents. With these findings, we can provide insights into how urban design and infrastructure in major cities can be optimized to improve people's daily quality of life. Although there is an abundance of research on the relationship between walkable cities and physical health, there is a gap in the research for its effects on mental health. The main question we are trying to answer is whether living in walkable cities improves the mental health outcomes of those residents. This was an important subject for us because an ongoing issue being brought up around different health policies is the inadequate access to mental health resources for residents; it is difficult for many people with and without insurance to have access to a mental health provider. Although there are certainly many different factors that affect a person's mental well-being, we wonder if striving to make cities more walkable can be one form of preventative measure for mental health illness. Provided that the research does justify the need for these efforts, perhaps there may be a future in which city design can improve mental health as well as the physical health of its residents, and more human-conscious and health-conscious cities and measures will develop as a result. We hope that our study of the data can contribute to this goal. We will provide a brief review of the existing literature, describe the data and measures for our analysis, visually illustrate our findings, and conclude with a review of the limitations of our research and implications.

## Literature Review

In this existing literature on walkability in cities, few studies have aimed to directly examine the relationship between the walkability and the impact on mental health outcomes. Many researchers have found links between walkability and physical health, as it is widely known and studied that physical health influences mental health outcomes.

Some studies have analyzed the impact of walkability on mental health; a key contribution is the article by Warner et al. in which researchers conducted a scoping review of studies in the existing literature that have examined the extent of the relationship between walkability and depression and anxiety in study participants. In several of the included studies, the researchers found that the overall walkability score was significantly associated with depression and anxiety symptoms when controlled for other factors such as the respondent's activity levels and the buffer distance to the respondent's home (Warner et al., 2022, p.61). Access to amenities, residential density, and street connectivity were also measured and incorporated as factors of walkability that were associated with reducing depression symptoms. Across multiple studies, the consistent findings were that particularly in urban settings, walkable environments promote social interaction and physical activity, which are two factors that are widely known in contributing to improved mental health. However, the researchers discuss how environmental and socioeconomic contexts can alter benefits of walkable areas. They also mention that it is necessary for future research to distinguish between definitions of walkability and how it is measured, as this can lead to varying results in the relationship to mental health outcomes. Interestingly, James et al. in their study focused on minority and low-income populations, specifically low-income African Americans and white Americans; what they discovered was that study participants living in areas with the highest walkability index had 6%

greater odds of experiencing moderate or more severe depression symptoms. In more deprived or low-income neighborhoods, higher walkability was associated with greater chances for depression symptoms, whereas in more affluent neighborhoods, walkability was associated with much lower odds of experiencing depression symptoms (James et al., 2017, p.74). In other words, walkability might not confer the same mental health benefits if neighborhoods have higher crime rates or poorly maintained infrastructure, whereas well-resourced areas reap the benefits more. This illustrates the need for more specific and nuanced research on walkability and mental health that accounts for other factors that are likely at play.

In another example, Zumelzu and Herrmann-Lunecke discuss the importance of the built environment and its corresponding factors on people's mental health in their article "Mental Well-Being and the Influence of Place: Conceptual Approaches for the Built Environment for Planning Healthy and Walkable Cities" (2021). The authors posit that the built environment is being more widely recognized as a determinant of human health; specifically, they explain that mental health is "related to all aspects of spatial design" (4). One key aspect of spatial design is walkability, which the authors did find to be significant in predicting mental health and well-being. While the scope of this study was limited to Chile and Latin American cities, they did emphasize the finding that environmental design which includes walkability as a consideration can increase quality of life for residents. Another study by Siquieria et al. studied the relationship between neighborhood walkability and the mental health of older adults in Brazil; these researchers measured depression and cognitive impairment in their sample of aging adults as well as the walkability index of where each individual was residing (Siquiera et al., 2022). They found that older adults living in places with a "high" and "highest" walkability index were 38% and 44% less likely, respectively, to experience cognitive impairment; in

contrast, they did not find an association between depression and walkability (Siquiera et al., 2022, p.5). While their findings are useful for our study, it does highlight the need for more research focused on those experiencing depression and how it is affected by walkability in their environment. The authors Buttazzoni, Doherty, and Minaker (2022) also describe how mental health outcomes can be explained by public health and urban planning concepts, and due to the projected increase of migration to cities in the coming years, they advocate for more research to focus on  understanding the influence of urban environments on mental health (Buttazzoni et al., 2022, p.48). The authors also highlight neuro-urbanism as a key framework for analyzing the links between urban environments and mental health outcomes, since this emerging field of study aids us in "understanding the effects of urban living and environments on neurological processes and enhancing the collaboration among neuroscience, public health, and planning, among other fields, to create healthier environments" (Buttazzoni et al., 2022, 51). City planning processes and choices can have significant implications for mental health because many of the social determinants of health are wrapped up in the design of the built living environment, which can affect individuals' lifestyles and therefore their physical and mental health outcomes (Buttazzoni et al., 2022, 50).

Noticeably, there have been few studies or analysis of the relationship between mental health and the walkability of Texas cities in particular. In the research literature, we found few cases of walkability research focused on Texas; the few that have focused on Texas cities have mainly been interested in the connection between walkability and physical health of residents. There are also few studies that center their analysis particularly on depression as a mental health outcome in relation to walkability in an individual's daily environment. Thus, our study seeks to close the gaps in the literature on walkability and mental health outcomes by engaging in a

deeper analysis of findings for the impact of walkability on depression experienced by Texas residents in three of its most populated cities.

## Research Question

Given the gaps in the existing literature on walkability and mental health, particularly in Texas cities, our project aims to answer the question: *Do walkable cities in Texas improve mental health outcomes for residents?*

Although no experiment is being conducted, we hypothesize that our review of the existing data will demonstrate a negative association between walkability and depression rates and will hopefully encourage more research on this question.

## Measures

Independent Variables

*Walkability Index:* We used the Walkability Index provided by the United States Environmental Protection Agency (EPA). This quantifies the degree in which a city is conducive to walking. There are many different factors that encompass that final walkability score. These include the availability of sidewalks, proximity to residential areas to essential services (grocery stores), and the overall pedestrian-friendliness of a city. This variable is important to our study because it represents the parts of urban design that we hypothesize may be in some way influential to mental health outcomes.

Dependent Variables

*Depression*: In our study the mental health status of residents in Dallas, Austin, and Houston is our dependent variable. This is measured through indicators of depression. This

provides insight into the mental well-being of individuals and are key factors for us to understand the potential mental health impacts of urban design on psychological health.

A higher walkability index suggests there is better infrastructure to support a walkable lifestyle, which also promotes more social interaction and physical activity. By understanding and examining the relationship between our two measures, this research can provide insight into how urban planning can be influenced and take into consideration how it can support the mental well-being of residents. While experiencing depression symptoms can be influenced by other factors, we wanted to isolate walkability as our independent variable. Therefore, if a significant relationship is found, this knowledge can influence policymakers and city planners to advocate for and create environments that foster more holistic wellbeing and may serve as a preventive measure for depression and anxiety.

## Data Visualizations

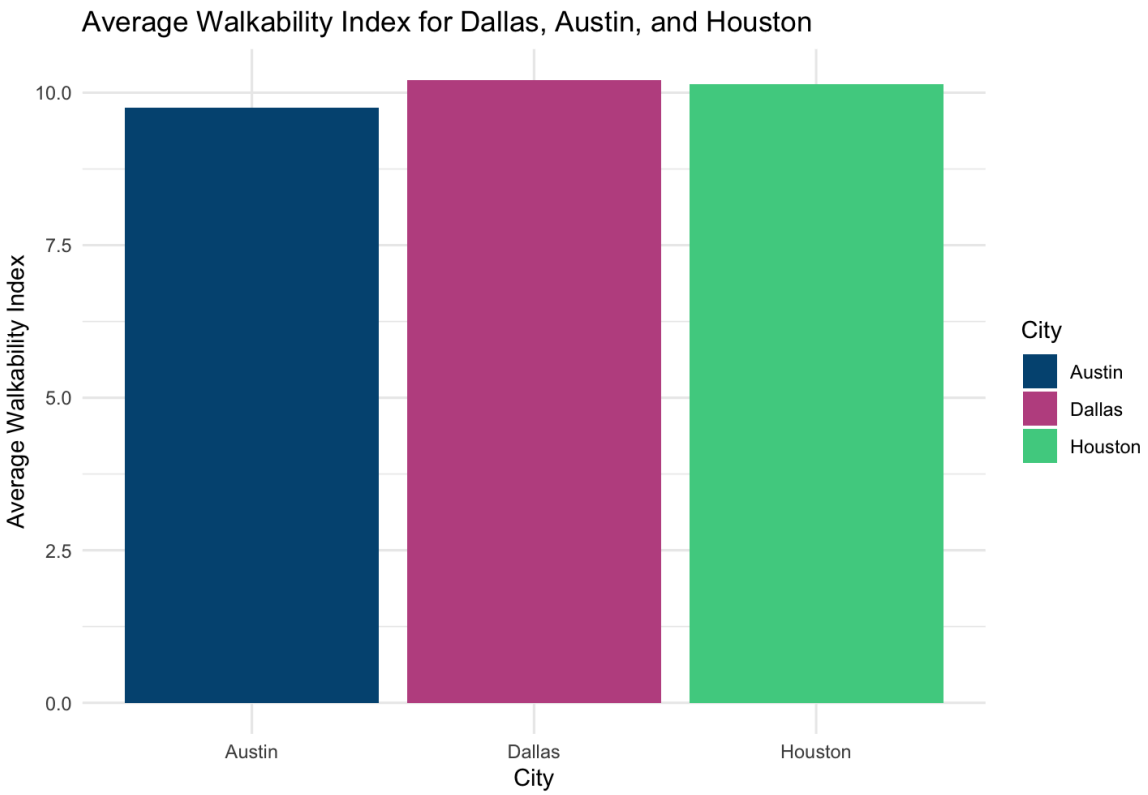


*Figure 1* - Bar Chart of Average Walkability Index for Dallas, Austin, and Houston

The bar chart in Figure 1 above illustrates the average walkability index across Dallas, Austin, and Houston. As conveyed by the bar chart, there is minimal difference in the walkability between these three Texas cities; Dallas has a slightly higher average walkability index as compared to Austin and Houston.

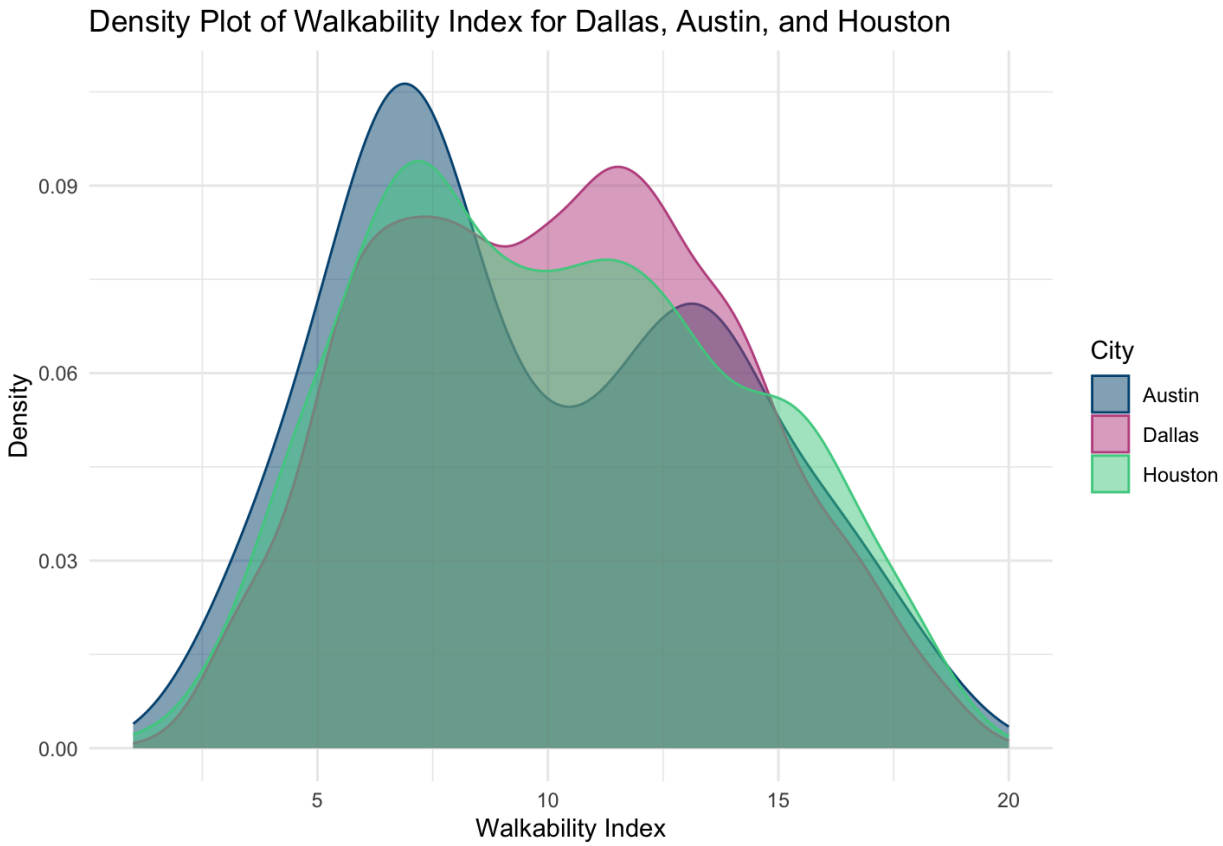


*Figure 2* - Density Plot of Walkability Index for Dallas, Austin, and Houston

The density plot in Figure 2 above demonstrates the variation in average walkability index for Dallas, Austin, and Houston. The y-axis shows the density, for which higher peaks indicate where most of the walkability index values are concentrated for each city. For Austin, the peak occurs earlier compared to the other cities, suggesting that most areas in Austin have less walkability as compared to the other cities. Dallas shows a wider and flatter curve, indicating a more evenly distributed walkability index across the city. Its peak occurs last of the three cities' peaks, which aligns with the fact that it has the highest average walkability index. Houston has a similar shape to Austin but peaks slightly later, indicating slightly higher walkability values in general compared to Austin.

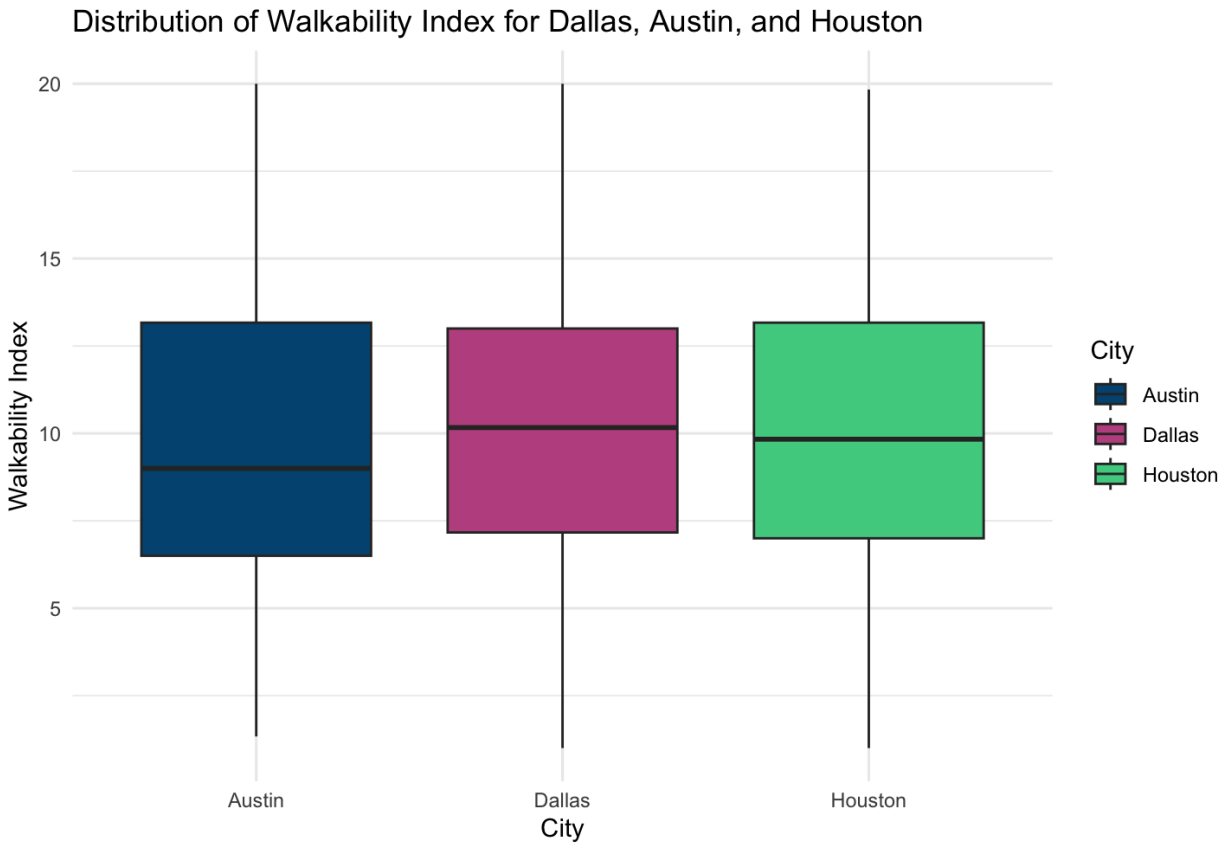


*Figure 3* - Boxplot Distribution of Walkability Index for Dallas, Austin, and Houston

In Figure 3 above, the boxplot distributions of the average walkability index for each Texas city are displayed. In this visualization, it is easier to notice that there is a slightly greater variability in the average walkability index in Austin, although the mean walkability index is the least out of all three cities. Dallas has the highest average walkability index as well as the least variation. Houston has a higher walkability index than Austin.

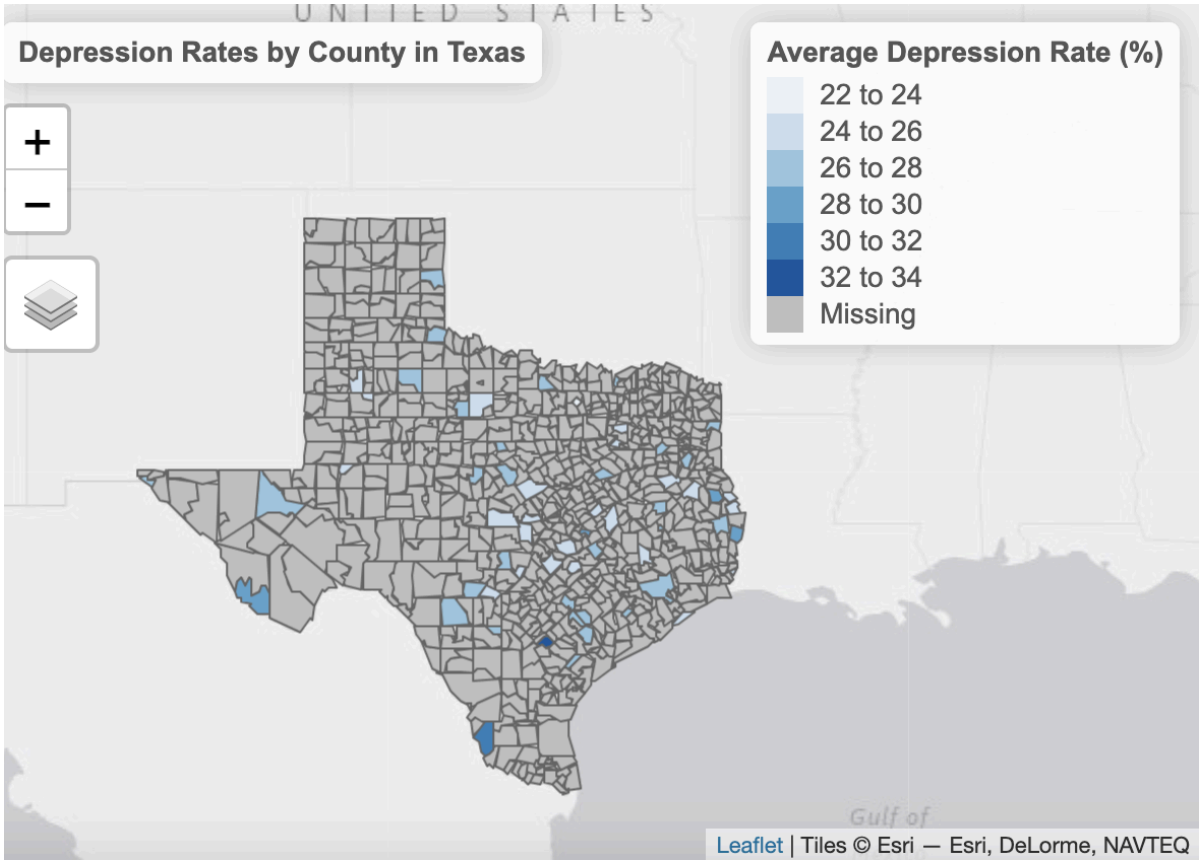


*Figure 4* - Choropleth Map of Depression Rates by County in Texas

The choropleth map above in Figure 4 shows the depression rates by county in Texas. Although we had limited data to work with, this choropleth map allows us to see the spread of depression rates across various counties in the state and distinguish where the depression rates are highest versus lowest. According to the shading patterns, the map shows slightly darker blues in the regions where Austin and Houston are located, as compared to the Dallas region, which is shaded lighter.

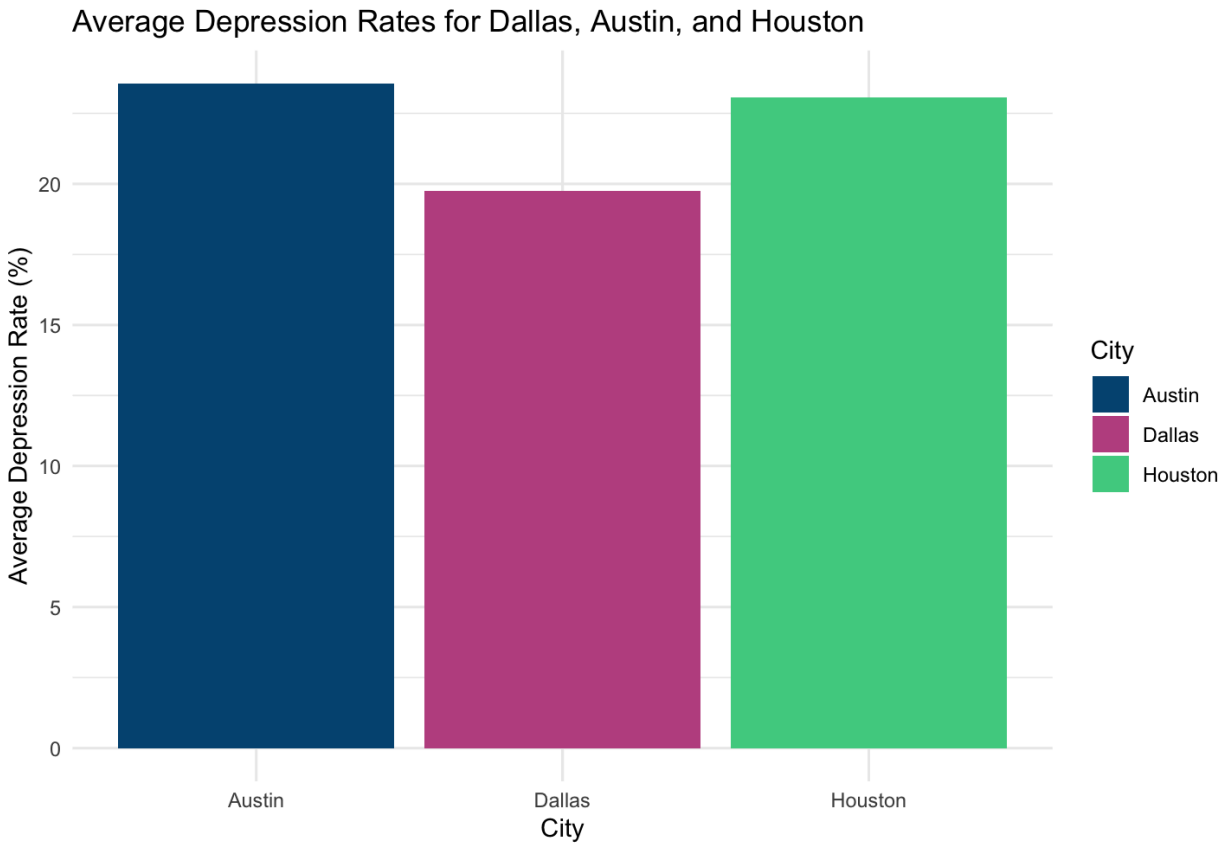


*Figure 5* - Bar Chart of Depression Rates for Dallas, Austin, and Houston

Figure 5 shows the average depression rate across Dallas, Austin, and Houston. Interestingly, we can see that Austin's average depression rate is the highest of the three cities, Houston's is the second highest, and Dallas has the lowest average depression rate, at less than 20%. Referring back to the bar chart in Figure 1 of average walkability in each city, this chart also supports the evidence that there may be a negative association between walkability and depression, since Dallas has the lowest average depression rate as well as the highest average walkability index; the reverse is true for Austin.

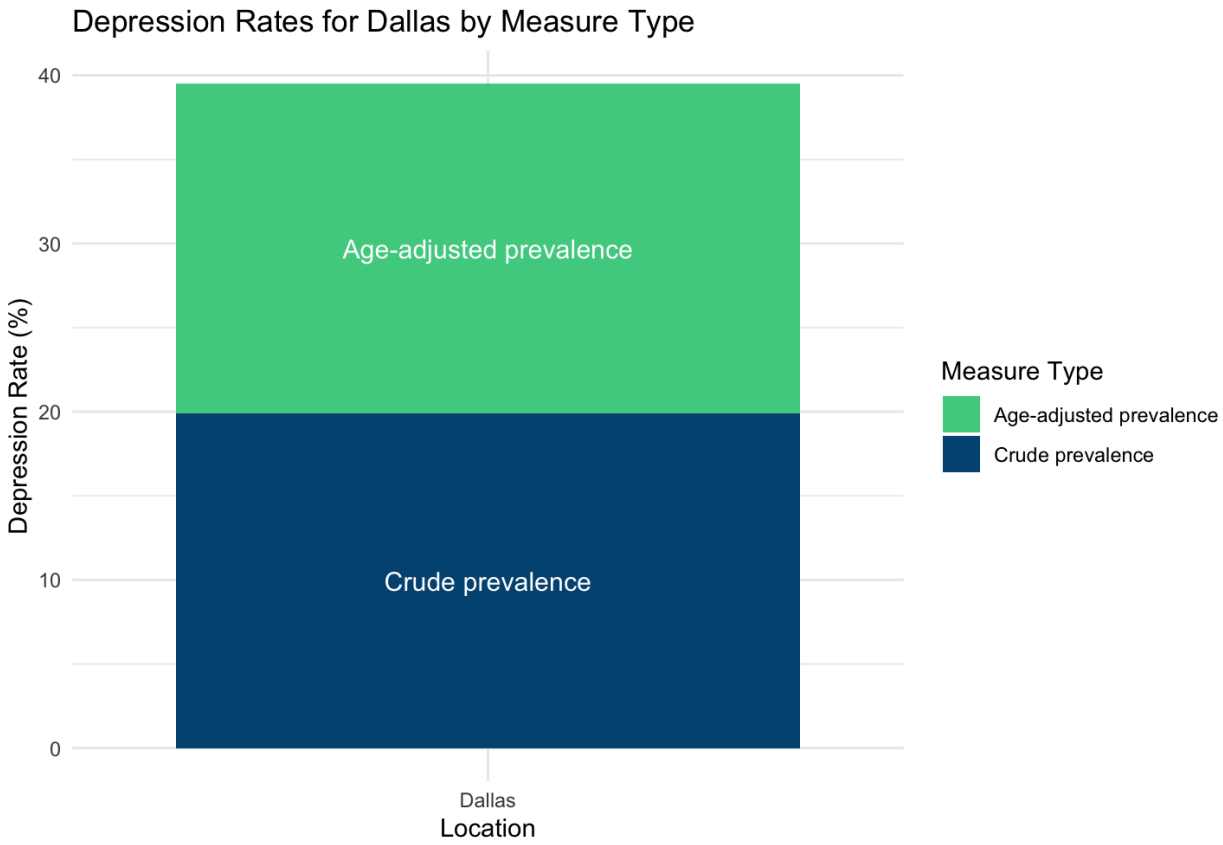


*Figure 6* - Depression Rates in Dallas by Measure Type

In this visualization, the dark blue plotted portion represents the crude prevalence of depression rates in Dallas, which is about 19.9%; this indicates the percentage of the total population that experiences depression, without adjusting for age or any other factors. The green portion is the depression rate adjusted for age, at 19.6% This suggests that after adjusting for age, the average depression rate in Dallas decreases slightly.

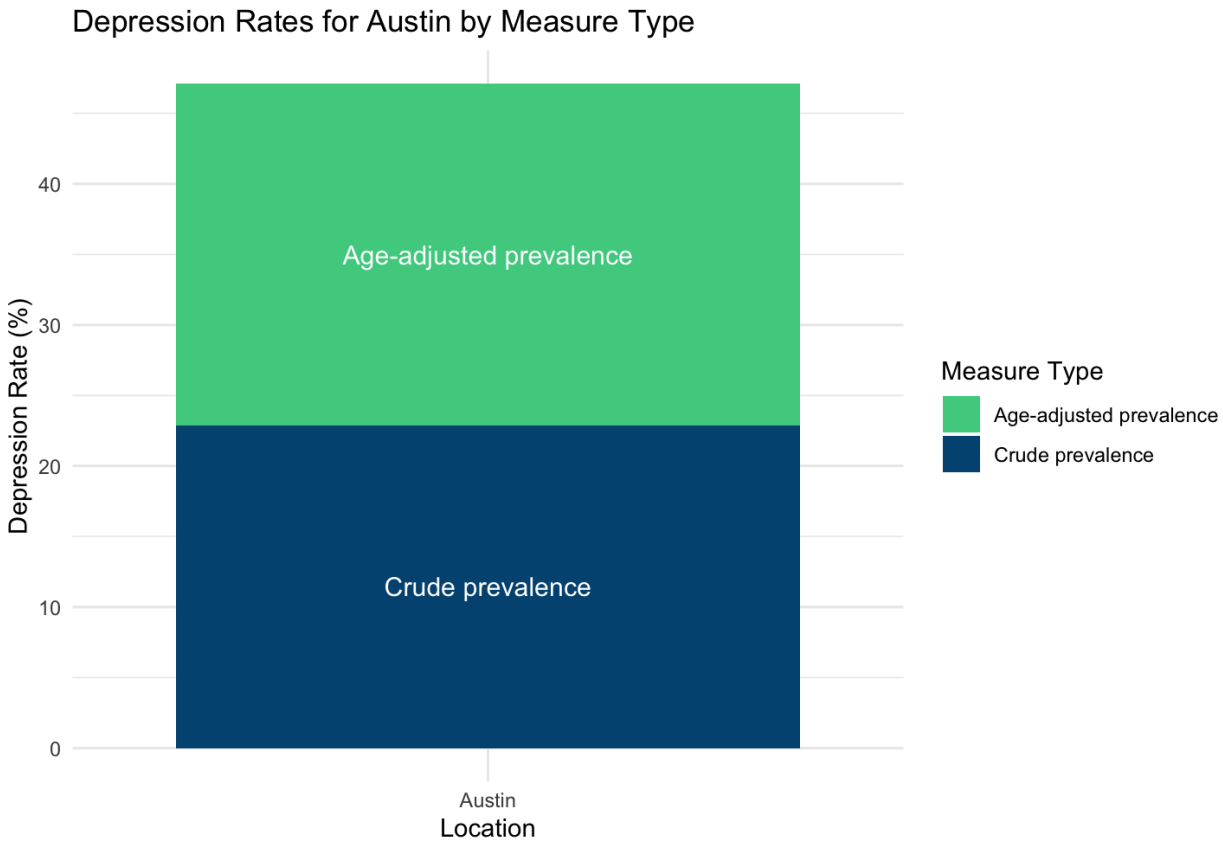


*Figure 7* - Depression Rates in Austin by Measure Type

The crude prevalence depression rate in Austin measures approximately 22.9%. The green block represents the age adjusted prevalence of depression rates, accounting for age. The rate is 24.2% which is considerably higher than the crude prevalence average depression rate. Thus, age seems to be a factor in depression rates in Austin.

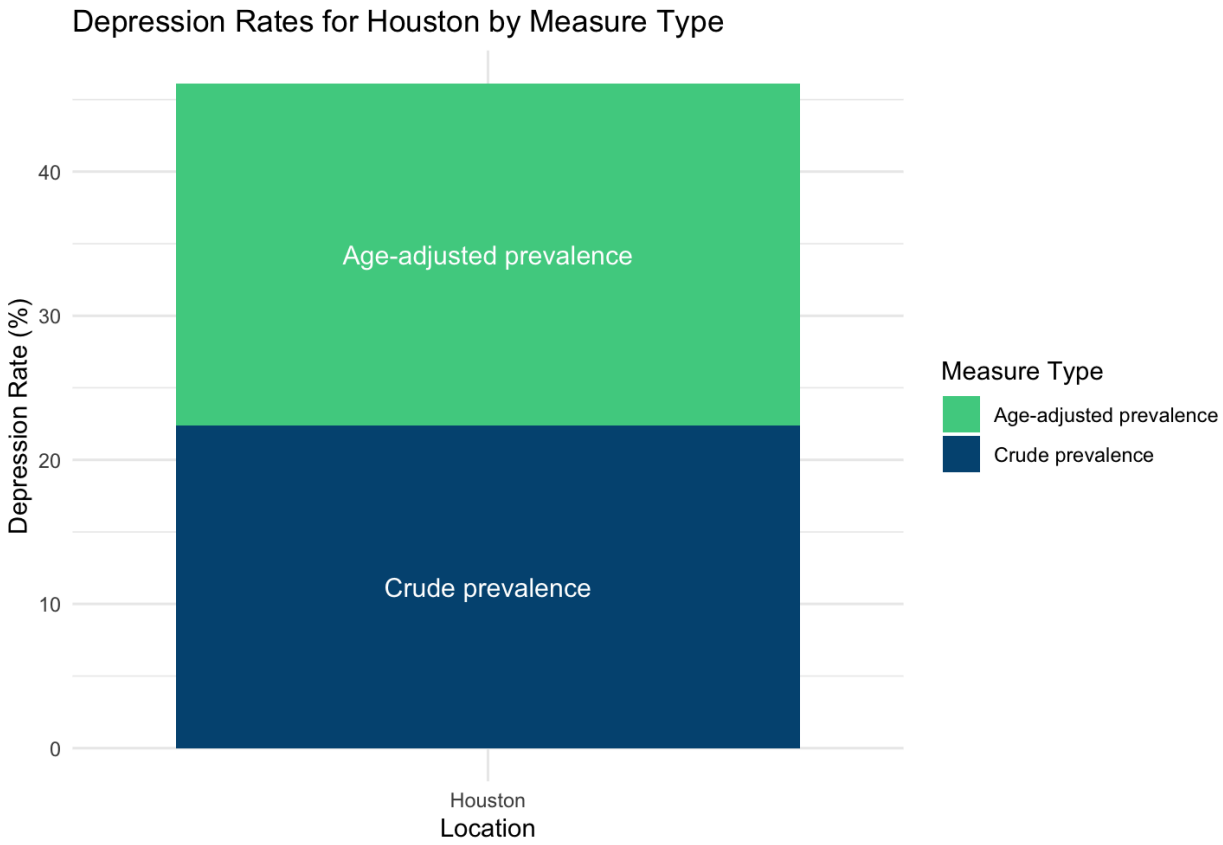


*Figure 8* - Depression Rates in Houston by Measure Type

Similarly to figures 6 and 7, Figure 8 displays the two measures of depression rates in Houston, by age-adjusted prevalence and crude prevalence. The crude prevalence represented by the blue portion is approximately 22.4%; this shows the depression rates for the total population, not accounting for age adjustments. The age-adjusted prevalence for Houston is 23.7%; thus, when controlling for age, the average depression rate in Houston is higher.

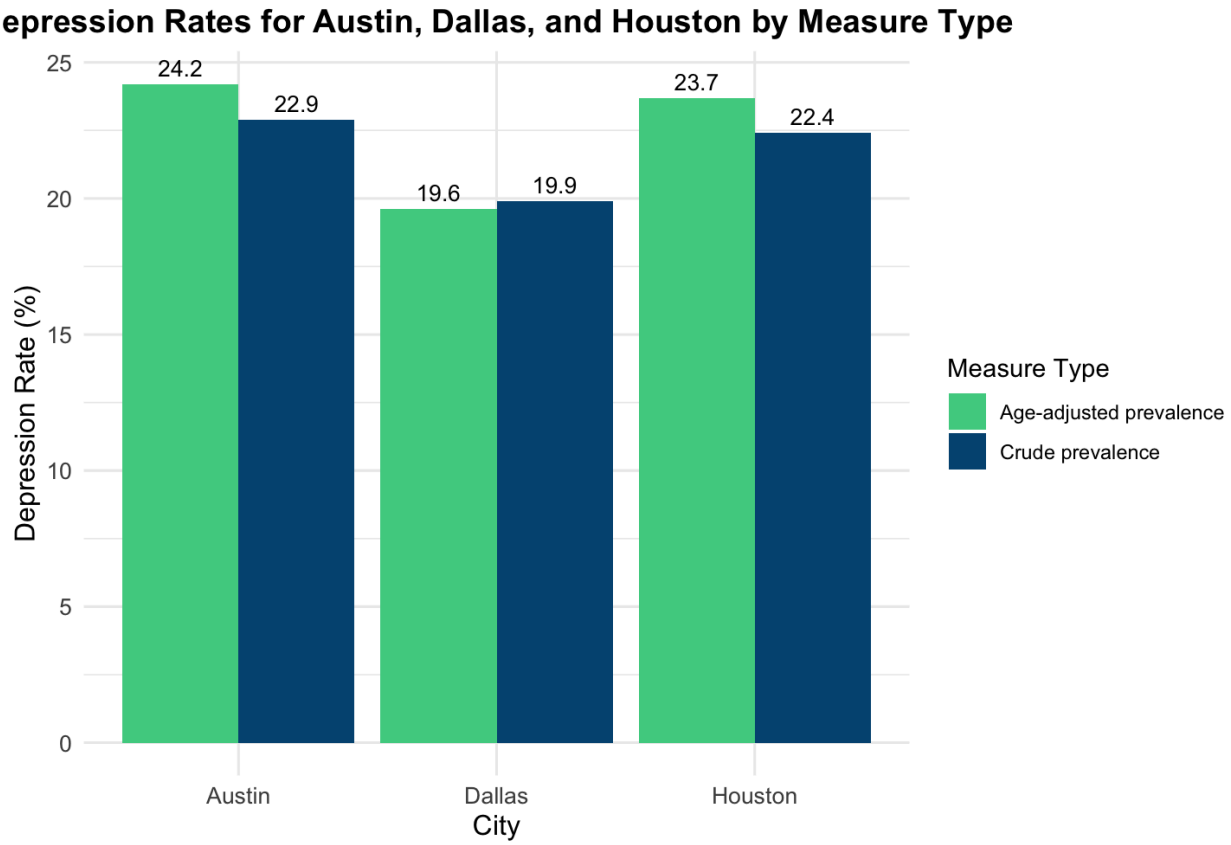


*Figure 9* - Depression Rates for Dallas, Austin, and Houston by Measure Type

In Figure 9 above, the depression rates for Dallas, Austin, and Houston are broken down by age-adjusted prevalence and crude prevalence. The age-adjusted prevalence for Dallas is the lowest at 19.6%, compared with 23.7% for Houston and 24.2% for Austin. The crude prevalence follows the same pattern - Dallas is the lowest at 19.9%, followed by Houston at 22.4%, and Austin at 22.9%. This data indicates that even when age is taken into account, Dallas still has

lower average depression rates than both Houston and Austin, and Austin still has the highest depression rates.

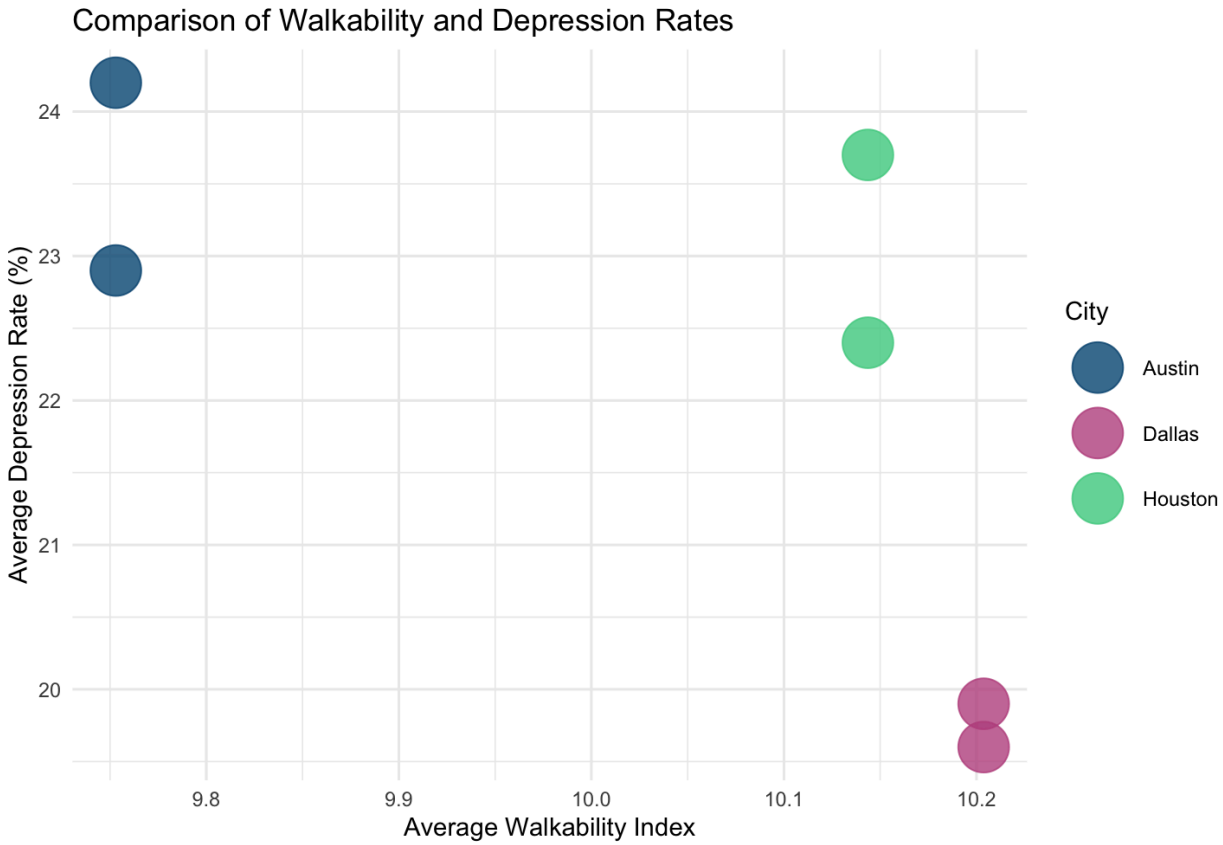


*Figure 10* - Scatter Plot Comparison of Walkability Index and Depression Rates for Austin, Dallas, and Houston

In Figure 10 above, we utilized a scatter plot to convey the relationship between walkability index and depression rates for each city. The two dots for each city represent the age-adjusted prevalence and the crude prevalence for average depression rates. According to the scatter plot, it is evident that Dallas has the highest average walkability index at about 10.2 while

having the lowest average depression rate at less than 20%. In contrast, Austin has a considerably low average walkability index of about 9.75 and a relatively high average depression rate of 23-24%. Houston's walkability index was on average 10.15, while the average depression rate ranged from 22.5% to nearly 24%.

## Code

The code conducts a comparative analysis between walkability indexes and the mental health data used for the study. Data from the walkability index and CDC mental health data were used to calculate aggregates across both data sets and determine average indexes across counties in Texas and average depression rates across the same counties. The first step was to filter both datasets to our respective counties and cities. Afterward, the data was further filtered down to the state as we noticed that other states had similar county names causing a mismatch in the output, e.g. Dallas, Alabama.

Additionally, spatial data from Texas county shapefiles were integrated with the walkability scores and the depression rates. This helped better visualize the mental health rates across different counties in Texas, namely in Figure 4 where depression rates are indicated by shading on the choropleth map.

The analysis continues to employ a variety of visualizations as seen in the above sections. These visualizations included bar charts, density plots, and box-plots to look at city level comparisons and trends. A bubble chart was then used to combine the data from both sets to create a visualization that involved both the walkability and the depression rates across the selected cities.

The approach used in this study utilizes statistical summaries and geospatial insights, offering a comprehensive perspective on the extent to which walkability scores across different cities may influence depression rates across different urban settings in Texas.

Below are some snippets from the applied code:

```
# Bar Charts Walkability
ggplot(combined_avg, aes(x = City, y = Average_WalkInd, fill = City)) +
  geom_col() +
  scale_fill_manual(
    name = "City",
    values = c("Dallas" = "#C05790", "Austin" = "#005682", "Houston" = "#4DD091")
  ) +
  theme_minimal() +
  ggtitle("Average Walkability Index for Dallas, Austin, and Houston") +
  xlab("City") +
  ylab("Average Walkability Index")
```

*Code 1*

The above code is used for visualizing the bar graph for average walkability across different cities in Texas seen in Figure 1. The different colors used help to visually differentiate the three cities and make the charts easily readable.

```r
# Visualization: Depression Rates for Dallas
ggplot(dallas_depression, aes(x = LocationName, y = Average_Depression, fill = Data_Value_Type)) +
  geom_col() +
  geom_text(aes(label = Data_Value_Type),
            position = position_stack(vjust = 0.5),
            color = "white", size = 4) +
  scale_fill_manual(
    name = "Measure Type",
    values = c("#4DD091", "#005682")
  ) +
  theme_minimal() +
  ggtitle("Depression Rates for Dallas by Measure Type") +
  xlab("Location") +
  ylab("Depression Rate (%)")

# Visualization: Depression Rates for Austin
ggplot(austin_depression, aes(x = LocationName, y = Average_Depression, fill = Data_Value_Type)) +
  geom_col() +
  geom_text(aes(label = Data_Value_Type),
            position = position_stack(vjust = 0.5),
            color = "white", size = 4) +
  scale_fill_manual(
    name = "Measure Type",
    values = c("#4DD091", "#005682")
  ) +
  theme_minimal() +
  ggtitle("Depression Rates for Austin by Measure Type") +
  xlab("Location") +
  ylab("Depression Rate (%)")
```

*Code 2*

The above code snippet is used to visualize individual depression rates across each city as seen in Figures 6-8. The hex code #4DD091 is used to highlight one of the measure values green, and the hex code #005682 is used to highlight the other measure value which is blue. Green indicates the age-adjusted prevalence, while blue is the crude prevalence.

These approaches using ggplot2 provide a comprehensive analysis of the walkability aggregates along with the depression rates, providing a framework to understand the influence of urban spaces and walkability on mental health factors.

## Findings

As illustrated in our visualizations of the data above, it can be determined that Dallas has a higher average walkability index than both Austin and Houston; furthermore, Dallas consistently had the lowest average depression rates out of the three Texas cities. This was true even when controlling for age. Houston, having a lower average walkability index than Dallas, also displayed higher average depression rates. Similarly, Austin had the lowest average walkability index of the three cities; it also was the city with the highest average depression rates, even when controlling for age. As represented through these data and visualizations, there seems to be a relationship between the average walkability index of a Texas city and the average depression rates experienced by the residents of that city. Overall, it seems that in Texas cities with a higher average walkability index, residents also experience less depression, on average. However, since we have not conducted any experiments or run any analyses, we cannot draw any definitive conclusions about the strength of this relationship.

## Conclusions & Implications

As we found in our review and visualization of the existing data on walkability in Dallas, Austin, and Houston, walkability does seem to play a role in the average depression rates experienced by these cities' residents. Through the data and the statistics, it can be gleaned that the Texas cities with higher average walkability index are also characterized by lower average depression rates. However, this is not a sufficient explanation; we have only looked at the general data for each of these cities, but much deeper and detailed research would need to be done to determine exactly what factors attributed to these cities or their urban design are producing the corresponding average depression rates. For example, in Figure 10, we can see

that Houston, despite having only a slightly lower average walkability index, was characterized by average depression rates more similar to Austin, which were considerably higher than Dallas. This could indicate that perhaps there is another factor influencing average depression rates in Houston and in the other Texas cities as well. We have only examined basic data relating to walkability index and depression rates, but we acknowledge that there are many other factors that come into play when trying to dissect the relationship between walkability in cities and mental health outcomes.

For instance, there are a multitude of ways in which walkability as a variable can be measured or quantified; in some cases, it can include intersection density, population density, land-use mix, access to public transit, access to community resources and amenities, and other physical attributes of a neighborhood (Warner et al., 2022). Since there is a lack of consensus on exactly which factors should be included and how they should be measured, it is difficult to study how walkability in general impacts the mental health outcomes of residents, and it will be even more difficult to describe or characterize this relationship with conclusivity.

In addition, there are other social and economic factors that play a role in mental health outcomes and daily living conditions that are not included in our data analysis. One such factor that is highly relevant in our lives today is income; individuals with greater income are able to have more choice and agency over where they live and what to consider when moving to a new area (James et al., 2017). Unfortunately, low-income individuals don't have that option, and therefore, it is necessary to control for these considerations when isolating the relationship between depression and walkability in the individual's environment. Mental health is also a broad subject encompassing myriad illnesses and issues, and similarly to walkability, there are innumerable factors that influence an individual human being's mental state that are not always

explained by their built environment. As mentioned, a more thorough analysis will control for other factors not relevant to our research question.

Notably, as we looked for data pertaining to mental health outcomes, we had difficulty finding and accessing raw mental health data. For example, when looking at the Texas Health Data website, it only provided us with a summary and brief paper as well as some data visualization tools. Ultimately, since we had difficulties finding other usable data, we relied on the CDC as our source; the mental health data they had available was specifically for depression and was organized by county rather than city. We decided to look more broadly at cities in order to be able to generate our charts and have meaningful representations, since we did not have consistent data for all the counties we had initially planned to include; however, this study and analysis would be greatly enhanced by more accessible data in order to study this question in more detail on smaller levels such as counties to see how counties and smaller areas such as neighborhoods vary from the city overall. We do recognize how gathering data in research is costly, yet at the same time, lack of critical research limits our ability to approach and analyze an issue or problem to the fullest extent. This points to the need for more data collection on mental health outcomes in Texas cities and counties, or if more robust data on these topics exist, efforts should be made to make the data more accessible for critical analysis and research.

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