UNIVERSITY of DENVER

COLORADO EVALUATION AND ACTION LAB

# The Intersection of Housing and Mental Health in Colorado

## Mapping Critical Social Determinants of Health

**Report Highlights:**

*Six percent of all census tracts in Colorado have a significantly higher prevalence of both rent-burdened households and mental health issues than the state average. These 71 priority area census tracts are most concentrated in five metropolitan regions: Pueblo, Denver, Colorado Springs, Fort Collins, and Grand Junction.*

*Sixteen percent of all census tracts in Colorado have a significantly higher prevalence of rent-burdened households than the state average.*

*Thirty-five percent of all census tracts in Colorado have a significantly higher prevalence of at least one of the following mental health issues: mental health distress, drug-related mortality, or suicide mortality (as compared to the state average).*

*A publicly-available, interactive, web-based map was developed to highlight the locations in Colorado where critical housing affordability and mental health issues intersect.*

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# Abstract

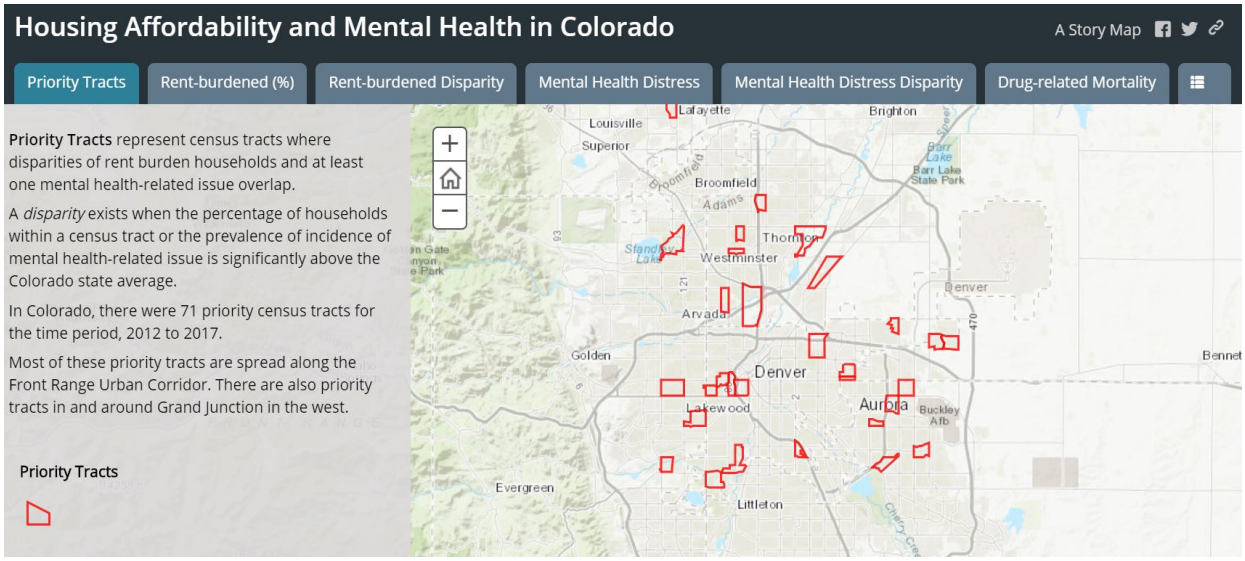
Affordable housing is a social determinant of health that creates a critical foundation for resilient and healthy communities. While it is clear that the stress of navigating unaffordable housing contributes to poor mental health, there is more to understand about the intersection of housing and mental health, especially related to the geographical locations in Colorado where these two persistent issues coincide.

Using Colorado statewide data at the census tract level, this study employed various geospatial analytical techniques to investigate geographic relationships and identify priority area census tracts where the following two critical issues coincided: housing unaffordability (defined as rent burden) and high prevalence of mental health issues (defined as mental health distress, drug-related mortality, and suicide mortality). In addition, these priority area census tracts were examined in relationship to access to mental health treatment within 30 minutes of driving. Other social determinants of health were also examined to provide more insight into the characteristics of these locations.

Six percent of all census tracts in Colorado have a significantly higher prevalence of *both* rent-burdened households *and* mental health issues than the state average. These 71 priority area census tracts are most concentrated in five metropolitan regions: Pueblo, Denver, Colorado Springs, Fort Collins, and Grand Junction.

**Interactive Mapping Tool Link:** http://arcg.is/D1e4C

A publicly-available, interactive, web-based map was developed to highlight the locations in Colorado where critical housing affordability and mental health issues intersect.




In identifying and providing a deeper understanding of these census tracts, this study offers policymakers guidance on where to target programs that support affordable housing and mental health and can inform zoning and planning decisions. This cross-system information can help policymakers to more effectively coordinate the allocation of resources addressing these two persistent issues.

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# Acknowledgements

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# Data Sources

This study utilized several publicly-available datasets available from the Colorado Department of Public Health & Environment (CDPHE, 2012-2016; 2013-2016). These data include mental health issues, various chronic conditions, behavioral factors, and locations of facilities for community and behavioral health centers, drug treatment and program resources, and substance use disorder and mental health resources. Social determinants of health data were acquired from the Centers for Disease Control and Prevention's Social Vulnerability Index (2012-2016). Housing data, including housing affordability (high housing costs associated with rent), were collected from the U.S. Census Bureau's American Community Survey (ACS, 2013-2017).

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# Introduction

Affordable housing is a social determinant of health that creates a critical foundation for resilient and healthy communities. While it is clear that the stress of navigating unaffordable housing contributes to poor mental health, there is more to understand about the intersection of housing and mental health, especially related to the geographical locations in Colorado where these two persistent issues coincide.

## Housing as a Social Determinant of Health

Social determinants of health are the "conditions in which people are born, grow, live, work and age that shape health."[1] In addition to housing affordability, social determinants of health include factors like socioeconomic status, education, neighborhood and physical environment, employment, and social support networks, as well as access to health care. Addressing social determinants of health is important for improving health and reducing deep-rooted disparities in health and health care.[2]

Affordable housing is defined as housing that costs less than 30% of a family's income.[3] Lack of access to affordable housing negatively affects health through several pathways. As the Robert Wood Johnson Foundation elaborates:

> The shortage of affordable housing limits families' and individuals' choices about where they live, often relegating lower-income families to substandard housing in unsafe, overcrowded neighborhoods with higher rates of poverty and fewer resources for health promotion (e.g., parks, bike paths, recreation centers and activities).[4]

Ultimately, lack of access to affordable housing is stressful, both physically and emotionally, especially when it may lead to eviction and homelessness. Not surprisingly, prior research has established the link between high housing costs and poor mental health.[5,6,7,8]

Affordable housing is defined as housing that costs less than 30% of a family's income. Lack of access to affordable housing negatively affects health through several pathways.

In Colorado, residents are experiencing this stress more and more frequently, as housing affordability is a growing concern. As the Colorado Health Institute recently noted in its August 2019 report, *Home Equity: A Vision of Housing Security, Health and Opportunity*, the average Colorado home price increased 77% in the past decade, but the state's median income went up just 4.5%.[9,10] Since 2013, median rents in Colorado have increased by 36%.[11] As of 2018, approximately 50% of renter households in Colorado are rent burdened, which is defined as paying 30% or more of household income on rent. Moreover, 24% are severely rent burdened, which is defined as paying more than 50% of household income on rent.[12]

Learning more about the exact locations in Colorado that are the most unaffordable (i.e., with the highest rent burden) could provide significant insight into the wellbeing of residents in those areas and guide policy recommendations that address housing affordability as a social determinant of health.

## Mental Health Care as a Growing Need in Colorado

Parallel to rising concerns about housing affordability, mental health issues in Colorado are also on the rise. The Colorado Health Access Survey (CHAS) is a survey administered to more than 10,000 randomly-selected households in the state every other year since 2009. The 2019 CHAS showed that 15.3% of Coloradans said they had poor mental health, which the survey defines as experiencing eight or more days of poor mental health in the past month, up from 11.8% in 2017.[13]

Furthermore, suicide rates are increasing in Colorado, which has the 10th highest suicide rate relative to other states.[14] Suicide mortality in Colorado increased from 16.5 per 100,000 persons in 2007 to 20.2 per 100,000 persons in 2017.[15] Deaths related to drug abuse and dependence, many associated with opioids, are also on the rise. From 2011 to 2015, the number of heroin-related deaths doubled,[16] and unintentional drug poisoning-related deaths increased by a dramatic 82% from 2004 to 2013.[17]

> Accessing needed mental health and substance use treatment remains difficult for many Coloradans. The 2019 CHAS highlighted that 13.5% of Coloradans did not get the mental health treatment that they needed, up from 7.6% in 2017.

Accessing needed mental health and substance use treatment remains difficult for many Coloradans. The 2019 CHAS highlighted that 13.5% of Coloradans reporting not getting the mental health treatment that they needed, up from 7.6% in 2017.[18] While 2019 CHAS results may also be a sign that Coloradans are becoming more comfortable talking about their mental health, regardless, many factors contribute to the inability to access mental health care, including a person's income, insurance, and the availability of mental health providers in the area.[19] Of those who reported that they did not get the mental health treatment that they needed on the 2017 CHAS, 35.2% said it was because they had a hard time getting an appointment.[20]

Learning more about the exact locations in Colorado where residents are experiencing a high prevalence of mental health issues *and* difficulties in accessing mental health treatment could provide significant insight into the wellbeing of residents in those areas. Especially when overlaid with housing affordability data, a spatial map showing the intersection of these three issues could highlight to policymakers the exact locations where resources and programs could be targeted to improve critical social determinants of health in Colorado. Even though this information cannot show causal relationships, the resulting information can guide the allocation of resources.

# Description of the Study: Guiding Research Questions

**Research Question 1: What is the geographic distribution of rent-burdened households and mental health issues in Colorado, and how do these issues overlap and concentrate spatially?**

**Research Question 2: What is the relationship between mental health care accessibility *and* the spatial overlap of rent-burdened households and mental health issues?**

**Research Question 3: What are the spatial relationships between mental health issues and other social determinants of health?**

Spatial analyses including descriptive and analytical mapping methods were used to examine the spatial overlap of households with high housing costs (defined as rent burden), mental health issues (defined as mental health distress, drug-related mortality, and suicide mortality), and other key social determinants of health (see Table 1) at the level of census tracts.

The goal of this study was to map census tracts with disparities in rent burden and mental health issues and to examine these disparities in relationship to other key social determinants of health (see Table 1). *Disparities* occur when a census tract's prevalence of rent burden or mental health issues is significantly higher than the state average; *significantly higher* is defined as one standard deviation or greater above the state average.

See the Methods section for more details on the specific variables and measures used in the spatial mapping process.

# Key Findings

This report puts the spotlight on census tracts where there are dual disparities in rent burden and mental health issues. There are 71 census tracts, primarily located in the metropolitan regions of Pueblo, Denver, Colorado Springs, Fort Collins, and Grand Junction, where communities are likely to benefit from geographically-targeted policies and programs that support affordable housing and access to mental health treatment. In this section, key findings related to rent disparities and mental health disparities are presented separately, and then in combination. The final key finding relates to access to mental health treatment.

**A publicly-available, interactive, web-based map was developed to highlight the locations in Colorado where critical housing affordability and mental health issues intersect: http://arcg.is/D1e4C**

**As an example, in three of Pueblo's census tracts, the rate of drug-related mortality is five to eight times higher than the state average. Increasing the capacity of existing substance abuse treatment facilities or dedicating resources to build new facilities is likely to improve the wellbeing of Pueblo metropolitan area residents.**

## Finding #1: Six percent of all census tracts in Colorado have a significantly higher prevalence of both rent-burdened households *and* mental health issues than the state average. These 71 priority area census tracts are most concentrated in five metropolitan regions: Pueblo, Denver, Colorado Springs, Fort Collins, and Grand Junction.

Rent burden and mental health disparities overlap spatially in 71 census tracts across 13 counties and are identified as priority areas within Adams, Arapahoe, Boulder, Delta, Denver, Douglas, El Paso, Jefferson, Larimer, Las Animas, Mesa, Montrose, and Pueblo counties (see Table 2). The spatial distribution of these dual disparities is mainly along the Front Range urban corridor but also found in central western Colorado.

While the Denver metropolitan region had the most census tracts with overlapping rent burden and mental health issues disparities, Pueblo had the highest overall disparities. In the Pueblo metropolitan region, there were nine census tracts where rent burden and mental health issues disparities overlapped. In Census Tracts 12, 22, and 24 in Pueblo, drug-related deaths were five to eight times higher than the state average. Census Tract 11 in Pueblo ranked as the highest priority among all 71 census tracts identified as priority areas.

## Finding #2: Sixteen percent of all census tracts in Colorado have a significantly higher prevalence of rent-burdened households than the state average.

Approximately 50% of all renter households in Colorado are rent burdened, defined as spending 30% or more of household income on rent. Of all the census tracts in Colorado, 16% (n=192) have a significantly higher rate of rent-burdened households than the state average (defined as one standard deviation or greater above the average). In these 16% of census tracts, on average, 69% of households are rent burdened.

Geographically, while these 16% of census tracts are found in both urban and rural areas, most are found along the Front Range urban corridor. Of these, approximately, 10% (n=19) are located in Denver.

## Finding #3: Thirty-five percent of all census tracts in Colorado have a significantly higher prevalence of at least one of the following mental health issues: mental health distress, drug-related mortality, or suicide mortality (as compared to the state average).

Of the 35% of census tracts (n=432), the census tracts with the highest number of mental health issues above the state average tend to be located along metropolitan regions along the Front Range urban corridor, such as in Pueblo, Colorado Springs, Denver, Fort Collins, Greeley, and in Grand Junction in central western Colorado.

**Finding #4: Three datasets were utilized to better understand mental health care accessibility in Colorado. Using the first dataset (Drug Treatment and Program Resources), 25% of Colorado's census tracts were considered underserved. Using the second dataset (LADDERS), 11% of census tracts were considered underserved. Using the third dataset (Community Behavioral Centers and Resources), 11% of census tracts were considered underserved.**

Details on mental health access and a map are located under "research question #2" and linked here.

*Served* was defined as living within 30-minutes driving distance from the physical locations of mental health care facilities.

In general, profiles of served and underserved census tracts have higher rates of suicide mortality, rent-burdened households, and greater exposure to lead risk. Served census tracts also have higher rates of drug-related mortality, despite access to treatment, suggesting potentially, that either access is inadequate (even more access to treatment is needed) or there are other barriers to access that play a more significant role, such as social stigma or cost.

# Implications

The 71 priority area census tracts identified by our study are locations where there exists great disparity, even within a state that is thriving by many other measures of economic success.[21] There is an urgent need to strengthen these communities through policies and programs that tap into the resources of the housing and mental health systems in Colorado, such as with permanent supportive housing.

> Identifying and providing a deeper understanding of priority area census tracts offers guidance on where to target programs that support affordable housing and mental health.
>
> This cross-system information can inform the allocation of resources addressing these two persistent issues.

## Using this Study's Data to Strengthen Cross-System Collaboration between Housing and Mental Health

In identifying and providing a deeper understanding of priority area census tracts, this study offers policymakers guidance on where to target programs that support affordable housing and mental health. This cross-system information can help policymakers to more effectively coordinate the allocation of resources addressing these two persistent issues and can inform zoning and planning decisions.

This data can be consulted to guide conversations between leaders and policymakers within the housing and mental health systems, such as those conversations occurring within the Colorado Behavioral Health Task Force.[22] The publicly-available, interactive, web-based map can be consulted to provide more context to any proposed policy that may improve issues related to housing, mental health, or any number of social determinants of health. For example, the many policy suggestions highlighted in the Colorado Health

Institute's August 2019 report, *Home Equity: A Vision of Housing Security, Health and Opportunity*, may be supplemented by the geographic information in this study.

### The Example of Permanent Supportive Housing

Rental assistance and improving access to supportive services is recommended for people struggling with mental illness and housing affordability. Within that spectrum of need, permanent supportive housing is a best practice for people who have been living without housing for a long time and have severe mental illness (and likely other chronic conditions or health needs).

According to the United States Interagency Council on Homelessness, permanent supportive housing "combines non-time-limited affordable housing assistance with wrap-around supportive services for people experiencing homelessness, as well as other people with disabilities."[23] Thus far, there appears to be moderate but growing evidence that permanent supportive housing increases housing stability and also lowers public costs by reducing the use of publicly-funded crisis services, including shelters, hospitals, psychiatric centers, jails, and prisons.[24]

This study may be used to identify areas where permanent supportive housing, or other less expensive rental assistance programs, could have the highest positive impact. The information in this study can be used to proactively propose policy solutions that may change the current trajectory of increasing difficulties accessing affordable housing in Colorado.

### Policies and Programs Targeting Mental Health Care Accessibility

This study's findings on mental health care accessibility can also be used to advocate for improving mental health and substance abuse treatment capacity in many regions of Colorado. Given the importance of regular therapy sessions for successful treatment (particularly for substance abuse, which may require inpatient or intensive outpatient treatment), additional strategies for reasonable access (i.e., driving distance shorter than 30 minutes) are essential to improve Colorado's mental health as a whole.

There are many innovative solutions currently being proposed, and policymakers and advocates of these solutions can use the detailed census tract information available through this study to support their proposals.[25,26]

Future studies are needed and could include a comparison of the population of people who live in priority area census tracts (i.e., with a high prevalence of mental health issues and rent burden) to the population of people who live in census tracts with a high prevalence of mental health issues but low rent burden. Are there any differences in these populations that may be associated with housing costs? Learning more about priority areas in Colorado and the populations residing within the priority areas can serve to inform policies and programs working to improve housing and health equity across the state.

# Methods

## Definitions of Terms

### Disparities

The goal of this study was to identify census tracts with *disparities* in rent burden and mental health issues and to examine these disparities in relationship to other key social determinants of health (see Table 1). *Disparities* occur when a census tract's prevalence of rent burden or mental health issues is significantly higher than the state average; *significantly higher* is defined as one standard deviation or greater above the state average.

### Priority Areas

Priority areas for intervention were defined as census tracts within metropolitan regions and counties where disparities in rent burden and mental health issues overlapped spatially.[27]

The census tract is the smallest, most precise geographical area wherein data was analyzed for this study. However, the county and the larger metropolitan region house the administrative and governing organizations that can affect policy change. Thus, priority areas were identified not just by census tracts, but also by the county and metropolitan regions of which they are a part.

### Mental Health Care Access

The definition of mental health care accessibility was based on driving distance to mental health treatment facilities. *Served* was defined as living within 30-minutes driving distance from the physical locations of mental health care facilities, as classified in three Colorado databases.

## Research Question 1: What is the geographic distribution of rent burdened households and mental health issues in Colorado, and how do these issues overlap and concentrate spatially?

To examine the geographic distribution between rent-burdened households and mental health issues, we first estimated disparities in census tracts per variable (mental health distress, drug-related mortality, and suicide mortality) by generating: (1) individual maps; (2) spatial overlap of mental health disparities maps; (3) spatial overlap of rent burden disparities *and* mental health disparities maps; and (4) ratios for census tract profiles. This culminated in the generation of a priority index.

**Priority Index**

The level of overall disparity by region was determined using a *priority index* that considered the number of census tracts by county where there was spatial overlap of disparities (rent burden and mental health issues), overlap of the count of mental health issues (mental health distress, drug-related mortality, and suicide mortality), and a profile of various social determinants of health in those tracts. The profile generally used a ratio that describes how many times higher the value of the social determinant of health in a census tract was relative to the state average. Values higher than 1.2 times - represented a significant level above the state average (i.e., a disparity); values equal to or below one suggested either equal to the state average or below the state average.

There were a few exceptions where the ratio was not used. They included mental health vulnerability (number of issues in each tract) and minority status (percentage of the population). For per capita income, when the ratio was less than one it represented a fraction of the state average (i.e., a disparity in income).

### Steps to Create the Priority Index

(1) Individual Maps

One of the main objectives was to generate thematic maps for rent burden and each mental health variable. Using the software ArcGIS (ESRI 2018, version 10.6.1), we developed several maps that characterized the spatial distribution of each variable by z-score. The z-score is a standardization of the variables by subtracting the value for a census tract from the average of all census tracts, and then dividing by the standard deviation of all census tracts. The z-scores were used to quantitatively estimate how far a variable deviated from the state average. A z-score of one or greater was selected as a threshold to identify census tracts with a potential rent burden disparity or mental health disparity (i.e., one standard deviation above the state average). The number of disparities per census tract were identified for the percentage of rent-burdened households, mental health distress, drug-related mortality, and suicide mortality, and mapped using a quantile classification, which is useful for comparing various datasets.

(2) Spatial Overlap of Mental Health Disparities Maps

To identify census tracts where more than mental health disparity was present, we used two approaches.[28] The first was a practical approach to assess multiple overlapping health issues in one location. Using Microsoft Excel, we generated a mental health vulnerability index variable (by counts) that characterized census tracts by the number of disparities present (range of 0 to 3). The second approach, using Excel and ArcGIS, created queries that identified the various combinations of disparities by census tracts. There were seven possible combinations: Mental Health Distress (M), Drug Overdose (D), Suicide (S), Mental Health Distress & Drug Overdose (MD), Mental Health Distress & Suicide (MS), Drug Overdose & Suicide (DS), and Mental Health Distress & Drug Overdose & Suicide (MDS).

(3) Spatial Overlap of Rent Burden Disparities and Mental Health Disparities Maps

To identify census tracts where rent burden disparity intersected with mental health disparity, we used Excel and ArcGIS to identify tracts of spatial overlap. Maps were generated at the state level, metropolitan level (seven regions), and local level (metropolitan zoomed in) to illustrate a set of potential priority

census tracts showing the combination of mental health disparities present. In addition, at the local level, we added a street layer and labeled census tracts by administrative numbers.

(4) Ratios for Census Tract Profiles

To support maps with spatial overlap, census tract profiles were created using ratios to describe the context of census tracts. Ratios of population health, housing, demographic, behavioral, and other social determinants of health (see Table 1) compared the value of each census tract to the state average by dividing the tract value from the state average for each variable. The ratio is a qualitative description, or crude measure, of how many times higher or lower a variable is compared to the state average. Each ratio, excluding minority (%), by census tract was then summed. All tracts per priority area (county) were also summed to generate a *priority index* (the higher the value, the greater priority for intervention). These profiles displayed in tables by category of social determinant of health supported the maps and helped to prioritize areas for intervention. The ratio served as a way to compare determinants of health within each census tract in a much simpler manner as compared to the z-score.

### Measures for Research Question 1

Rent-burdened households were measured as the percentage of renter-occupied housing units that spent at least 30% or more of their household income to pay rent (as determined by the U.S. Census Bureau's American Community Survey, 2013-2017).[29]

Mental health issues were measured in three ways, and the data came from Colorado Department of Public Health and Environment (CDPHE) datasets:[30]

(1) Prevalence (%) of frequent mental health distress among adults (18+), defined as experiencing more than 14 mentally unhealthy days of stress, depression, and/or problems with emotions within a 30-day period (2013-2016);

(2) Drug poisoning or drug overdose age-adjusted mortality rate (per 100,000 persons) associated with either prescription opioid analgesic or heroin as the underlying cause of death (2012-2016); and

(3) Suicide age-adjusted mortality rate (per 100,000 persons), (2012-2016).

## Research Question 2: What is the relationship between mental health care accessibility and the spatial overlap of rent-burdened households and mental health issues?

### Network Analysis

To identify *served* versus *underserved* census tracts in terms of health care accessibility, we used ArcGIS Network Analyst and ArcGIS Online. Using locations of health care facilities related to mental health in Colorado (i.e., as identified in the databases of: Drug Treatment and Programs Resources, Substance Use Disorder & Mental Health Resources, and Community Behavioral Centers), service areas within 30 minutes of driving from each facility were created using actual street networks. The 30-minute driving break value was adopted from CDPHE Health's workforce planning and assessment Health Professional Shortage Area (HPSA) designation.[31] The service areas were then matched to census tracts. Corresponding census tracts were categorized as either *served* (within the 30-minute driving distance) or *underserved* (longer than the

30-minute driving distance). Mental health issues and housing cost and quality characteristics were averaged to represent the differences between *served* and *underserved* census tracts.

### Measures for Research Question 2

Spatial network analyses were conducted using ArcGIS to identify health care accessibility areas for three types of mental health facilities. In this study, *accessible* is defined as within 30-minutes driving distance from physical locations of mental health facilities, as identified in the three datasets below.

(1) The Drug Treatment and Program Resources dataset includes 19 locations that focus on treatment for substance abuse. These are methadone clinics and narcotic addiction programs. The data is managed by the Office of Emergency Preparedness and Response at CDPHE.

(2) The Licensing and Designation Database and Electronic Records System (LADDERS) dataset is a much broader dataset that consists of 681 facilities that provide mental health services, including substance abuse treatment. The services may be outpatient, inpatient, residential, crisis, and more. The dataset includes 13 of the 19 facilities in the Drug Treatment and Program Resources dataset and is managed by the Colorado Department of Human Services.

(3) The Community Behavioral Centers and Resources data includes information on 219 facilities that provide services for mental health and substance abuse issues, including 113 facilities that overlap with the LADDERS database. The data is managed by the Office of Emergency Preparedness and Response at CDPHE.

## Research Question 3: What are the spatial relationships between mental health issues and other social determinants of health?

### Regression Analysis

To explore associations further and identify potential predictors, we utilized Global (Non-Spatial) and Local Regression (Spatial) methods, Ordinary Least Squares (OLS), and Geographically Weighted Regression (GWR) in ArcGIS.[32] GWR is a local form of regression that utilizes distance, assigns geographic weights by place, and accounts for the influence of the nearest neighbors—in our case, census tracts. Thus, rather than generating an output of one correlation coefficient (r) and coefficient of determination (r-squared) for the entire study area, there are coefficients for each census tract, which are mapped. We tested each variable individually and explored combinations of variables in a multiple regression. In general, many variables were correlated, which can lead to misspecification of models.

To address collinearity, we used principal component analysis to generate non-correlated variables (factors). From the determinants dataset, a total of seven dimension factors was the result (independent variables), which we explored in relation to mental health issues, employing the two aforementioned regression methods. Table 1 shows the variables included in the regression and principal component analyses. To simplify the analysis, we excluded the other social determinants of health (e.g., asthma and diabetes) as predictors, because overall, they did not improve the results.

Table 1. Social Determinants of Health Variables in Regression Analysis and Principal Component Analysis

| Social Determinant of Health Variable | Measurement |
|---|---|
| Delayed Medical Care | % of population |
| Smoking Prevalence | % of population |
| No Medical Check Up | % of population |
| Perception of Poor Physical Health | % of population |
| No Physical Activity | % of population |
| Per Capita Income | U.S. dollars |
| Living Below the Federal Poverty Line | % of population |
| Unemployment | % of population |
| No High School Diploma | % of population |
| Age 65 or Older | % of population |
| Age 17 or Younger | % of population |
| Single Parent with Children Under 18 | % of population |
| Minority (all except White, non-Hispanic) | % of population |
| Limited English (Age 5 and older) | % of population |
| Multiple Unit Housing (10 or more units) | % of housing units |
| Mobile Homes | % of population |
| Overcrowding (More People Than Rooms) | % of population |
| No Vehicle | % of households |
| No Health Insurance | % of population |
| Lead Risk | % of population |
| Homes Built Before 1980 | % of total units |
| Homes with Incomplete Plumbing | % of occupied units |
| Homes with Incomplete Kitchen | % of occupied units |
| Rent-Burdened Households (30% or more of household income) | % of occupied units |

### Measures for Research Question 3

In the regression analyses, the following social determinants of health were examined in relation to mental health issues: no physical activity, smoking prevalence, no high school diploma, poor physical health, delayed medical care, age of structure (i.e., homes built before 1980), minority (i.e., non-White), per capita income, living below the federal poverty level, unemployment, single parent household, owning a vehicle, overcrowding, and rent burden. Health outcomes, such as asthma prevalence and hospitalization rates, diabetes prevalence and hospitalization rates, and obesity prevalence, were also assessed in relation to mental health issues.

## Study Limitations

This study has several limitations. While the results regarding mental health distress are significant, it should be noted that the regression associations are limited. The mental health distress variable is based on modeled data that combines self-reported frequency of mental health issues with social and behavioral factors. Thus, the associations between mental health distress and social determinants may be confounded because variables such as poverty were used to model the mental health data at the census tract level. In a future study, a mental health outcome like hospitalization would have a better measure.

Moreover, the measurement of housing affordability is generally acknowledged to be difficult, and the "30% of income" threshold may be too inflexible to be accurate.[33] Because it is possible that higher-income households can spend more than 30% of income on housing and not be financially burdened, there is concern that the 30% standard may overestimate housing affordability problems for higher-income households. On the other hand, the 30% threshold may also be inadequate to characterize housing affordability issues for the lowest income households, wherein even spending a minimal portion of income on housing will still not leave enough left over to cover basic non-housing living costs.[34]

# Results

## Research Question 1

*What is the geographic distribution of rent-burdened households and mental health issues in Colorado, and how do these issues overlap and concentrate spatially?*

> **Six percent of all census tracts in Colorado have a significantly higher prevalence of both rent-burdened households *and* mental health issues than the state average.**
>
> **These 71 census tracts, identified as priority areas, are most concentrated in five metropolitan regions: Pueblo, Denver, Colorado Springs, Fort Collins, and Grand Junction (see Table 2).**
>
> **The highest disparities were found in the Pueblo metropolitan region.**

Figure 1 provides an overview of the framework for the spatial analysis to answer Research Question 1. The focus of this study's results related to Research Question 1 is on the dark grey, "high-high" section of Figure 1, the priority areas that have a high prevalence of rent-burdened households and a high prevalence of mental health issues.

Figure 1. Framework for Spatial Analysis of Rent Burdened Households and Mental Health Issues

| **Spatial Overlap Analysis**<br><br>Identifying Priority Areas | | **Mental Health Issues**<br><br>Measured by mental health distress, drug-related mortality, and suicide mortality | |
|---|---|---|---|
| | | **High** | **Low** |
| **Rent Burden** | **High** | Areas with high prevalence of rent-burdened households and high prevalence of mental health issues (i.e., priority areas) | Areas with high prevalence of rent-burdened households and low prevalence of mental health issues |
| | **Low** | Areas with low prevalence of rent-burdened households and high prevalence of mental health issues | Areas with low prevalence of rent-burdened households and low prevalence of mental health issues |

The findings related to Research Question 1 are presented in this order: (1) Priority area census tracts with a significantly higher prevalence of *both* rent-burdened households *and* mental health issues than the state average; (2) Census tracts that have a significantly higher prevalence of rent-burdened households than the state average; and (3) Census tracts that have a significantly higher prevalence of at least one of the following mental health issues: mental health distress, drug-related mortality, or suicide mortality (as compared to the state average).

### (1) Priority Area Census Tracts with a Significantly Higher Prevalence of *Both* Rent-Burdened Households *and* Mental Health Issues

Six percent of all census tracts in Colorado have a significantly higher prevalence of *both* rent-burdened households *and* mental health issues than the state average. *Significantly higher* is defined as one standard deviation or greater above the state average and is also referred to as a *disparity*.

As seen in Table 2, these 71 census tracts, identified as priority areas, are most concentrated in five metropolitan regions: Pueblo, Denver, Colorado Springs, Fort Collins, and Grand Junction. The census tract is the smallest, most precise geographical area wherein data was analyzed for this study. However, the county and the larger metropolitan region house the administrative and governing organizations that can affect policy change. Thus, priority areas were identified not just by census tracts, but also by the county and metropolitan regions of which they are a part.

The highest disparities were found in the Pueblo metropolitan region, followed by the Denver and Colorado Springs metropolitan regions.

Table 2. Priority Index by County and Metropolitan Region, Ranked Highest to Lowest Priority

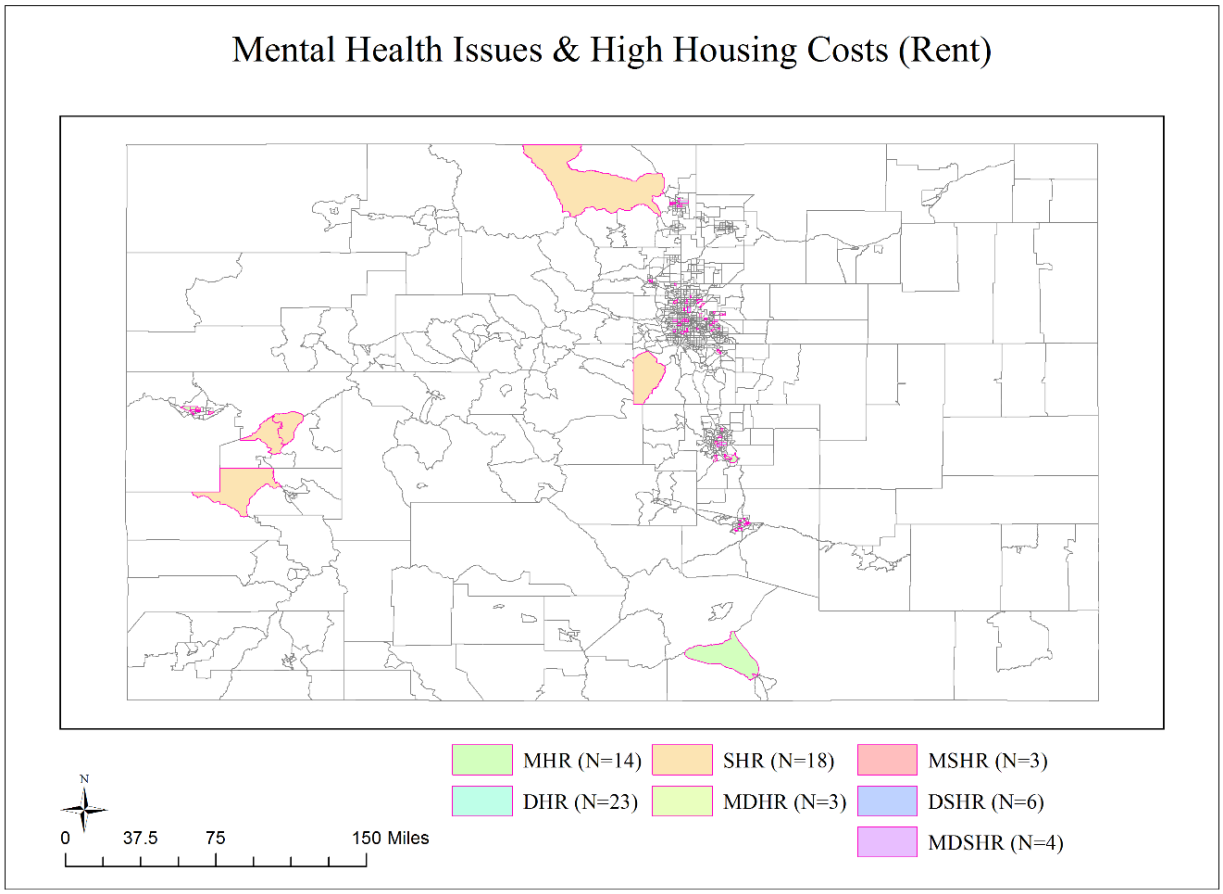
| Rank | County | Metropolitan Region | Priority Index |
|---|---|---|---|
| 1 | Pueblo | Pueblo | 425 |
| 2 | Adams | Denver | 404 |
| 3 | Denver | Denver | 362 |
| 4 | El Paso | Colorado Springs | 283 |
| 5 | Larimer | Fort Collins | 262 |
| 6 | Arapahoe | Denver | 194 |
| 7 | Mesa | Grand Junction | 177 |
| 8 | Jefferson | Denver | 120 |
| 9 | Boulder | Boulder | 82 |
| 10 | Delta | | 57 |
| 11 | Las Animas | | 40 |
| 12 | Montrose | | 26 |
| 13 | Douglas | Denver | 13 |

A detailed, intricate view of the spatial overlap of rent burden and mental health disparity can be seen in Figure 2. This figure highlights several combinations of rent burden and mental health disparities at the census tract level across Colorado, including:

- mental health distress with rent burden (MHR);
- drug-related mortality with rent burden (DHR);
- suicide mortality with rent burden (SHR);
- mental health distress and drug-related mortality with rent burden (MDHR);
- mental health distress and suicide mortality with rent burden (MSHR);
- drug-related mortality and suicide mortality (DSHR); and
- mental health distress, drug-related mortality, and suicide mortality with rent burden (MDSHR).

The total count of these identified census tracts is 71, because in total, rent burden and mental health disparities overlap spatially in 71 (6%) census tracts across 13 counties. These are the identified priority areas. A more detailed view can be found in the interactive map available online, and it clearly displays all of the colors that are represented in the map key.

Figure 2. Map of the Spatial Overlap of Mental Health and Rent Burden Disparities in Colorado

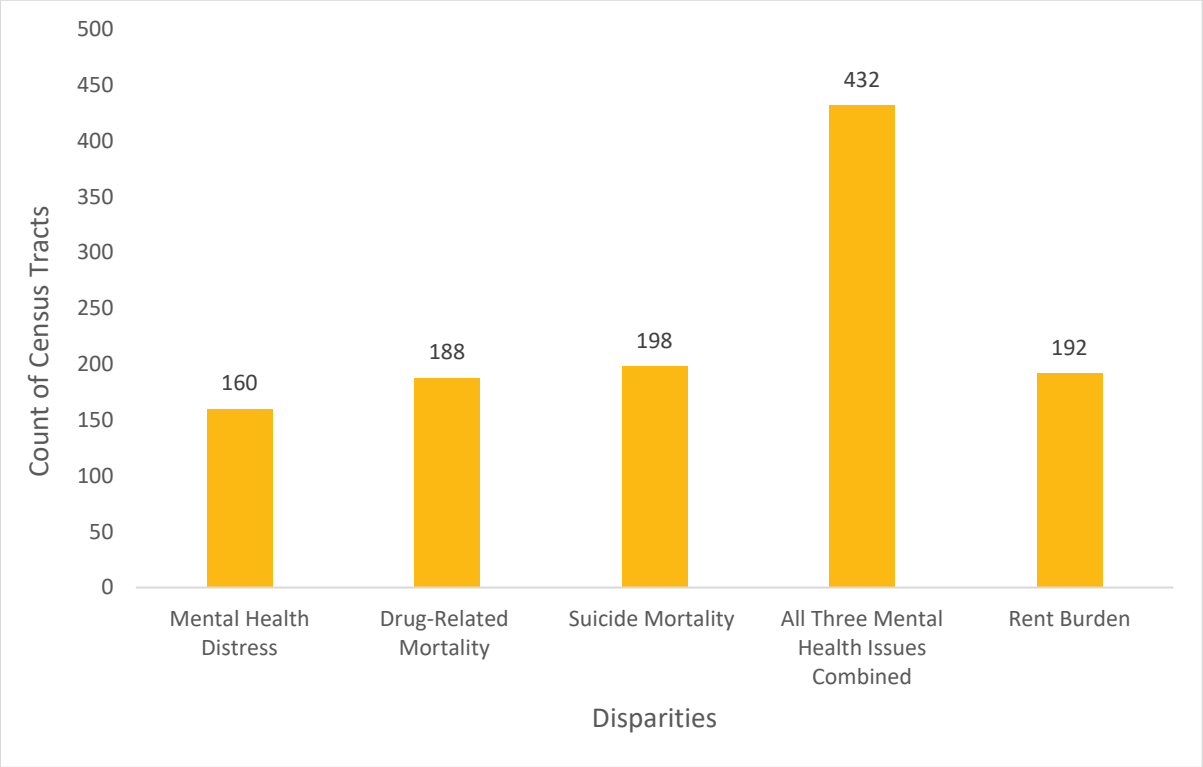



In terms of housing affordability, priority area census tracts also have a greater share of the population that are mortgage-burdened. Furthermore, these census tracts have a greater share of the population who lives in a mobile home (at 5.7% on average), which has been associated with housing inadequacy.[35,36] Priority area census tracts also have a greater share of the population who receives Food Stamp/Supplemental Nutrition Assistance Program (SNAP) support (18.8%) and are living in poverty (10.7%).

In addition, a preliminary analysis using general linear regression (data not shown) that explored the significance of these aforementioned relationships, strongly suggests that being lower income and minority increases the risk for mental health issues and rent burden.

Showing data on the dual mental health and housing disparities in a different way, Figure 3 shows the number of census tracts in Colorado that have the following disparities in: (1) the three measured mental health issues (mental health distress, drug-related mortality, and suicide mortality); (2) all three mental health issues combined; and (3) rent burden. Among disparities in mental health issues, suicide was most prevalent (n=198 tracts, 16%) followed by drug-related mortality (n=188 tracts, 15%).

Figure 3. Count of Colorado Census Tracts with Mental Health and Rent Burden Disparities




## A Closer Look at the Pueblo Metropolitan Region

**In the Pueblo metropolitan region, there were nine priority area census tracts where rent burden and mental health disparities overlapped.**

**In Census Tracts 12, 22, and 24 in Pueblo, drug-related mortality was five to eight times higher than the state average.**

**Census Tract 11 in Pueblo ranked as the highest priority among all 71 census tracts identified as priority areas.**

While the Denver metropolitan region had the most census tracts with overlapping rent burden and mental health issues disparities, Pueblo had the highest overall disparities. In the Pueblo metropolitan region, there were nine census tracts where rent burden and mental health issues disparities overlapped. Five of these tracts reported at least two to three mental health disparities (of mental health distress, drug-related mortality, and suicide mortality). Drug-related mortality particularly stood out. For example, in Census Tracts 12, 22, and 24, drug-related deaths were five to eight times higher than the state average, which is estimated at 19.8 per 100,000 persons.

Furthermore, in Census Tract 11, which ranked the greatest priority among all 71 tracts of spatial overlap, 26 out of 27 social determinants of health were significantly above the state average. See Table 4 for details.

Lastly, the following other social determinants of health stood out for the nine identified priority area census tracts in Pueblo: no high school diploma (2.7 times higher than the state average); living in mobile home (2.4 times higher than the state average); plumbing and kitchen deficiencies (20.3 and 10.8 times higher than the state average, respectively); per capita income (40% of the state average); living below the poverty line (4.2 times higher than the state average); unemployment (2.5 times higher than the state average); single parent household (2.5 times higher than the state average); and having no vehicle (3.1 times higher than the state average).

Figure 4 illustrates the specific census tracts in Pueblo with the greatest disparities. This figure highlights several combinations of rent burden and mental health disparities at the census tract level, including:

- mental health distress with rent burden (MHR)
- drug-related mortality with rent burden (DHR)
- suicide mortality with rent burden (SHR)
- mental health distress and drug-related mortality with rent burden (MDHR)
- mental health distress and suicide mortality with rent burden (MSHR)
- drug-related mortality and suicide mortality (DSHR), and
- mental health distress, drug-related mortality, and suicide mortality with rent burden (MDSHR)

Figure 4. Map of Priority Area Census Tracts in the Pueblo Metropolitan Region

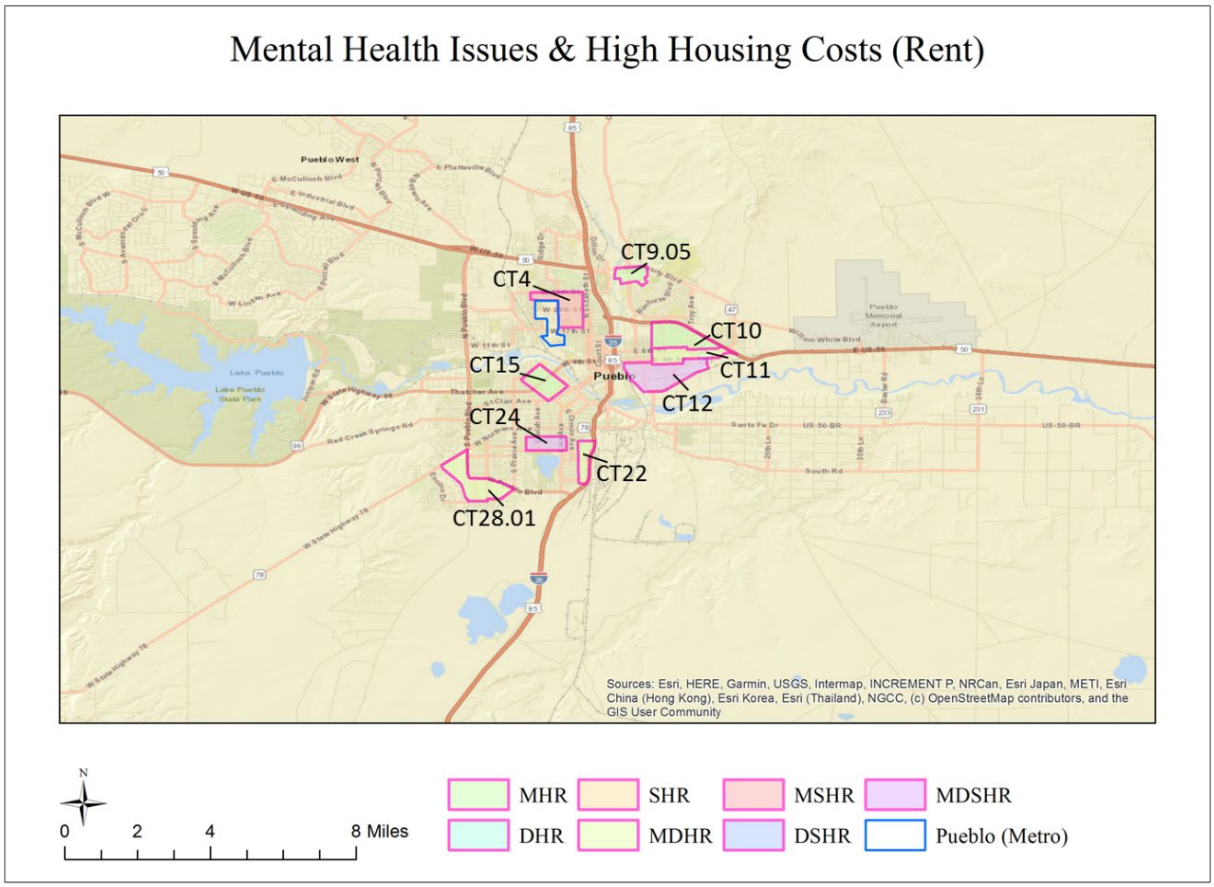


Table 3. Profile of Social Determinants of Health in the Pueblo Metropolitan Region

| Census Tract Profile | | Pueblo Census Tracts | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Category** | **Determinant** | **CT10** | **CT11** | **CT12** | **CT15** | **CT22** | **CT24** | **CT28.01** | **CT4** | **CT9.05** |
| Behavior | Smoking Prevalence | 1.5 | 1.4 | 1.5 | 1.5 | 1.4 | 1.4 | 1.3 | 1.5 | 1.5 |
| Behavior | No Physical Activity | 1.3 | 1.3 | 1.5 | 1.3 | 1.4 | 1.4 | 1.4 | 1.3 | 1.1 |
| Education | No High School Diploma | 2.3 | 2.7 | 2.4 | 1.6 | 2.0 | 2.1 | 1.1 | 1.4 | 0.3 |
| Health | Asthma Prevalence | 1.6 | 1.7 | 1.8 | 1.7 | 1.7 | 1.7 | 1.6 | 1.7 | 1.8 |
| Health | Asthma Hospitalization Rate | 1.8 | 2.4 | 1.9 | 1.3 | 2.8 | 1.6 | 1.3 | 1.3 | 1.5 |
| Health | Diabetes Prevalence | 2.1 | 2.8 | 2.4 | 1.6 | 2.1 | 2.3 | 2.3 | 1.6 | 1.3 |
| Health | Diabetes Hospitalization Rate | 2.6 | 3.3 | 3.2 | 2.0 | 3.8 | 2.0 | 1.9 | 2.0 | 1.9 |
| Health | Drug Death Rate | 1.5 | 3.0 | 6.1 | 0.0 | 8.6 | 5.3 | 2.2 | 0.0 | 0.0 |
| Health | Mental Health Distress Prevalence | 1.8 | 1.9 | 1.7 | 1.5 | 1.5 | 1.7 | 1.5 | 1.6 | 1.5 |
| Health | Obesity Prevalence | 1.5 | 1.6 | 1.6 | 1.4 | 1.6 | 1.5 | 1.5 | 1.4 | 1.4 |
| Health | Suicide Rate | 0.7 | 1.6 | 1.6 | 0.0 | 0.0 | 2.8 | 1.4 | 1.6 | 0.0 |
| Health | Mental Health Vulnerability | 1 | 2 | 3 | 1 | 2 | 3 | 2 | 2 | 1 |
| Health care | Delayed Medical Care | 1.5 | 1.4 | 1.4 | 1.2 | 1.3 | 1.4 | 1.1 | 1.2 | 1.2 |
| Health care | Uninsured | 1.6 | 1.3 | 1.4 | 0.8 | 0.8 | 1.5 | 0.7 | 1.2 | 1.0 |
| Housing | Mobile Home | 1.0 | 2.4 | 0.6 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| Housing | Overcrowded | 2.0 | 1.6 | 2.2 | 0.8 | 0.1 | 0.8 | 0.0 | 2.2 | 2.4 |
| Housing | Lead Risk | 1.8 | 1.6 | 1.8 | 1.6 | 1.5 | 1.8 | 1.8 | 1.8 | 1.3 |
| Housing | Plumbing Deficiency | 9.7 | 20.3 | 5.0 | 8.3 | 0.0 | 0.0 | 0.0 | 7.0 | 0.0 |
| Housing | Kitchen Deficiency | 5.9 | 10.8 | 2.6 | 3.1 | 0.0 | 1.8 | 6.9 | 2.6 | 0.0 |
| Housing | Mortgage Burden | 1.1 | 0.6 | 1.8 | 0.8 | 1.7 | 1.1 | 1.3 | 0.9 | 1.1 |
| Housing | Rent Burden | 1.5 | 1.5 | 1.4 | 1.2 | 1.5 | 1.5 | 1.4 | 1.3 | 1.3 |
| Race/ethnicity | Minority % | 70.5 | 78.2 | 78.2 | 47.0 | 66.2 | 62.5 | 57.9 | 50.9 | 49.7 |
| Socioeconomic | Per Capita Income | 0.4 | 0.4 | 0.4 | 0.7 | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 |
| Socioeconomic | Poverty | 3.3 | 4.2 | 3.5 | 2.0 | 3.2 | 1.6 | 1.6 | 1.9 | 1.8 |
| Socioeconomic | Unemployment | 3.0 | 2.5 | 4.7 | 0.9 | 1.8 | 1.9 | 0.6 | 1.0 | 1.4 |
| Support | Single Parent Household | 1.5 | 2.5 | 2.9 | 1.1 | 1.9 | 1.2 | 1.9 | 1.4 | 1.4 |
| Transportation | No Vehicle | 1.5 | 3.1 | 2.4 | 1.4 | 2.3 | 1.5 | 2.0 | 1.1 | 1.9 |

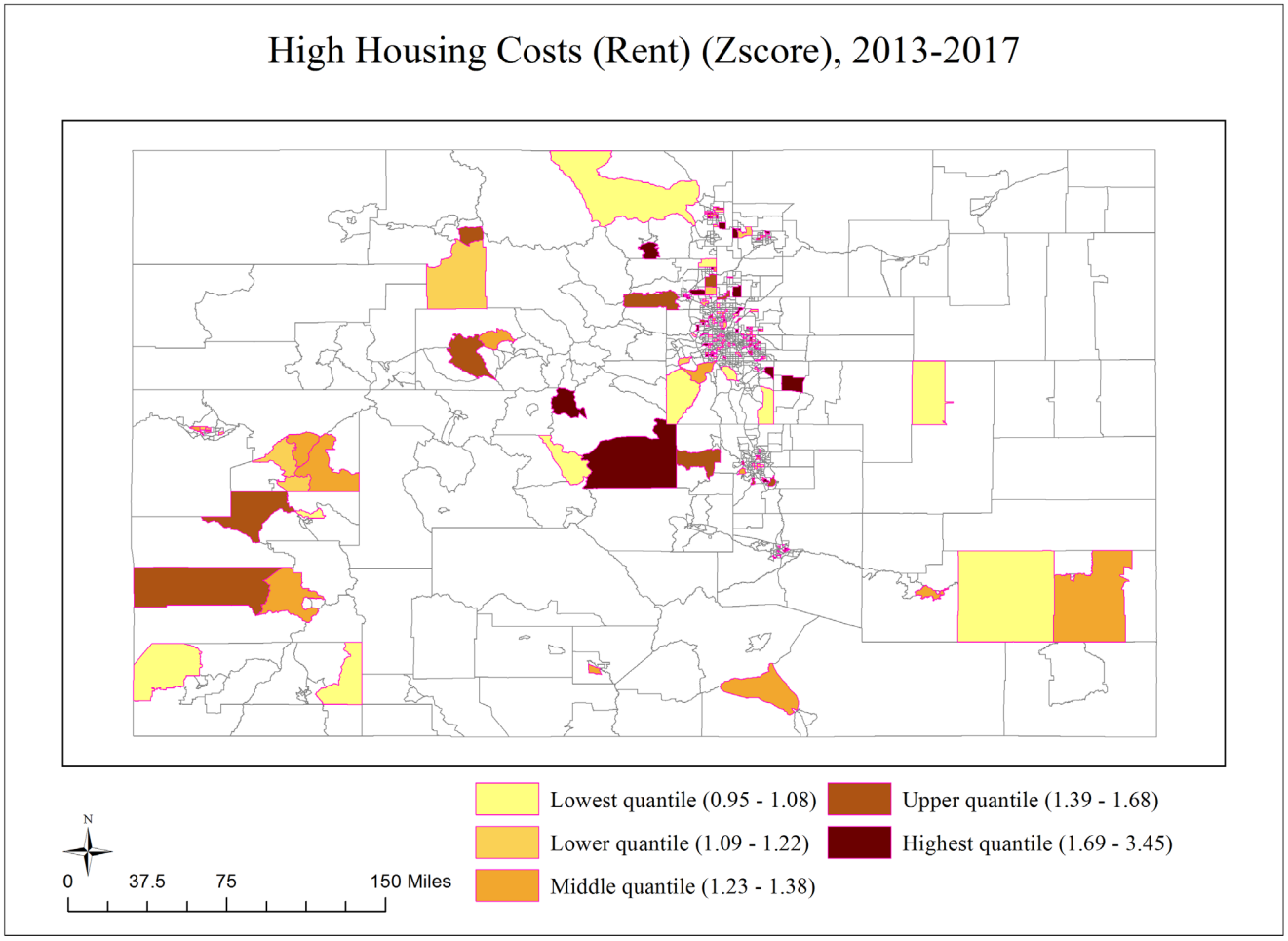
*Note.* Gold indicates when the social determinant of health value was at least 1.2 times above the state average. Red indicates census tracts where there exists more than one mental health issue disparity (mental health distress, drug-related mortality, or suicide mortality).

### (2) Census Tracts that have a Significantly Higher Prevalence of Rent-Burdened Households than the State Average

Figure 5 illustrates the census tracts where the prevalence of rent-burdened households is significantly higher as compared to the state average. *Significantly higher* is defined as one standard deviation or greater above the state average and is also referred to as a *disparity*. The online interactive map provides more ability to examine results.

Census tracts with the highest rent costs are shaded in dark red and dark orange. As with mental health issues, the highest rent burden disparity is found along the Front Range urban corridor. Approximately 10% (n=19) of significantly more rent-burdened census tracts are located in Denver.

Figure 5. Map of Rent Burden Disparity in Colorado




**(3) Census tracts that have a significantly higher prevalence of at least one of the following mental health issues: mental health distress, drug-related mortality, or suicide mortality (as compared to the state average).**

Another key finding of this study is that 35% of all census tracts in Colorado have a significantly higher prevalence of at least one of the following mental health issues: mental health distress, drug-related mortality, or suicide mortality (as compared to the state average). *Significantly higher* is defined as one standard deviation or greater above the state average and is also referred to as a *disparity*. Figure 6 illustrates the locations of these 35% (n=432) of census tracts.

Census tracts with the highest number of mental health issues above the state average are highlighted in dark blue and tend to be located in metropolitan regions. At least 100 census tracts reported two to three overlapping mental health issues (of mental health distress, drug-related mortality, and suicide mortality).

Figure 6. Map of Mental Health Disparity in Colorado

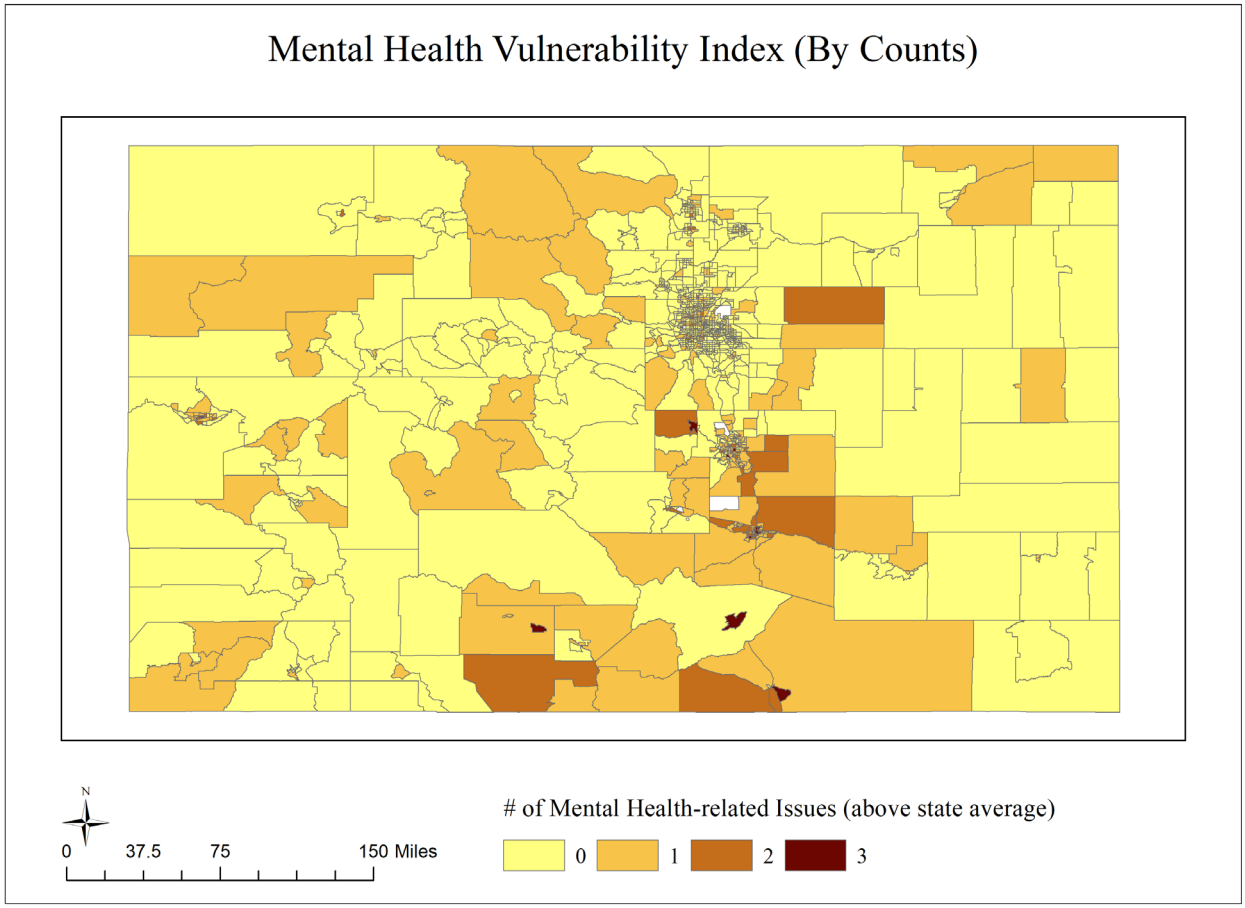



Table 4 shows the prevalence of mental health issues in different types of identified census tracts (the types were defined in Figure 1), including priority area census tracts. It should be noted that mental health distress and suicide mortality do not differ much between priority area census tracts (i.e., tracts with high mental health issues and high rent burden) and tracts with high mental health issue prevalence *and* low rent costs. What explains these observations (where rent burden does not seem to make a difference) warrants further investigation, particularly to understand the role of housing affordability and how it may or may not interact with other social determinants of health.

Table 4. Prevalence of Mental Health Issues for Different Types of Census Tracts

| | Mental Health Distress Prevalence (%) | Drug-Related Mortality Rate (per 100,000 persons) | Suicide Mortality Rate (per 100,000 persons) |
|---|---|---|---|
| Priority Area Census Tracts: High Prevalence of Rent-Burdened Households and High Prevalence of Mental Health Issues (n=71 census tracts) | 10.7 | 14.6 | 27.0 |
| Low Prevalence of Rent-Burdened Households and High Prevalence of Mental Health Issues (n=361 census tracts) | 10.8 | 11.5 | 26.8 |
| High Prevalence of Rent-Burdened Households and Low Prevalence of Mental Health Issues (n=121 census tracts) | 8.7 | 1.1 | 9.0 |
| Low Prevalence of Rent-Burdened Households and Low Prevalence of Mental Health Issues (n=681 census tracts) | 8.7 | 1.4 | 11.7 |

## Research Question 2

*What is the relationship between mental health care accessibility and the spatial overlap of mental health issues and rent-burdened households?*

**Three datasets were utilized to better understand mental health care accessibility in Colorado. Using the first dataset (Drug Treatment and Program Resources), 25% of Colorado's census tracts were considered underserved. Using the second dataset (LADDERS), 11% of census tracts were considered underserved. Using the third dataset (Community Behavioral Centers and Resources), 11% of census tracts were considered underserved.**

**Most priority area census tracts along the Front Range urban corridor were considered served, except for one census tract in Larimer County (part of the Fort Collins metropolitan region) and one census tract in Jefferson County (part of the Denver metropolitan region), both of which have high rates of suicide mortality.**

Figure 7 compares the served (light blue solid) census tracts to the underserved (striped) census tracts (as identified in the Drug Treatment and Program Resources dataset). According to this first dataset, 136 census tracts were underserved, meaning they do not have access to substance abuse treatment facilities within 30 minutes of driving time. Priority area census tracts are highlighted in orange stripe with a red outline. At a smaller scale, they are seen as red points, particularly along the Front Range urban corridor.

Figure 7. First Dataset: Map of Mental Health Care Access According to Colorado Drug Treatment and Program Resources Dataset

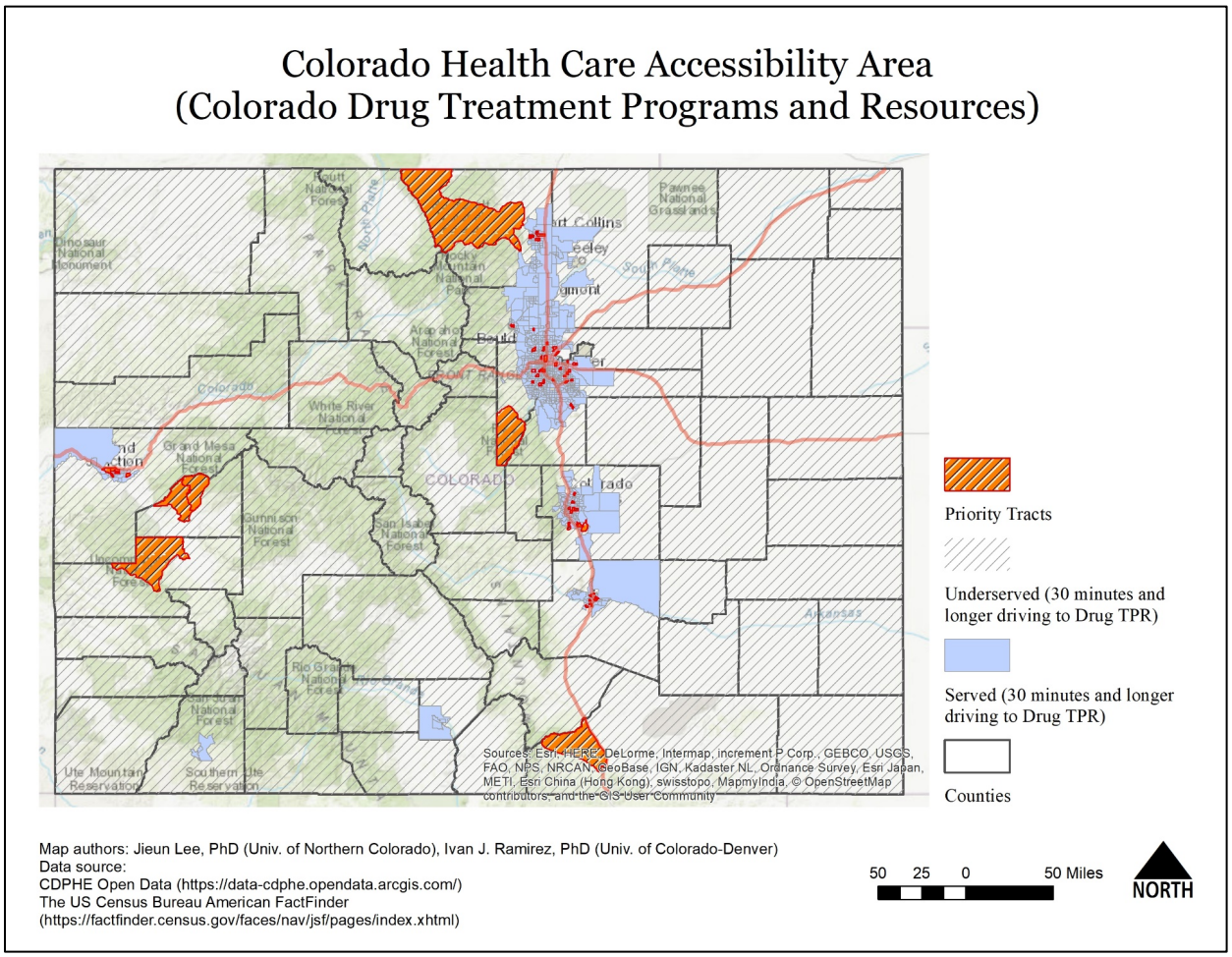



Figure 8 compares the served (light pink solid) census tracts to the underserved (striped) census tracts (as identified in the LADDERS dataset). According to this second dataset, 311 census tracts were underserved, meaning they do not have access to mental health care treatment facilities, including substance abuse treatment facilities, within 30 minutes of driving time. Priority area census tracts are highlighted in orange stripe with a red outline. At a smaller scale, they are seen as red points, particularly along the Front Range urban corridor.

Figure 8. Second Dataset: Map of Mental Health Care Access According to LADDERS Dataset

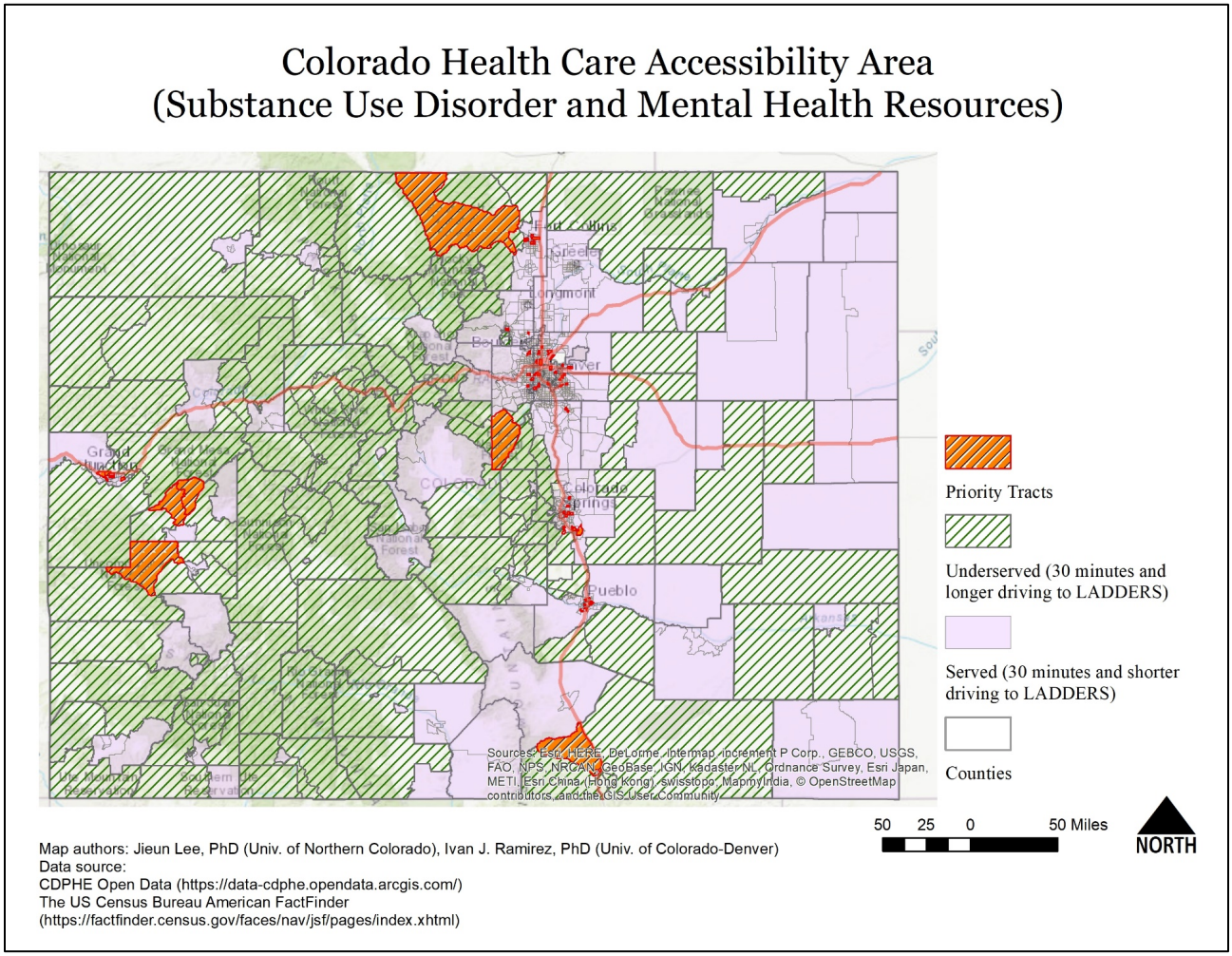
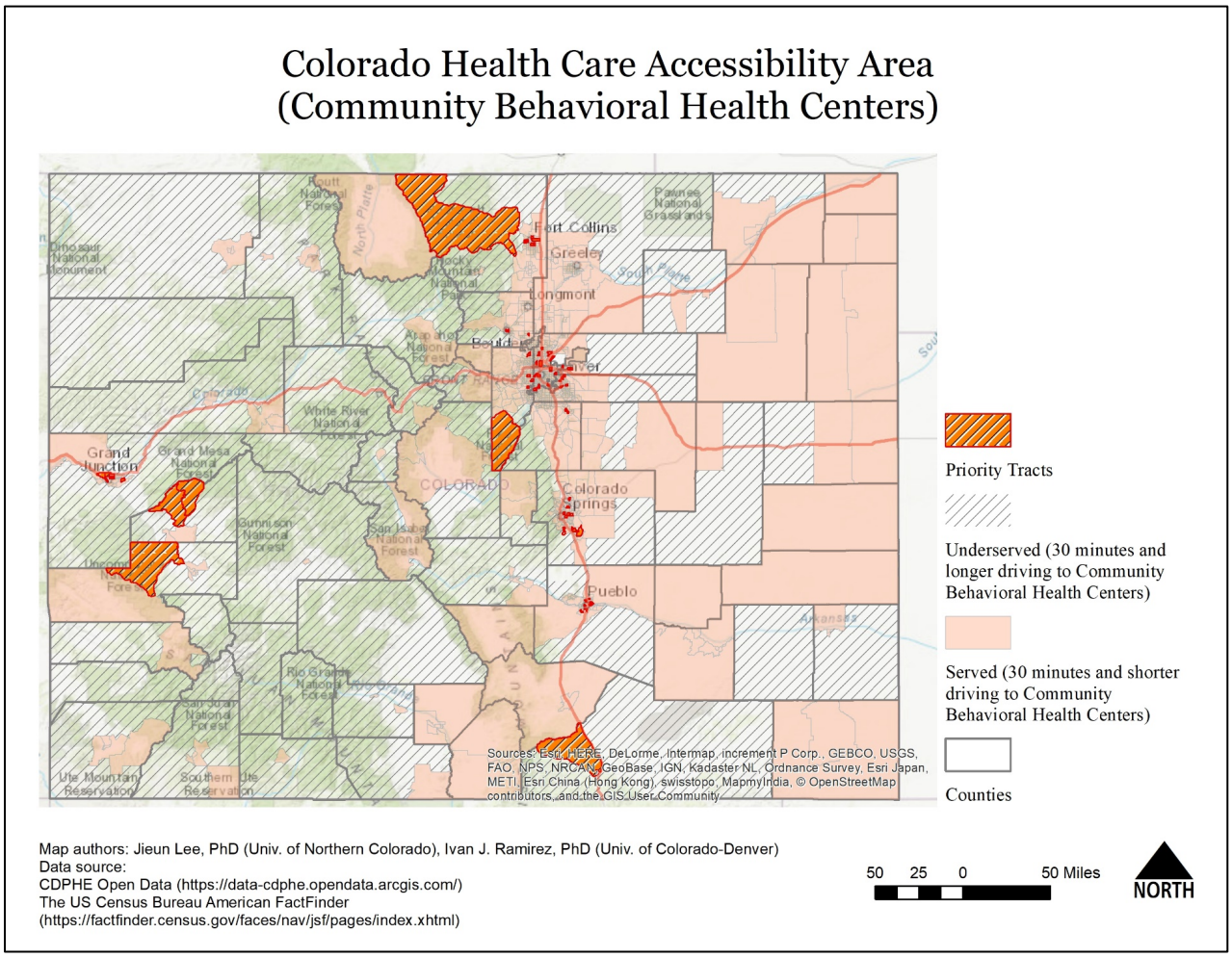



Figure 9 compares the served (light orange solid) census tracts to the underserved (striped) census tracts (as identified in the Community Behavioral Centers and Resources dataset). According to this third dataset, 138 census tracts were underserved, meaning they do not have access to community behavioral health centers facilities within 30 minutes of driving time. Priority area census tracts are highlighted in orange stripe with red outline. At a smaller scale, they are seen as red points, particularly along the Front Range urban corridor.

Figure 9. Third Dataset: Map of Mental Health Care Access According to Community Behavioral Centers and Resources Dataset




## What are the Differences between Served and Underserved Areas?

To explore the differences between census tracts that have access to mental health treatment (served) and those that do not have access (underserved), we examined profiles of mental health issues and social determinants of health in both groups. In general, profiles of served and underserved census tracts revealed that underserved areas have higher rates of suicide, rent-burdened households, persons living in mobile homes, and greater exposure to lead risk. Served census tracts also have higher rates of drug-related mortality, despite access to treatment, suggesting potentially, that either access is inadequate (even more access to treatment is needed) or there are other barriers to access that play a role, such as social stigma or cost.[37]

Table 5 shows the number of census tracts that were underserved compared to those served in relation to the average of drug-related mortality (per 100,000 persons) and the average of suicide mortality (per 100,000 persons) by accessibility type.

Table 5. Mental Health Care Accessibility and Prevalence of Mental Health Issues

| Dataset and Mental Health Care Access in Colorado Census Tracts | Prevalence of Drug-Related Mortality (per 100,000 persons) | Prevalence of Suicide Mortality (per 100,000 persons) |
|---|---|---|
| (1) Drug Treatment and Programs Resources | | |
| Underserved (n=311 census tracts) | 2.0 | 17.0 |
| Served (n=923 census tracts) | 6.1 | 16.6 |
| (2) LADDERS | | |
| Underserved (n=138 census tracts) | 8.2 | 17.7 |
| Served (n=1096 census tracts) | 5.5 | 16.6 |
| (3) Community Behavioral Centers and Resources | | |
| Underserved (n=136 census tracts) | 1.5 | 18.3 |
| Served (n=1,098 census tracts) | 5.5 | 16.5 |

## Research Question 3

*What are the spatial relationships between mental health issues and other social determinants of health?*

**Three measures of mental health issues were examined: mental health distress prevalence, drug-related mortality rate, and suicide mortality rate.**

**Social determinants of health associated with behavior and perception of health (e.g., smoking, poor physical health, and no physical activity) and economic stability (e.g., rent burden, unemployment, and poverty) had the most significant effects on mental health distress prevalence.**

**Spatially, mental health distress was predicted more accurately along the Front Range urban corridor including in Colorado Springs and Pueblo and in western Colorado (e.g., Grand Junction).**

**The seven dimensions of social determinants of health did not offer practically meaningful insight into drug-related mortality or suicide mortality.**

### Principal Component Analysis

The goal of the principal component analyses (PCA) was to reduce 27 potentially correlated indicators of social determinants of health into several variables composed of discrete combinations that could then be entered into a regression model. Table 6 shows the seven dimensions generated by the PCA.

Table 6. Principal Component Analysis

| Factor | Summary of the Dimensions | Dominant Variables | Variance Explained % |
|---|---|---|---|
| 1 | Demographic Characteristics: Education/Ethnicity/Socioeconomic | limited English, no high school diploma, overcrowding, minority, no health insurance, single parent household | 32.2 |
| 2 | Health/Behavior | smoking, poor physical health, lack of physical activity | 11.9 |
| 3 | Housing Quality 1 | lead risk, homes built before 1980, population 65 and older | 9.6 |
| 4 | Economic Stability | rent burden, unemployment, poverty | 6 |
| 5 | Urban/Transportation | multi-housing units, no vehicle | 5.6 |
| 6 | Health Care | no medical check-ups | 5.1 |
| 7 | Housing Quality 2 | plumbing and kitchen deficiencies | 4.4 |

## Geographically Weighted Regression Analyses

Three separate spatial models (GWR) were used to assess how the seven dimensions relate to: (a) mental health distress; (b) drug-related mortality rate; and (c) suicide mortality rate.

**80% of the variance in mental health distress was explained by regressing seven dimensions of social determinants of health.**

**17% of the variance in drug-related mortality rate was explained by regressing the same seven dimensions of social determinants of health.**

**12% of the variance in the suicide mortality rate was explained by regressing the same seven dimensions of social determinants of health.**

## Mental Health Distress

Prior to the GWR model analyses, non-spatial regression models (OLS) were used for comparison and to provide some initial insight. The dimensions of (a) health/behavior (Factor 2; e.g., smoking, poor physical health, and no physical activity) and (b) economic stability (Factor 4; e.g., rent burden, unemployment, and poverty) had the most significant effects on mental health distress (see Table 7). Overall the OLS model with all seven dimensions explained 51% of the variance, respectively.

Table 7. Output from the Non-Spatial Regression Analysis (OLS)

| Mental Health Distress Prevalence | | | | |
|---|---|---|---|---|
| **Variable** | **StdCoef** | **StdE** | **T** | ***p*-value** |
| Constant | 0.00 | 0.04 | 216.85 | 0.000 |
| FAC1 | 0.05 | 0.04 | 2.58 | 0.010 |
| FAC2 | 0.65 | 0.06 | 23.90 | 0.000 |
| FAC3 | -0.05 | 0.04 | -2.60 | 0.009 |
| FAC4 | 0.25 | 0.04 | 12.17 | 0.000 |

Table 7. Output from the Non-Spatial Regression Analysis (OLS)

| Mental Health Distress Prevalence | | | | |
|---|---|---|---|---|
| **Variable** | **StdCoef** | **StdE** | **T** | ***p*-value** |
| FAC5 | 0.08 | 0.05 | 3.48 | 0.001 |
| FAC6 | -0.14 | 0.06 | -5.03 | 0.000 |
| FAC7 | -0.01 | 0.06 | -0.45 | 0.652 |

When all seven dimensions were included in the GWR model, 80% of the variance was explained. Spatially, mental health distress was predicted more accurately in the Front Range urban corridor (including Colorado Springs and Pueblo) and in western Colorado (e.g., Grand Junction), suggesting that other factors are needed to explain patterns of mental health distress in regions such as northern Colorado.

In Figure 10, census tracts where there exists a strong association between mental health distress and other social determinants of health (see Table 1 for list) are highlighted in dark brown. The census tracts with lighter colors represent places where other factors may explain the association.

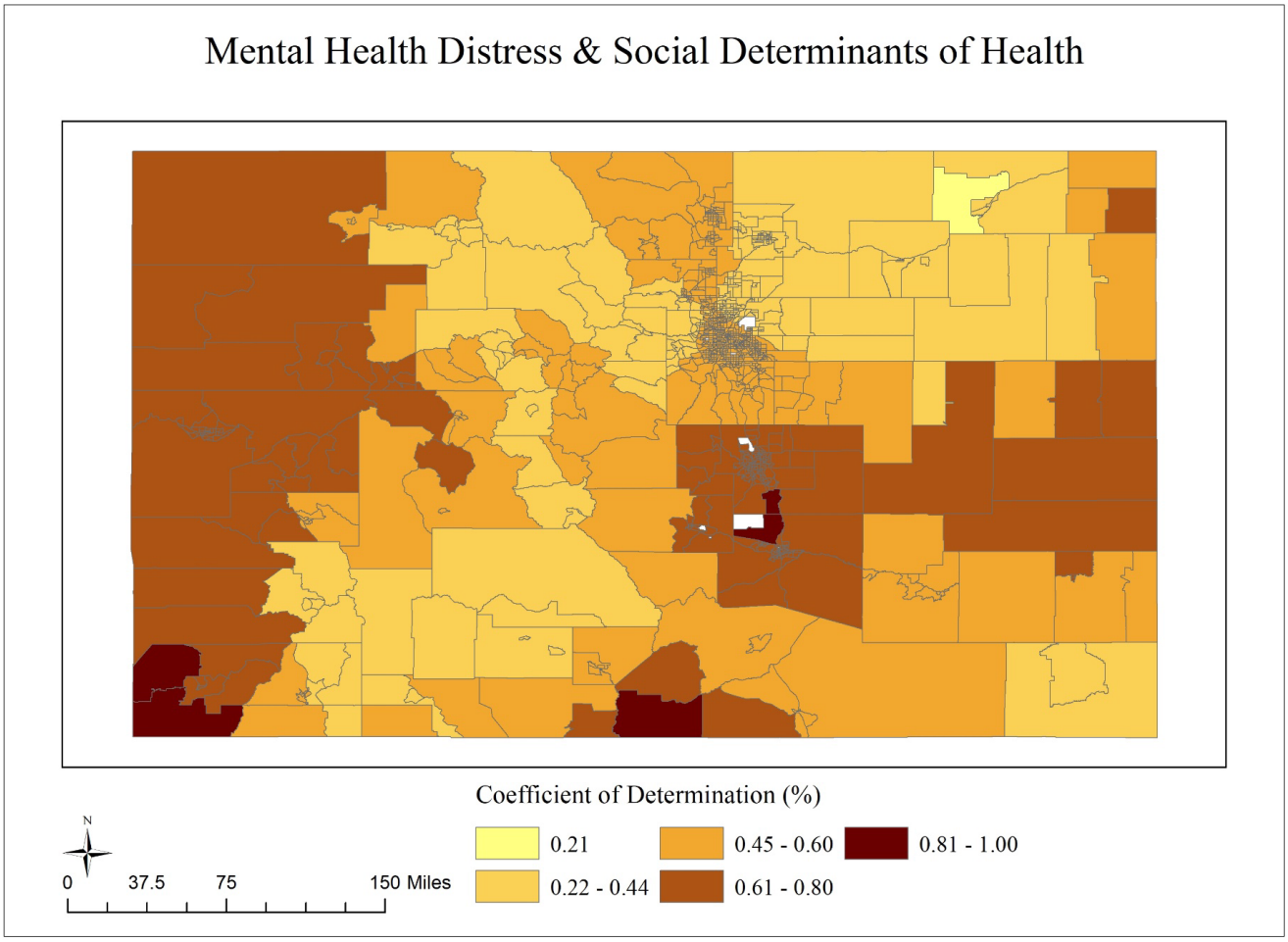
### Rationale for GWR Regression Model

Table 8 displays the main statistics used for comparing the non-spatial model (OLS) with the spatial model (GWR) in terms of the overall model performance. The AICc is the Akaike Information Criterion, which takes into account the complexity of the model and is used to compare different regression models explaining the same variable. Between two models, a lower AICc indicates a better performance. As Table 8 shows, the GWR improves all three models, but does best with regards to mental health distress. Supporting these models are the coefficients of determination (r-squared) which shows a good fitness of the models, explaining ~80% of the variance in the spatial patterns for mental health distress.

Table 8. Summary Statistics from the Regression Analyses

| | **AICc** | | **R-Squared** | | **Adj. R-Squared** | |
|---|---|---|---|---|---|---|
| **Variable** | **GWR** | **OLS** | **GWR** | **OLS** | **GWR** | **OLS** |
| Mental Health Distress Prevalence | 3635.35 | 4560.37 | 0.80 | 0.52 | 0.78 | 0.51 |
| Drug Poisoning & Drug Overdose Mortality Rate | 9078.14 | 9084.06 | 0.17 | 0.15 | 0.16 | 0.15 |
| Suicide Rate | 10257.40 | 10274.47 | 0.12 | 0.04 | 0.07 | 0.04 |

Figure 10. Map that Shows the Relationship between Mental Health Distress and Other Social Determinants of Health in Colorado




# Conclusion

Overall, this study identified priority area census tracts within Colorado where there is a high prevalence of rent-burdened households and mental health issues *and* where mental health care access is limited. Profiles of these census tracts provide further support that the persistent social inequalities that underlie the intersection of housing and mental health issues require a cross-system response from federal, state, and local governments.

While this study did not find a "silver bullet," or one single predictive social determinant of health that can predict rent burden or mental health issues, it does present compelling evidence of a broader web of social and public health problems present at the local level in many Colorado counties. It supports, preliminarily, the 2019 county-level study by the Robert Wood Johnson Foundation that demonstrated that households struggling with greater housing cost burdens are also burdened with poorer health outcomes.[38]

This study's findings, and especially its publicly-available mapping tool, can substantially inform future policy proposals that target the intersection of housing and mental health in Colorado.

# Endnotes

[1] Artiga, S., & Hinton, E. (2018). Beyond health care: The role of social determinants in promoting health and health equity. *KFF: Henry J Kaiser Family Foundation*, para. 1. Retrieved from https://www.kff.org/disparities-policy/issue-brief/beyond-health-care-the-role-of-social-determinants-in-promoting-health-and-health-equity/

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