EXPLORING THE RELATIONSHIP OF URBAN FORM AND MENTAL HEALTH IN THE 500 LARGEST CITIES OF THE UNITED STATES

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ABSTRACT

Exploring the Relationship of Urban Form and Mental Health in the 500 Largest Cities of the United States

Daniel Sam Harrison

Sustainable development efforts frequently focus on understanding and promoting the factors that influence health and wellbeing. Urban environments have received attention in recent years as spaces which can increase psychological distress. Despite hypothesized reports of urban environments being less conducive to good mental health then natural environments, few studies have investigated the effects of urban form characteristics (size, density, nuisances, transportation, and housing characteristics) and mental health measures at the city level. Using 2014 data from the 500 largest cities in the United States, this thesis evaluates the relationship between urban form and aggregate self-report scores of poor mental health. Results suggest that elements of the built environment have a direct influence on mental health status. The aim of this study is to test the association of urban form characteristics and psychological distress using a cross-sectional analysis of individual health survey responses. Mental health data were collected for a study of Center for Disease Control health characteristics in the 500 largest cities in the United States. Urban form data was collected from both United States Census and GIS datasets such as the Center for Neighborhood Technology's Housing and Transportation Affordability Index (H+T Index). Linear regression analysis and factor analyses were used to estimate the relationship between psychological distress and urban form characteristics. Results suggest that urban density is negatively associated with mental health status at city level. This finding is logical and confirms earlier research. While measures of housing cost and diversity were slightly negatively associated with mental health, measures of transportation cost and employment access were slightly positively associated.

Keywords: urban density, built environments, mental health, psychological distress.

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Chapter 1

INTRODUCTION

As the world becomes increasingly urbanized, significant concerns about environmental, social, and public health issues have emerged. Urban spaces located within the public realm provide an opportunity to promote positive mental health through environmental design. The implementation of measurable design interventions has considerable human benefits, including positive environmental change and improved health and well-being. Empirical evidence from many disciplines has supported the development of urban environments that promote flourishing mental health, though there is little guidance for the incorporation of such spaces into planning efforts. This research explores how urban environments can be designed to promote psychological restoration and improve human health and well-being.

In 2014, the world's urban population accounted for 54 percent of the total global population (WHO 2016). By 2070, 66 percent of the world's population is projected to reside in urban areas (UN 2014). Rapid urbanization has promoted the rise of sustainable development, or "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (UNO 1987). This trend has implications for the design of urban spaces that fulfill psychological needs.

Research from a variety of fields has demonstrated the psychological benefits of natural environments. Exposure to natural settings can reduce stress (Ulrich 1984), promote recovery from attentional fatigue (Kaplan & Kaplan 1989), and even improve overall health (Laumann, Gärling & Stormark 2003). Studies have shown that natural environments have greater restorative potential than urban environments (Hartig, Evans, Jamner, Davis & Gärling 2003, Herzog, Black, Fountaine & Knotts 1997, Ulrich et al. 1991). As van den Berg, Hartig, & Staats (2007) suggest, psychological factors can serve as a barrier to achieving urban sustainability. Dense urban areas present stressors such as traffic noise, crowded spaces, and pollution that inhibit public health and individual well-being. Multiple studies have shown that exposure to natural environments can reduce stress and promote psychological wellbeing (Hartig 2004, Kaplan & Kaplan 1989, Ulrich 1983). As a result, the integration of design interventions that are conscious of mental health has emerged as an important topic in planning and urban design (Berto 2014).

Chapter 2

LITERATURE REVIEW

While most research on environmental design in relationship to mental health has focused on natural environments (Fuller, Irvine, Devine-Wright, Warren & Gaston 2007, Hartig et al. 1991, Twedt, Rainey & Proffitt 2016) or comparisons between urban and natural environments, (Berto et al. 2008, Gulwadi 2006, Hartig et al. 1997, Hartig & Staats 2006, Herzog et al. 2003), certain studies have evaluated the restorative potential of urban environments. Several of these studies suggest that certain urban settings can contribute to positive mental health in a way that is equivalent to, or even greater than, natural environments (Herzog et al. 2003, Nasar & Terzano 2010, van den Berg, Jorgensen & Wilson 2014).

Literature on urban environments has provided an insufficient amount of information about the role of specific elements of urban form in the restorative experience (van den Berg 2014)**.** This paper presents a framework of restorative urban design that is reflective of the relationship between the built environment and psychological well-being. This research attempts to bridge the gap between current research on restorative environmental design and implantation of urban spaces that promote positive mental health.

2.1 Urban Design Context: Challenges and Opportunities

In urban areas, residents have reported that exposure to nature has positive health benefits. In a nationwide survey of urban dwellers in the Netherlands, the vast majority (95%) of respondents said that visiting nature is a useful way of obtaining relief from stress (Frerichs 2004). Furthermore, Staats, van Gemerden & Hartig reported that urban residents preferred being in a park-like setting over being at home, in the city center, or riding transit when experiencing attentional fatigue. In settings where exposure to urban nature is limited, the presence of green roofs has shown to be perceived as restorative (White & Gatersleben 2011) and promote affective recovery (Lee, Williams, Sargent, Williams, and Johnson 2015).

Restorative Environmental Design has emerged as a design paradigm that considers the restorative effects of urban form elements. A well designed built environment can facilitate recovery from mental fatigue, and contribute to decreased aggression and violence (Sullivan & Chang 2011). Furthermore, the built environment can promote social interaction among neighbors (Kuo et al. 1998) and increase levels of social support among community members in social settings (Brown et al. 2009). Empirical research has demonstrated that certain built environments, such as museums (Kaplan, Bardwell, & Slakter 1993) places of worship (Herzog, Ouellette, Rolens, & Koenig 2010; Herzog, Gray, Dunville, Hicks, & Gilson 2013) and homes (Hartig 2012) can serve as restorative settings. The most current study of restorative urban environments was conducted by Staats, Jahncke, Herzog, & Hartig (2016). In their quasi-experimental study, the researchers investigated the restorative potential of three common urban settings, cafés, shopping malls, and parks, concluding that such everyday leisure places can serve as restorative environments.

Several studies have suggested that the integration of natural features into urban environments can improve their restorative potential. Nordh, Hartig, Hagerhall & Fry (2009) found that small "pocket parks" in Norwegian cities can have a similar restorative quality as larger regional parks if they are designed with a high degree of "naturalness" as measured by the amount of grass and tree coverage within the space. The relationship between naturalness and perceived restoration potential was also studied by Grahn & Strgsdotter (2009), who found that urban green spaces that possessed qualities of refuge and species richness were preferred by stressed individuals. While not explicitly related to restorative environments, Bentley (2011) designed a set of design strategies to integrate nature into urban spaces across different scales

In a landmark study, Sjerp De Veries (2003) and his colleagues investigated the relationship between urban greenspace and human health. The researchers found that there is a correlation between the greenness of people's living environments and mental and physical health. Furthermore, the study found that the amount of water and the presence of gardens is positively associated with the number of symptoms affecting an individual. Though there is a limited body of research involving the restorative qualities of urban greenspace, several studies have demonstrated that the presence of feature such as trees, flowers, and grass effects preferences for "green" urban environments (Hartig & Staats 2006, Todorova et al. 2004, van den berg et al. 2003).

Among natural features in urban settings, trees have been shown to be the most important factor influencing environmental preferences (Todorva et al. 2004). Further studies have shown that ratings of restoration likelihood in urban streetscapes increase with an increase in the number of street trees and the presence of flower beds (Lindal & Hartig 2015), and that certain types of trees (i.e. deciduous) are preferred over others (i.e. coniferous) (Summit & Sommer, 1999).

Poor design of residential neighborhoods had been shown to contribute to negative health consequences. Studies of low-income housing projects in Chicago by

Kuo & Sullivan (2001; Kuo 2001) revealed that residents that have access to green spaces, both directly and indirectly, performed better on standardized tests of attention than residents without access to greenery. A related study by Taylor, Kuo, and Sullivan (2002) showed that children residing in inner city areas with views of greenery performed better on attentional tests than those who did not. Residing in a neighborhood with poor design qualities has been linked to lifelong depression (Galea, Ahern, Rudenstine, Wallace & Vlahov 2005). In a study of schoolchildren living in dilapidated urban environments, Gifford and Lacombe (2006) found that these students were rated as having higher levels of psychological distress than their peers in non-depilated housing. Numerous other studies (Weich et. al 2001; Weich et. al 2002; Araya et. al 2007; Thomas et. al 2007) considered housing and neighborhood characteristics, including the presence of vacant land, graffiti, presence of yards/gardens, condition of sidewalks/pavements, access to parking, and presence of hedges and fences.

Urban public gathering spaces, such as plazas, have been evaluated for restoration potential. Abdulkarim and Nasar (2014) considered whether Whyte's (1980) elements of plazas—seating, triangulation, and food—make public spaces more accessible. The researchers found that all three elements contributed to the restorativeness of public plazas. Likewise, Hidalgo et al. (2006) discovered that, within urban settings, historic-cultural and recreational public spaces had the greatest restoration potential. The researchers also found an important correlation between attractive urban environments and restorativeness.

Transportation service quality can affect mental health in several ways. High transportation level of service can reduce emotional stress by improving access to essential educational and employment sites (Stutzer and Fray 2007), improving connections among community members (Olsson et al. 2012), and reducing crowding at transit stations (Allen et al 2008). Access to affordable public transport and transit-oriented development can reduce transportation costs, leaving more money to purchase goods and services. Conversely, people with long journeys to and from work report significantly life satisfaction than those with shorter journeys (Stutzer and Fray 2007).

Within urban environments, streetscapes are a site of restorative potential. Todorova (2003) found that the presence of flowers within streetscapes has a positive influence on psychological well-being, as participants reported such streetscapes as more restful. Further environmental preference literature (Kalmbach & Kielbaso 1979, Sommer, Guenther & Barker 1990, Wolf 2009) has demonstrated that residents prefer the presence of street trees within urban streetscapes. However, further empirical research is needed to connect environmental preferences to psychological restoration.

A strain of research has investigated the role of architectural characteristics in promoting psychological restoration. Galindo & Hidalgo (2005) found that openness in built environments can positively affect the probability of restoration. Studies have shown that physical components of building form can influence preference in urban settings (Stamps 1999; 2005). Lindal & Hartig (2013) found that architectural variation (entropy) can have a positive effect on restoration potential, whereas building height had a negative effect. Studies have investigated the relationship between household density (Saito 1993; Rukack 1994; Maxwell 1996; Sadowski 1999; Evans et al. 2001) and population density (McGrath 2004; Saha 2005, Weich 2003; Peen 2004). A range of measures of mental health were used, including depression, anxiety, schizophrenia and suicide.

Studies have shown a link between exposure to neighborhood violence and poor mental health (Norris & Kaniasty 1994; Pastore et al. 1996; Lai 1999; Latzman & Swisher 2005). Neighborhood violence was defined by both passive (witnessing a crime or arrest) and active (having possessions stolen, being the victim of a verbal or physical attack). One study (Moses 1999) found that exposure to neighborhood violence was associated with poorer mental health in females but not males.

The design of the built environment can profoundly influence mental health and well-being. As the world's urban population continues to grow, the need for specific, measurable and feasible design interventions is required more so than ever. In addition to urban public spaces, campus settings such as colleges, hospitals, and workplaces should be built with restorative design practices in mind. Advances in digital imaging allow for greater manipulation and control of variables (Stamps 2010), as well as the creation of realistic environments. Future research on restorative urban environments should synthesize best practices in environmental psychology research and emerging trends in digital technology to envision and create more restorative urban spaces.

2.2 Mental Health and the City

Mental health is fundamental to good overall health and is linked to socioeconomic outcomes across the lifespan. In recent years, there has been a heightened recognition of the importance of good mental health and wellbeing (WHO 2001; 2002, U.S. Department of Health and Human Services 1999). The growing awareness of mental health promotion influences a wide range of policy on public health, planning, education, and social inclusion. These policy developments are spurred by a growing evidence base involving the effectiveness of interventions related to positive mental health.

Positive mental health is more complex than the absence of a clinically defined mental health disorder. The World Health Organization (WHO) defines mental health as “a state of wellbeing in which the individual realizes his or her abilities, copes with the normal stresses of life, works productively and fruitfully, and makes a contribution to his or her community” (WHO 2001). Empirical evidence from the Cambridge Well-being Institute (2011) shows that mental health exists on a spectrum, with the majority the population existing in the middle of this spectrum.

A ground-breaking U.S. Department of Health and Human Services (1999) report found about 17% of US adults are considered to be in a state of optimal mental health. Evidence has found that many mental health disorders, especially depressive disorders, are strongly related to the lack of preventative measures such as health screenings, the occurrence of risk behaviors such as physical inactivity, binge drinking, and insufficient sleep (Chapman et al. 2005). Access to preventive healthcare services, such as getting routine physical checkups, receiving recommended vaccinations on appropriate schedules, and screening for symptoms of disease can reduce morbidity and mortality from chronic diseases. In 2011, around two-thirds of U.S. adults reported having seen a doctor for a general physical examination in the last year (Xu et al. 2011). The same survey found that approximately 25 percent of adults participated in no leisure-time physical activity. In 2010, a total of 17.1% of adults reported binge drinking on an occasion in the past 30 days (CDC 2010). Lastly, a 2012 study found that almost onethird of U.S. adults reported usually getting insufficient sleep, defined as less than seven hours per night on average (Ford et al. 2012).

Positive mental health is a broad construct which involves both eudemonic and hedonic determinates at the individual, community, city, national, and global levels. Urban planners should recognize the importance of place in explaining the geographical variation of mental health status, with a focus on how elements of urban form affect economic activity, social cohesion, and public safety. Based on this literature, I hypothesize that objective measures of the urban environment influence individuals' self-reported mental health status in the 500 largest U.S. cities.

Table 2.1. Summary of Urban Mental Health Mechanisms

Category	
Design	Can have both positive and negative effect on mental health.
Density	Positive outcomes: walkability, connectivity, access to services and amenities Negative outcomes: overcrowding and traffic.
Nuisances	Increase with density but can be mitigated. Pollution and noise can have negative impact on mental health.
Greenness	Exposure to green space has positive associations on urban mental health.
Transport	Mixed. Commuting time may have a negative impact, active transportation and access have a positive impact.
Housing	High urban housing costs can lead to more crowing in low income areas. Architectural variation at neighborhood level and positive housing conditions can have a negative effect on mental health.

Chapter 3

RESEARCH DESIGN AND METHODS

3.1 Overall Research Design

The analysis utilized census-tract level data for the 500 largest cities in the United States[1]. Data were obtained from a variety of secondary sources that typically contain information for over 500 U.S. cities (e.g. The Center for Neighborhood Technology, ESRI Demographics, U.S. Census Bureau). The sample included information from all U.S. states, from New York, NY (2010 population: 8,175,133 to Burlington, VT (2010 population: 42,417). The objective of the study is to explore the relationship between urban form and mental health through a correlational analysis. Regression modelling was used to determine if and to what degree these variables are related.

3.2 Dependent Variable: Mental Health

The dependent variable in this analysis was self-reported mental health collected by the Center for Disease Control (CDC) via telephone survey using the Behavioral Risk Factor Surveillance System (BRFSS), which for many states, is the "only available source of timely, accurate data on health-related behaviors" (https://catalog.data.gov/dataset/cdc-behavioral-risk-factor-surveillance-system-brfss). The 500 Cities Project fills a critical need in health-related planning by making available data for both large cities as well as smaller areas within those cities.

[1] The 500 cities project included data from the 497 largest American cities and will includes data from the largest cities in Vermont (Burlington – population: 42,417), West Virginia (Charleston – population: 51,400) and Wyoming (Cheyenne – population: 59,466) to ensure inclusion of cities from all the states; bringing the total to 500 cities.

Participants were asked to state the number of days within the past 30 days that their mental health was not good. All information was collected through daily telephone surveys of adults age eighteen and over, and modeled to provide estimates of mental health at census tract and city levels. Measures of frequency included the annual prevalence, which was divided into crude and age-adjusted (standardized by the direct method to the year 2000 standard U.S. population with 95% confidence intervals) statistics. The age-adjusted measure, aggregated to city level was used in the analysis.

Table 3.1. Summary of Dependent Variable

Outcome Variable		Source
Mental Health	Age-adjusted prevalence, aggregated at city level	CDC 500 Cities Data https://www.cdc.gov/500cities/

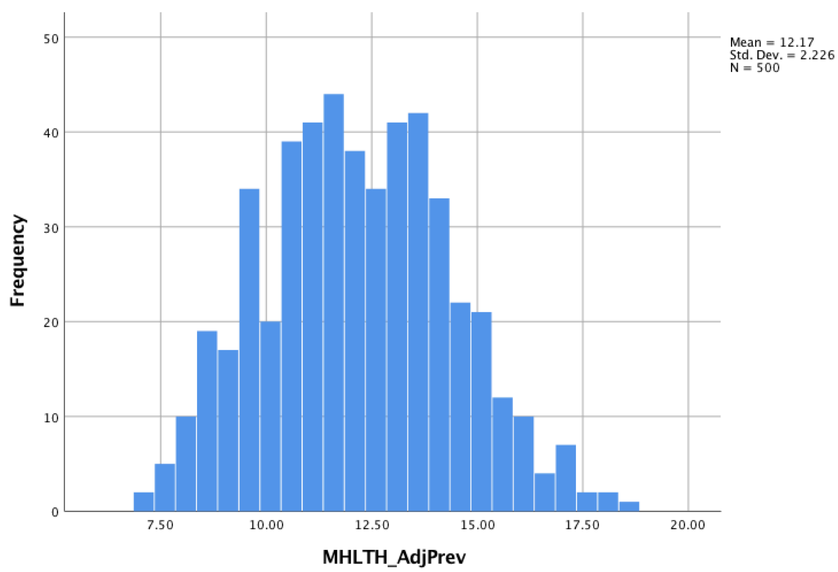

Figure 3.1. Distribution of Dependent Variable

As shown in Figure 3.1, the distribution of the dependent variable and is fairly normal and the assumption of normality is not a problem in the dataset.

3.3 Independent Variables

Several measures, including characteristics of the physical environment, socioeconomic, and diversity factors were aggregated at the city level. Urban form measures were separated into five categories: size, density, nuisances, transportation, and housing. Socioeconomic measures included housing and transportation costs, vehicle miles traveled, transit access, and employment access. The diversity measure included a single measure of racial diversity.

Urban form measures were collected from the Center for Neighborhood Technology's Housing and Transportation Affordability Index (H+T Index). This index was developed as a more complete measure of location affordability and includes several urban form characteristics in its model. The index was constructed at the Census block group level. Data sources and methods are described in the table below. For each variable, data obtained at the tract or block group level were aggregated to the city level, by identifying and summarizing tracts located within the census-defined city limits of the selected 500 cities. Demographic measures were also taken from the H+T index. To approximate income at the city level, the study included measures of housing and transportation expressed as a percentage of total income.

Table 3.2. Urban Form Variables

Indicator	Description
Housing Costs % Income for the Regional Typical Household	Derived from 2015 ACS. Median selected monthly owner costs for owners with a mortgage and median gross rent, averaged and weighted by the ratio of owner-to-renter occupied housing units from the tenure variable for every block group in a CBSA.
Transportation Costs % Income for the Regional Typical Household	Modeled based on three components of transportation behavior: auto ownership, auto use, and transit use.
Compact Neighborhood Score (0-10)	Independent variables: gross household density, regional household intensity,

	percentage of single family detached housing, percentage of rental housing, block density. Regression equation: autos per household.
Jobs Access Score (1-10)	Independent variables: employment gravity, employment mix index. Regression equation: autos per household.
Diversity Index (1-100)	Derived from ESRI Demographic Data. Shows the likelihood that two persons chosen at random from the same area belong to difference racial or ethnic groups.
Residential Density	Average number of households per residential acre for the Census blocks within the block group weighted by count of households. Total households obtained at the block level from the 2010 US Census and TIGER/Line files were used to define blocks.
Gross Household Density	Calculated from the 2013 ACS. Number of households in a census block group divided by the area of land within the block group.
Regional Household Intensity	Constructed using a gravity model which considers both the quantity of, and distance to, all households, relative to any given block group. Using an inverse-square law, intensity is calculated by summing the total number of household divided by the square of the distance to those households, but does not include the households within the block group. This quantity allows us to examine both the intensity of housing development in the region around the block group.
Percent Single Family Detached Households	Calculated using the 2013 ACS data by dividing the number of households living in single family detached housing by the total number of households in the Census block group.

Additional health control variables from the CDC comprised three categories: health outcomes, prevention measures, and unhealthy behaviors. The variables are summarized below (CDC 500 Cities Methodology).

Table 3.3. Health Variables

Health Outcomes	
Arthritis among adults aged≥18 years	Respondents aged ≥18 years who report having been told by a doctor, nurse, or other health professional that they had arthritis.
Current asthma prevalence among adults aged≥18 years	Weighted number of respondents who answer "yes" both to both of the following questions: "Have you ever been told by a doctor, nurse, or other health professional that you have asthma?" and the question "Do you still have asthma?"
High blood pressure among adults aged ≥18 years	Respondents aged ≥18 years who report ever having been told by a doctor, nurse, or other health professional that they have high blood pressure. Women who were told high blood pressure only during pregnancy and those who were told they had borderline hypertension were not included.
Cancer (excluding skin cancer) among adults aged ≥18 years	Respondents aged ≥18 years who report ever having been told by a doctor, nurse, or other health professional that they have any other types (besides skin) of cancer.
Chronic kidney disease among adults aged ≥18 years	Respondents aged ≥18 years who report ever having been told by a doctor, nurse, or other health professional that they have kidney disease.
Chronic obstructive pulmonary disease among adults aged ≥18 years	Respondents aged ≥18 years who report ever having been told by a doctor, nurse, or other health professional that they had chronic obstructive pulmonary disease (COPD), emphysema, or chronic bronchitis.
Coronary heart disease among adults aged ≥18 years	Respondents aged ≥18 years who report ever having been told by a doctor, nurse, or other health professional that they had angina or coronary heart disease.
Diagnosed diabetes among adults aged ≥18 years	Respondents aged ≥18 years who report ever been told by a doctor, nurse, or other health professional that they have diabetes other than diabetes during pregnancy.

Physical health not good for ≥14 days among adults aged ≥18 years	Respondents aged ≥18 years who report 14 or more days during the past 30 days during which their physical health was not good.
Prevention	
Visits to dentist or dental clinic among adults aged ≥18 years	Respondents aged ≥18 years who report having been to the dentist or dental clinic in the previous year.
Taking medicine for high blood pressure control among adults aged ≥18 years with high blood pressure	Respondents aged ≥18 years who report taking medicine for high blood pressure.
Cholesterol screening among adults aged ≥18 years	Respondents aged ≥18 years who report having their cholesterol checked within the previous 5 years.
Unhealthy Behaviors	
Current smoking among adults aged ≥18 years	Respondents aged ≥18 years who report having smoked ≥100 cigarettes in their lifetime and currently smoke every day or some days.
No leisure-time physical activity among adults aged ≥18 years	Respondents who answered "no" to the following question: "During the past month, other than your regular job, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?"
Obesity among adults aged ≥18 years	Respondents aged ≥18 years who have a body mass index (BMI) ≥30.0 kg/m^2 calculated from self-reported weight and height.
Sleeping less than 7 hours among adults aged ≥18 years	Respondents aged ≥18 years who report usually getting insufficient sleep (<7 hours for those aged ≥18 years, on average, during a 24-hour period)

Due to time and resource constraints, measures of greenness, noise, housing, and crime were omitted from the statistical analysis. Future studies should incorporate aggregated GIS measures of these factors to provide more reliable and valid findings.

In this study, two analytical methods are used. First, factor analysis is used to summarize health variables into a single component variable. Second, multiple multivariate linear regressions are used to predict mental health status, using the health component, socioeconomic variables, and built environment variables described above. A suite of models was examined, that included various combinations of variables to identify the best model for predicting mental health. The independent variables with no significant associations with the outcome variable, or those that would cause multicollinearity issues with weaker impact had been removed from the final model. Only the final models are presented here. The test set of models included (a.) a model containing only a factor summarizing the 26 health variables (b.) a model containing job access score, compact neighborhood score, housing costs, transportation costs, and diversity index and (c.) a model containing the health variables, job access score, compact neighborhood score, housing costs, transportation costs, and diversity index.

Chapter 4

RESULTS

Factor analysis was used to summarize health variables into a single variable using SPSS Statistics (IBM Corporation). Factor analysis is a data reduction technique that can reveal the true underlying structure of a set of related variables (Child 2006). Several assumptions must be met for a factor analysis to be valid. Samples must be randomly collected, and larger sample sizes tend to create more stable estimates. A key goal of factor analysis is to represent relationships among variables parsimoniously while keeping variables meaningful (Child 2006). Table 4.1 shows the total variance of all health variables.

Table 4.1. Total Variance of Health Indicators

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	9.419	72.452	72.452	9.419	72.452	72.452
2	1.322	10.171	82.623	1.322	10.171	82.623
3	.794	6.104	88.727			
4	.522	4.014	92.741			
5	.236	1.817	94.558			
6	.215	1.651	96.210			
7	.172	1.323	97.532			
8	.108	.830	98.362			
9	.074	.572	98.935			
10	.061	.472	99.407			
11	.041	.313	99.720			
12	.021	.159	99.879			
13	.016	.121	100.000			

Extraction Method: Principal Component Analysis.

Table 4.2. Component Matrix of Health Indicators

Component Matrix[a]

	Component 1	Component 2
ARTHRITIS_AdjPrev	.818	.510
BPHIGH_AdjPrev	.883	.126
BPMED_AdjPrev	.695	.382
CASTHMA_AdjPrev	.751	.385
CHD_AdjPrev	.951	-.016
COPD_AdjPrev	.922	.214
CSMOKING_AdjPrev	.872	.331
DENTAL_AdjPrev	-.855	.409
DIABETES_AdjPrev	.872	-.421
KIDNEY_AdjPrev	.730	-.295
LPA_AdjPrev	.877	-.347
OBESITY_AdjPrev	.905	.067
PHLTH_AdjPrev	.881	-.331
SLEEP_AdjPrev	.804	-.131
STROKE_AdjPrev	.948	-.070
TEETHLOST_AdjPrev	.942	.089

Extraction Method: Principal Component Analysis.

a. 2 components extracted.

A total of three models were performed in the final statistical analysis. Multilevel linear regression was performed to associations between city-level factors and self-rated mental health using SPSS Statistics (IBM Cooperation). Linear regression is a tool that allows planning researchers to predict the value of a single variable, known as the outcome or dependent variable, from a value of one or more other variables. There are many potential issues that can cause inefficiency or bias into a linear regression model (Allen 1997). One of these issues is multicollinearity which occurs when two or more independent variables are highly correlated with each other, causing inefficient estimates by affecting standard errors and t-values of the regression model. The results of each model are described below.

A total of three models were performed in the final statistical analysis. Multilevel linear regression was performed to test associations between city-level factors and self-rated mental health using SPSS Statistics (IBM Cooperation). Linear regression is a tool that allows planning researchers to predict the value of a single variable, known as the outcome or dependent variable, from a value of one or more other variables. There are many potential issues that can cause inefficiency or bias into a linear regression model (Allen 1997). One of these issues is multicollinearity which occurs when two or more independent variables are highly correlated with each other, causing inefficient estimates by affecting standard errors and t-values of the regression model. The results of each model are described below.

This first model predicts mental health with a single independent variable, health.

Table 4.3. Model 1

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.891[a]	.794	.794	1.011290974000 000

a. Predictors: (Constant), REGR factor score 1 for analysis 1

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1963.563	1	1963.563	1919.962	.000[b]
	Residual	509.309	498	1.023		
	Total	2472.872	499			

a. Dependent Variable: MHLTH_AdjPrev

b. Predictors: (Constant), Health

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	12.167	.045		269.016	.000		
	Health	1.984	.045	.891	43.817	.000	1.000	1.000

a. Dependent Variable: MHLTH_AdjPrev

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions (Constant)	Variance Proportions REGR factor score 1 for analysis 1
1	1	1.000	1.000	.50	.50
	2	1.000	1.000	.50	.50

a. Dependent Variable: MHLTH_AdjPrev

The final Model Summary table shows an R square value of 0.794, meaning that health variables, explain 82.6% of the variance in mental health the sample. The 'ANOVA' table shows an F statistic of 1919.962 at a significance level of < 0.001, meaning that the model as a whole is significant and that there is less than one chance in a thousand that our results are due to chance. The Coefficients table contains two important pieces of information: the estimated values for the parameters in the regression equation (shown as 'B'), and the significance of the independent variable (shown as 't' and a corresponding 'Sig.' level). Health has an estimated coefficient of 1.984; the positive sign indicates that as overall physical health in a city is associated with higher mental health status. This finding is logical and confirms earlier research.

The second model predicts mental health with independent variables (excluding health) that were significant and did not have multicollinearity issues.

Figure 4.4. Model 2

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.610[a]	.372	.366	1.772694597000000

a. Predictors: (Constant), Divers, emp_ovrll_ndx_C, h_ami_C, t_ami_C, compact_ndx_C

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	920.504	5	184.101	58.585	.000[b]
	Residual	1552.368	494	3.142		
	Total	2472.872	499			

a. Dependent Variable: MHLTH_AdjPrev

b. Predictors: (Constant), Divers, emp_ovrll_ndx_C, h_ami_C, t_ami_C, compact_ndx_C

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.694	1.174		2.295	.022		
	compact_ndx_C	.756	.091	.485	8.333	.000	.376	2.662
	emp_ovrll_ndx_C	.209	.054	.172	3.891	.000	.654	1.530
	h_ami_C	-.160	.014	-.460	-11.553	.000	.803	1.245
	t_ami_C	.348	.029	.678	12.139	.000	.408	2.453
	Divers	.018	.005	.130	3.415	.001	.872	1.146

a. Dependent Variable: MHLTH_AdjPrev

The Model Summary table shows an R square value of 0.372, meaning that racial diversity, housing costs, transportation costs, employment access, and neighborhood compactness explain 37.2% of the variance in mental health the sample. The 'ANOVA' table shows an F statistic of 58.525 at a significance level of < 0.001, meaning that the model as a whole is significant and that there is less than one in a thousand chance that our results are due to chance. The Coefficients table contains two important pieces of information: the estimated values for the parameters in the regression equation (shown as 'B'), and the significance of the independent variable (shown as 't' and a corresponding 'Sig.' level). Neighborhood compactness has an estimated coefficient of .756; the positive sign indicates that as compactness increases, psychological distress increases. This finding is logical and confirms earlier research. Both employment access and transportation costs were positively associated with poor mental health. Housing costs were slightly negatively associated with poor mental health, while racial diversity was very slightly positively associated.

The final model includes all values that were significant and did not have multicollinearity issues.

Table 4.5. Model 3

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.909[a]	.826	.824	.932971090000000

a. Predictors: (Constant), REGR factor score 1 for analysis 1, compact_ndx_C, Divers, emp_ovrll_ndx_C, h_ami_C, t_ami_C

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2043.748	6	340.625	391.327	.000[b]
	Residual	429.124	493	.870		
	Total	2472.872	499			

a. Dependent Variable: MHLTH_AdjPrev

b. Predictors: (Constant), Health, compact_ndx_C, Divers, emp_ovrll_ndx_C, h_ami_C, t_ami_C

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Toleran ce	VIF
' (Constant)	10.008	.651		15.384	.000		
compact_ndx_C	.144	.051	.092	2.838	.005	.333	3.001
emp_ovrll_ndx_C	-.088	.029	-.072	-2.981	.003	.602	1.660
h_ami_C	.044	.009	.127	4.796	.000	.499	2.004
t_ami_C	-.011	.018	-.022	-.619	.536	.283	3.530
Divers	.010	.003	.076	3.786	.000	.868	1.153
Health	2.240	.062	1.006	35.923	.000	.449	2.230

a. Dependent Variable: MHLTH_AdjPrev

The final Model Summary table shows an R square value of 0.826, meaning that demographic, built environment, socioeconomic, and health, explain 82.6% of the variance in mental health the sample. The 'ANOVA' table shows an F statistic of 381.962 at a significance level of < 0.001, meaning that the model as a whole is significant and that there is less than a one in a thousand chance that our results are due to chance. The Coefficients table contains two important pieces of information: the estimated values for the parameters in the regression equation (shown as 'B'), and the significance of the independent variable (shown as 't' and a corresponding 'Sig.' level). Health has an estimated coefficient of 2.240; the positive sign indicates that as overall physical health in a city is associated with higher mental health status. This finding is logical and confirms earlier research. Neighborhood compactness has an estimated coefficient of .144, meaning that density characteristics can have a negative effect on mental health. This finding is logical and confirms earlier research. While measures of housing cost and diversity were slightly negatively associated with mental health, measures of transportation cost and employment access were slightly positively associated.

Chapter 5

DISCUSSION

This study is among the first to investigate the relationship between urban form and psychological distress at the city level using one of the most valid and comprehensive metrics available nationally, the Center for Disease Control's 500 Cities index. Modeling revealed that of all urban form categories, density measures were the only significant factor influencing psychological distress. These findings are supported by several other studies (Weich et al. 2001, 2001; Berke et al. 2007; Saarlos et al. 2011) that demonstrate the ways that the built environment, specific components of urban density, contribute to psychological distress.

Weaker relationships were observed for the variables used to measure housing cost and diversity factors at the city level. Although both were positively associated with poor mental health, neither emerged as a significant predictor in the regression models. While the hypothesized link between urban form and poor mental health was confirmed, the absence of association for the other variables was unexpected. These results reflect previous research (Thomas et al. 2007) that suggest that psychosocial characteristics may be more influential to mental health than built environment attributes. Further research should examine the association between psychosocial factors, physical environment characteristics, and mental health in greater detail.

Many studies have shown the mental health benefits provided by urban form elements are linked to specific features of the built environment, such as housing characteristics (Weich et. al 2001; 2002) the presence of green space (Mass et. al 2009), land-use mix (Mass et. al 2009, Yang and Matthews 2010, Saarloos et al. 2011), walkability and neighborhood connectivity (Berke et al. 2007, Thomas et. al 2007, Yang and Matthews 2010), and the presence of environmentally hazardous sites (Yang and Matthews 2010, Downey & Van Willigen 2005). Perhaps density was not a sufficient proxy for the quality of the built environment. Future studies could attempt to quantify the quality of the built environment at city level using a more diverse set of indicators. Although some research highlights significant associations between built environment quality and mental health, they typically only consider one or a few variables in their analysis. An opportunity for further research is to use a factor analysis to examine the relationships between objective measurements of urban form and mental health at multiple scales.

A primary challenge of evidencing the relationship between the built environment and mental health and wellbeing is obtaining reliable mental health data at an appropriate population level to carry out an analysis. Most current research relies on self-reported health data or localized studies with small sample sizes. Reliable data on the presence of psychological distress is particularly difficult to find because clinical diagnoses are often imprecise or unrecorded. Therefore, it remains challenging to show how mental health is influencing the design of our cities over time and to reveal relationships to environmental attributes. As the global mental health challenge continues to rise, future research should consider the relationship between the urban environment and mental health through a longitudinal approach.

Several methodological challenges face research on urban form characteristics and mental health. One of the most critical challenges is the lack of objective measures of urban form qualities in relation to mental health state. An opportunity for planning researchers and practitioners is to develop a "mental health score" for urban environments. Similar indexes have been developed for walkability (Ewing & Handy 2009), transit access (Center for Neighborhood Technology 2016) and park quality (Trust for Public Land 2017). As smart location mapping and neighborhood efficiency become more integral to the planning practice (Environmental Protection Agency 2017), mental health characteristics should be added to these objective measures of urban form.

More understanding of the association between urban form characteristics is important for planning and public health as we aim to expose the benefits of specific characteristics in urban areas and apply these benefits as design and policy interventions. Successful policy initiatives should consider moderator effects when addressing mental health issues in urban areas. Research has shown that older persons (Brown et al. 2009, Saarlos et al. 2011), women (Evans et al. 2006) and low-income persons (Thomas et al 2007) may be more vulnerable to adverse psychological effects of urban form components. Such an understanding of the contextual factors shaping the relationship between urban form and mental health will be critical in addressing the global mental health challenge.

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