RELATIONSHIP BETWEEN THE BUILT ENVIRONMENT, PHYSICAL ACTIVITY, AND CHRONIC DISEASE AMONG INDIVIDUALS WITH DISABILITIES IN RURAL COMMUNITIES

by

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A thesis submitted in partial fulfillment of the requirements for the degree of

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ABSTRACT

Relationship Between the Built Environment, Physical Activity, and Chronic Disease Among Individuals with Disabilities in Rural Communities

by

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Chronic disease prevention is closely linked with physical activity. Unfortunately, most people do not meet the recommended amounts of exercise to secure the benefits. A significant determinant of individual propensity to engage in physical activity is the built environment. The purpose of this thesis is to quantify the complex relationship between physical activity and chronic disease prevalence, framed by the specific of the built environment. It is hypothesized that focusing specifically on the rural built environment and the population with disabilities will highlight potential disparities between these intricate variables.

The thesis spans two studies to explore the statistical relationship between incidences of chronic disease and rates of physical activity for the focal populations. Each study conducts independent-sample $t$ tests to evaluate the varying hypotheses and possible disparities that may exist as a result of the built environment.
Chapter 2 addresses the defined variables for select western states. Findings affirm the relationship between the built environment and physical activity. The rural population with disability has the lowest percentage of individuals achieving sufficient levels of both aerobic and muscle-strengthening exercises. The relationship between chronic disease prevalence, disability, and the built environment is statistically significant, albeit small. Further research should explore factors beyond the built environment that complicate the health of individuals with disability.

Chapter 3 examines the relation between physical activity and the built environment for varying disability classifications. Minimizing barriers to physical activity is a high priority due to its effectiveness at preventing the compounding health problems associated with obesity. Individuals with disability often face increased barriers to physical activity and often maintain a more sedentary lifestyle. It is hypothesized the impact of the rural built environment on physical activity may vary significantly between differing disability classifications.

The study found high statistical significance for the rural and urban physical activity comparison for individuals with disability resulting from physical, mental, or emotional impairments. The lack of significance for the three remaining objectives indicates a complex relationship between disability classifications and physical activity that cannot be explained through a single variable.
Relationship between the Built Environment, Physical Activity, and Chronic Disease Among Individuals with Disabilities in Rural Communities

Nicholas F. Tanner

Increased risk for chronic disease is closely associated with individual nutrition, tobacco use, and physical inactivity. This thesis focuses on physical activity as a means of preventing select chronic diseases. A major barrier preventing engagement in physical activity is the built environment. Populations residing in rural environments are not afforded the abundance of opportunities for physical activity prevalent in most urban networks. Of the demographic living in rural environments, individuals with disability face additional barriers to physical activity than those without disability. This leads to a higher prevalence of chronic diseases associated with sedentary lifestyles among populations with disability. Few studies address the correlation between physical activity, chronic disease, and the built environment as they relate to individuals with disability.

This thesis utilized independent samples $t$ tests to evaluate variation among physical activity levels and the prevalence of chronic disease. In the first paper, four research objectives defined the parameters for comparison: (1) physical activity for individuals with disability in rural versus urban environments; (2) physical activity in rural environments for individuals with and without disability; (3) prevalence of chronic disease for individuals with disability in rural versus urban areas; and (4) prevalence of chronic disease in rural environments for individuals with and without disability.
The four research objectives of the second paper are: (1) rural and urban physical activity comparison for the highest disability classification; (2) rural and urban physical activity comparison for individuals with disability using equipment; (3) rural and urban physical activity comparison for individuals with disability resulting from physical, mental, or emotional impairments; and (4) rural and urban physical activity comparison for individuals not reporting disability. The 2011 Behavioral Risk Factor Surveillance System (BRFSS) provided the data used to evaluate the correlation between these variables.

The results of both studies indicate important statistical significance relating the rural built environment to lower levels of physical activity for individuals with disability. The varied statistical significance and small effect sizes, however, were contrary to the hypothesis and warrants further exploration of the complex relationship regarding the built environment, physical activity, and chronic disease.
I would like to express immense gratitude to my committee, Dr. Keith Christensen, Dr. Shujuan Li, and Dr. Judith Holt. They have been patient throughout the several years it has taken me to complete this research. I fell trap to the misnomer that life after school would provide ample time for the research and writing I found difficult to schedule during my graduate coursework.

Each member of my committee responded to multiple requests for meetings, reading long-winded drafts, and signing the stacks of forms required throughout this process. In particular, I would like to thank my major professor, Dr. Keith Christensen, for going above and beyond to help me complete this thesis. He provided nudging encouragement and the ongoing deadlines I desperately needed to get to this point. Thanks, Keith, for guiding my ideas and interests early in the process, editing my many, many drafts, and answering my unending questions about running statistical operations.

Nicholas F. Tanner
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CHAPTER 1
INTRODUCTION

Many of the chronic diseases currently plaguing society can be prevented through targeted health behaviors, particularly physical activity (Owen, Salmon, Koohsari, Turrell, & Giles-Corti, 2014). Facets of the built environment are of particular importance due to their direct bearing on an individual’s propensity to engage in physical activity (Brownson, Hoehner, Day, Forsyth, & Sallis, 2009). Unfortunately, populations residing in rural environments are less likely to meet the recommended amounts of activity that aid in chronic disease prevention (Frost et al., 2010). Subsequently, persons within this demographic exhibit a higher diagnosis of chronic diseases, particularly those ailments correlated with sedentary lifestyles: hypertension, coronary heart disease, diabetes, obesity and depression (Sallis, Floyd, Rodríguez, & Saelens, 2012).

Within the rural population, individuals with disability face increased barriers to physical activity (Rimmer, Riley, Wang, Rauworth, & Jukowski, 2004). This thesis supposes that the impact of the rural built environment on physical activity and, by default chronic disease prevalence, is likely compounded for individuals with disabilities in rural communities. The presumed culprits limiting opportunities for physical activity are mobility constraints, a lacking precedent for universal design, and limited access to resources.

Many studies evaluate the relationship of the built environment to physical activity, yet few to none research and quantify the complex relationship between disability, exercise, chronic disease, and environment. This thesis explores the likely
correlation between chronic disease prevalence and rates of physical activity among individuals with disabilities in rural built environments.

**Health Status**

Health status is a measure of physical and mental well-being across a population. Many organizations seek to summarize health status in the U.S. as a means of prioritizing statewide, regional, and national health initiatives. Such efforts include renowned groups including the World Health Organization (WHO), Healthy People 2020 and the Behavioral Risk Factor Surveillance System (BRFSS). Each organization documents their findings and makes available the myriad public health initiatives aimed at improving and increasing awareness of diverse health trends, prevention, and management strategies (Centers for Disease Control and Prevention, n.d.; U.S. Department of Health and Human Services, 2011). The overarching intent of these efforts is to promote the creation of physical, and even social, environments that foster improved health behaviors; ultimately alleviating health care costs associated with preventable health issues (Vogeli et al., 2007).

The pervasiveness of chronic disease in a population is a leading factor monitored and summarized in reports of health status. Any increase in the recorded prevalence of chronic diseases for any demographic is significant reason for pause and study (Bauer, Briss, Goodman, & Bowman, 2014; Lorig et al., 1999; World Health Organization, 2012). Monitoring the frequency of diseases prioritizes health concerns, ultimately allowing for more targeted and effective prevention initiatives.

When analyzed against other high-income counties, key health indicators in the
U.S. are consistently lower, specifically examining reported rates of obesity, diabetes, heart disease, chronic lung disease, and disability (Bauer et al., 2014). According to the *Global Status Report on Noncommunicable Diseases*, chronic diseases—defined as cardiovascular, respiratory, cancer, and diabetes—killed 36 million people, comprising approximately two thirds of the worldwide death count in 2008 (World Health Organization, 2011). A study conducted in 2005 in the U.S. reported 63 million Americans exhibited multiple chronic diseases (Vogeli et al., 2007). More recently, estimates indicate upwards of 50.9% of adults in the U.S. have at least one chronic disease (Ward & Schiller, 2013).

The persistent climb of chronic disease throughout the U.S. is a major health concern as prevention methods are clearly documented by research. Risk for these diseases is strongly associated with tobacco use, poor diet, alcohol consumption, high blood pressure, hyperlipidaemia, and physical inactivity, (Farley, Dalal, Mostashari, & Frieden, 2010; Mokdad, Marks, Stroup, & Gerberding, 2004). While this list is not exhaustive of all the culprits that increase risk for chronic disease, it captures several essential behaviors which heighten individual susceptibility.

**Health Behavior**

Certain health behaviors have direct bearing on the prevention of many chronic diseases. This thesis pinpoints the role of physical activity in prevention. It is well documented that various forms of physical activity provide critical and effective methods in the prevention and management of these ailments (Bauer et al., 2014; Bunnell et al.,
Physical inactivity increases the risk of specific chronic diseases, namely: noninsulin-dependent diabetes, coronary heart disease, obesity, hypertension, colon cancer, osteoarthritis, osteoporosis, cardiovascular disease, cancer, and depression (Ewing, Schmid, Killingsworth, Zlot, & Raudenbush, 2003; Schoenborn & Stommel, 2011). Understanding why levels of physical activity are persistently low in the U.S. continues to be a high priority for many public health researchers (Frost et al., 2010). Determining and evaluating the primary obstacles to physical activity may be integral to improving American’s health in the upcoming decades.

In 1997, nearly 74% of adults in the U.S. did not meet the recommended amounts of physical activity—30 minutes of moderate-intensity activity, 5 days per week, or 20 minutes of vigorous-intensity activity, 3 days per week (Pratt, Macera, & Blanton, 1999; CDC, 2008). According to other researchers, the percentage of adults reaching the recommended amount of physical activity progressed minimally between 1998 and 2008 (Carlson, Fulton, Schoenborn, & Loustalot, 2010).

Current standards, dictated by the 2008 Physical Activity Guidelines for Americans, define the recommended level of physical activity as 150 minutes of moderate-intense activity per week, or 75 minutes of vigorous-intense activity per week (CDC, 2008). While these numbers are seemingly daunting, research suggests that even small, consistent amounts of physical activity can reduce the risk of specific chronic diseases (Lee et al., 2012; National Research Council, 2005; Schoenborn & Stommel,
That said, further research is needed to better address the precise barriers preventing Americans from meeting the recommended amounts of physical activity (Gray, Zimmerman, & Rimmer, 2012).

**Built Environment**

The built environment is a known factor that promotes or hinders physical activity (Day & Cardinal, 2007; Sallis et al., 2009) and is dependent on community planning efforts at the professional and public level. The built environment referenced here includes land use patterns and planning, transportation systems, designated recreation areas, and accessibility to community amenities.

Due to the strong correlation with health, efforts to reduce problems compounded by sedentary lifestyles have shifted focus to the built environment and locations where populations exhibit low health statuses (Hodgson, 2011; Reynolds et al., 2007). Understanding the components of the built environment that encourage physical activity may positively impact the health status of U.S. adults (Bunnell et al., 2012; King & Clarke 2014).

Heath et al. (2006) identified 13 cross-sectional studies published between 1993-2003, each crediting the benefit of community-scale design—as well as land use policies and practices—to increase physical activity. Diverse housing types, mixed land use, housing density, access to open space, the connectivity and continuity of sidewalks, and components of the street-scale aid the promotion of physical activity in a community (Durand, Andalib, Dunton, Wolch, & Pentz, 2011; Heath et al., 2006; McCormack,
Additional factors of the built environment which promote engagement in physical activity are convenient recreational environments, neighborhood environmental quality, aesthetics, vegetation, trail type and characteristics, the proportion of green space, perception of safety, and the overall impression of activity-friendliness of the neighborhood (Handy, Boarnet, Ewing, & Killingsworth, 2002; Hoehner, Ivy, Brennan-Ramirez, Handy, & Brownson, 2007). With these elements in mind, the quality of available amenities in the built environment should not be understated and has consequential impact on one’s personal disposition to be physically active.

**Rural Built Environment**

Urban and rural communities characterize the extreme locations of the built environment in the U.S. Each setting provides varying degrees and qualities of the amenities described in the previous section. Of particular significance are findings that physical inactivity is frequently higher in rural populations (Frost et al., 2010; Parks, Housemann, & Brownson, 2003; Wilcox, Castro, King, Housemann, & Brownson, 2000), thus supporting the reality of location dependent impediments to physical activity.

Environmental factors which lessen individual likelihood to be physically active in rural America include limited access to safe, walkable areas, recreation facilities, and parks (Barnidge et al., 2013; Lutfiyya, Chang, & Lipsky, 2012; Parks, Housemann, & Brownson, 2003). Additionally, rural areas often have limited monetary resources available from local and state funds to promote the development of public amenities to
encourage physical activity (Frost et al., 2010; Hodgson, 2011).

Despite these known issues, limited research focuses on the relationship between the rural environment and chronic disease prevalence (Kegler, Swan, Alcantara, Feldman, & Glanz, 2014). Significant variation between urban and rural communities limits the applicability of existing research conducted in urban environments (Casey et al., 2008; Frost et al., 2010). Research that quantifies chronic disease prevalence and physical activity levels by distinct environmental typologies would provide insight into the particular impact brought about by the built environment.

**Individuals with Disabilities**

Existing literature focuses on the built environment generally, providing a holistic representation of these communities (Lishner, Levine, & Patrick, 1996). This excludes unique challenges faced by smaller demographics within larger population. Supporting research suggests that the built environment does impact physical activity differently across demographic subgroups (Kremmers et al., 2006).

Individuals with disability represent one such group that is disproportionally affected by location (Quintas et al., 2014). While individuals with disabilities represent a significant 18.7% (56.7 million) of the total U.S. population (Brault, 2012), few studies target the impact of the built environment on their levels of physical activity (Gray et al., 2012; Rimmer et al., 2004). This realization highlights the need for demographic specific research to better understand the issues surrounding physical activity.

Pertinent research regarding this topic suggests that the prevailing impediments to
physical activity include inaccessibility to recreation programs and fitness facilities (Rimmer et al., 2004; Rimmer, Riley, Wang, Rauworth, 2005), environmental supports (Spivok, Gauvin, Brodeur, 2007, 2008), and community mobility (Shumway-Cook et al., 2002). Persons with disability, and others exhibiting similar impairment conditions such as the elderly and obese, are most often the least active groups in a given population (Haskell, Blair, & Hill, 2009).

One study concluded that individuals with disabilities’ engagement in leisure-time activity range from as low as 8% to as high as 36% depending on demographics (Rimmer, 1999). Conversely, a sample population of individuals without a disability indicates that 56% of this group participates in leisure-time physical activity (Rimmer et al., 2004). Increased obstacles for persons with disability continue to foster sedentary behavior. This escalates susceptibility to chronic disease and quickens the onset of secondary health conditions (Dannenberg et al., 2003; Rimmer, 1999).

It is assumed that individuals with disability in rural environments have the greatest barriers to physical activity and exhibit the highest rates of chronic disease. This hypothesis highlights the need to examine and substantiate the problematic relationship between chronic disease, physical activity, built environments, and disability.

Barriers to physical activity resulting from inaccessibility disproportionately affect individuals with disabilities when compared to individuals without disabilities (Spivok et al., 2008).Disconnected pedestrian ways, insufficient signage, and coarse pathway textures introduce additional impediments that negatively influence universal access for persons with disability (Spivok et al., 2007). Furthermore, individuals with disabilities
are more likely to encounter mental barriers to physical activity (Spivok et al., 2008), that are only further heightened by the physical barriers constructed in the built environment.

Decreased opportunities for physical activity compound the tendency among individuals with disability to succumb to sedentary lifestyles, thus partially contributing to a widespread persistence of chronic disease among this demographic (Agency for Healthcare Research and Quality, 2007; Rimmer et al., 2004). To effectively target rural planning policies, professionals need detailed information to understand the impediments of the built environments on activity levels for this population (Christensen, Holt, & Wilson, 2010; Crews & Zavotka, 2006).

Each research element addressed and defined above filters the broad issues at hand. This thesis addresses the specific relationship between chronic disease prevalence and physical activity for individuals with disability in the rural built environment of the West. Subsequent chapters delve into specific topics that contribute to a clearer understanding of the topic.

Chapter 2 examines this complicated relationship utilizing survey data reported by individuals from Arizona, Nevada, Oregon, Utah, and Washington. Chapter 3 furthers this research and pinpoints the correlation between physical activity and the built environment by classifying levels of disability. The final chapter provides a culminating summary of the results for each chapter and briefly delves into the professional application to landscape architecture and the need for interdisciplinary efforts among design, planning, and health fields to resolve public health crises.
References


Heath, G. W., Brownson, R. C., Kruger, J., Miler, R., Powell, K. E., & Ramsey, L. T. (2006). The effectiveness of urban design and land use and transport policies and practices to increase physical activity: a systematic review. *Journal of Physical Activity and Health, 3*(1), s55-s76.


CHAPTER 2

THE RELATIONSHIP BETWEEN THE BUILT ENVIRONMENT, PHYSICAL ACTIVITY, AND CHRONIC DISEASE AMONG INDIVIDUALS WITH DISABILITIES IN RURAL COMMUNITIES IN THE WESTERN UNITED STATES

Abstract

**Background:** The impact of the built environment on physical activity and incidence of chronic disease for persons residing in rural communities with a disability are not well understood.

**Objective:** Four research objectives defined the parameters of the study: (1) physical activity for individuals with disability in rural versus urban environments; (2) physical activity in rural environments for individuals with and without disability; (3) prevalence of chronic disease for individuals with disability in rural versus urban areas; and (4) prevalence of chronic disease in rural environments for individuals with and without disability.

**Methods:** Data sets derive from the 2010 Rural-Urban Commuting Area codes (RUCAs) and the 2011 Centers for Disease Control and Prevention’s (CDC) Behavioral Risk Factor Surveillance System (BRFSS). Data analysis correlates with the 2011 BRFSS respondents in specific Western states. Independent $t$ tests assessed the statistical significance of the variables in this study.

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1 Chapter 2 was coauthored by Nicholas Tanner and Keith Christensen for submission to *Disability and Health Journal.*
**Results**: The results indicate high significance for research objectives 1, 2 and 4. Although objective 3 is not statistically significant the percentage of those in rural locations with two or more chronic diseases is higher than urban respondents.

**Conclusions**: The results confirm that features of the built environment have bearing on an individual’s propensity to engage in physical activity with rural populations with disability being the least likely to meet the recommended amounts of exercise and some bearing on increased risk for hypertension, diabetes, and obesity. Further research should explore additional components of the rural environment that complicate the health status of individuals with disability.

**Introduction**

*Health Status*

The public health conversation regarding the global disease burden continues to shift its rhetoric from communicable to non-communicable diseases. The annual rise of individuals exhibiting at least one non-communicable, chronic disease is indicative of a severe health epidemic.\textsuperscript{1-3} In 2008 alone, chronic diseases accounted for two-thirds (36 million) of the worldwide death count\textsuperscript{4} and pose the greatest undisputable threat to global health status. These statistics further confirm the unprecedented demand on health care caused by chronic diseases.\textsuperscript{5,6}

In 2006 approximately half of the non-institutionalized population with one or more chronic disease accounted for 84% of the total health care expenses in the U.S.\textsuperscript{7} Despite relatively high access to health care, the current U.S. health status ranks consistently low in comparison to other high-income countries; particularly in regards to
obesity, diabetes, heart disease, chronic lung disease, and disability. 

Reports indicate that from 2001 to 2010 health care professionals recorded a 26% increase in the number of persons exhibiting two or more chronic diseases in the U.S. The growth of this trend adds another layer of complexity when tackling intervention and prevention strategies.

Although the high prevalence of chronic diseases persists in the U.S., research indicates an acute public awareness of prevailing causes and effective prevention methods. The leading behaviors highly associated with developing chronic diseases are tobacco use, poor diet, physical inactivity, alcohol consumption, high blood pressure, and hyperlipidaemia. While this list is not exhaustive of all factors that contribute to an increased risk for chronic disease, it categorizes research efforts and aids in determining the effectiveness of intervention strategies. The specific scope of this study revolves around the influence of physical inactivity on the prevalence of chronic diseases.

**Health Behavior**

As a dominant cause of chronic disease, consistently low levels of physical activity in the U.S. remain at the forefront of public health initiatives. Physical inactivity increases individual risk for multiple chronic diseases, specifically: non-insulin-dependent diabetes, coronary heart disease, obesity, hypertension, colon cancer, osteoarthritis, osteoporosis, cardiovascular disease, cancer, and depression. There is an undisputable correlation between physical inactivity and poor health.

Regular physical activity is an effective means of chronic disease prevention, particularly when an individual meets the prescribed standard for physical activity. However, even in moderate amounts, physical activity can help prevent certain chronic
Despite scientific affirmation regarding the critical benefits of physical activity, estimates suggest upwards of 74% of adults in the U.S. do not meet the recommended levels.\textsuperscript{24,25} 

Despite knowing the benefits, the general populous still encounters mental and physical barriers to regular participation in physical activity. Research on effective and targeted physical activity interventions that encourage compliance to a physically active lifestyle is urgently needed.\textsuperscript{26,27} Targeting region specific exercise patterns, as opposed to national statistics, may yield clues regarding successful promotion of physical activity.

\textit{Health Behavior in the Western U.S.}

Figure 2-1 depicts county-level rates of physical inactivity in the U.S. The southern region of the U.S. appears to have the highest concentration of physical inactivity, while the western states display the highest rates of activity. This supports the notion that regional differences—cultural, environmental, or otherwise—contribute to varying levels of physical activity throughout the U.S. Another study affirms regional disparities and concluded that 32% of adults in the South report no leisure time physical activity; whereas, only 22% of adults in the West report no physical activity.\textsuperscript{28}

A CDC publication titled \textit{State Indicator Report on Physical Activity} provides more concrete numbers regarding physical activity levels at the state level.\textsuperscript{29} In that study the CDC reported three levels of physical activity as summarized in Table 2-1. Comparing the regional findings, the western states consistently report significantly higher rates of activity and lower rates of inactivity than other portion of the country.

### Table 2-1

**Regional Estimates of Physical Activity, 2010**

<table>
<thead>
<tr>
<th>Region</th>
<th>Active</th>
<th>Highly active</th>
<th>No leisure-time physical activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>West&lt;sup&gt;a&lt;/sup&gt;</td>
<td>69.4</td>
<td>48.6</td>
<td>22.40</td>
</tr>
<tr>
<td>South&lt;sup&gt;b&lt;/sup&gt;</td>
<td>60.9</td>
<td>40.4</td>
<td>27.16</td>
</tr>
<tr>
<td>Midwest&lt;sup&gt;c&lt;/sup&gt;</td>
<td>64.5</td>
<td>40.2</td>
<td>26.10</td>
</tr>
<tr>
<td>Northeast&lt;sup&gt;d&lt;/sup&gt;</td>
<td>66.3</td>
<td>44.9</td>
<td>23.80</td>
</tr>
</tbody>
</table>

*Note. Information summarized from the information in the CDC’s State Indicator on Physical Activity, 2010.*

<sup>a</sup> Includes the following states: Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, Utah, Washington, Wyoming.

<sup>b</sup> Includes the following states: Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, Tennessee, Texas, South Carolina.

<sup>c</sup> Includes the following states: Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, Wisconsin, West Virginia, South Dakota.

<sup>d</sup> Includes the following states: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia.
Research that concentrates on the western U.S. may clarify the confounding effects of regional inhibitors and promoters of physical activity. In addition, such analyses may discover an effective means of encouraging physical activity in other regions of the country where specific practices, planning efforts, or accessibility-minded development may not be implemented.

**Built Environment**

The built environment is known to promote and hinder physical activity. The built environment most commonly includes land use patterns, transportation systems, designated recreation areas, community scale, and accessibility. Distinct patterns in the built environment may provide the necessary context to explain regional fluctuations in physical activity. More in-depth evaluations concerning the intricate role of the environment toward physical activity became a priority in the last two decades, with public health initiatives endorsing environmental and policy changes. Many of these discussions and research topics stem from professionals in the field of planning and architecture.

Research demonstrates that the provision of connected walkways, mixed-use development, and a human-scaled environment increases unstructured physical exercise, while low-density development lends itself to automobile dependency and adverse health outcomes. These low-density, sprawling developments have been related to a higher prevalence of chronic diseases, particularly those attached to the confounding impacts of obesity. In contrast, evaluations of neighborhoods with high walkability yield a demographic exhibiting increased exercise levels with decreased rates of obesity and its
associated chronic diseases.\textsuperscript{33,35}

More recent findings further provide a positive correlation between access to recreational opportunities and activity behaviors in adults.\textsuperscript{16,36,37} Such conclusions indicate proximity and continuity as major components for motivating personal engagement in physical activity. Hypertension, heart disease, mental wellbeing, diabetes, and obesity are key health indicators with significant correlations to both physical activity and the built environment.\textsuperscript{3,22}

The built environment provides a platform for understanding one of the hurdles to increased physical activity in the U.S. Interdisciplinary collaboration between health and design professionals could provide the catalyst from both areas of expertise to reduce this barrier to physical activity. However, rather than specifying individual obstacles, this paper maintains a holistic approach to determining the statistical correlation of the built environment to physical activity. This paper maintains a general survey of the built environment by comparing urban and rural built environments in the western U.S.

\textit{Rural Built Environment}

Urban and rural communities characterize the extremes of the built environment. The degree of urbanization is one of several factors impacting physical activity with research suggesting higher reports of inactivity for populations in rural areas.\textsuperscript{11,38,39} Nationally, the potential of being physically inactive is 43.1\% more likely in the most rural locations than the most urban communities.\textsuperscript{28} This factor, linked to the built environment, is indicative of unique challenges exhibited by the rural demographic. Admittedly, additional factors including varied climates and seasons, socioeconomic
status, and minority groups are common confounding variables for physical activity. However, the focus on a rural population in this research provides a contrast to the urban areas more often documented.

**Individuals with Disability**

The built environment impacts physical activity differently across demographic subgroups. Individuals with disability represent one such group disproportionately affected by the built environment. While individuals with disabilities represent a significant 18.7% (56.7 million) of the total U.S. population, few studies target or synthesize the impact of the built environment on physical activity for these individuals in rural localities.

Persons with disability, and others exhibiting similar impairment conditions such as the elderly and obese, are the least active group regardless of location. Barriers to physical activity from poor accessibility disproportionally affect individuals with disabilities.Disconnected pedestrian trails, inadequate signage, and uneven pathway textures create additional obstacles that negate the goal of providing universal access. Furthermore, individuals with disabilities are more likely to encounter mental barriers to physical activity. Decreased opportunities for physical activity and increased barriers further a sedentary lifestyle, contributing to the rampant increase and persistence of chronic diseases among individuals with disability.

It is assumed that individuals with disability in rural environments have the most barriers to physical activity and will exhibit the highest rates of chronic disease. To evaluate these disparities there is a need for an improved understanding of the link
between the built environment, physical activity, and chronic disease prevalence. This paper evaluates the multifaceted impact of rural versus urban dwelling and disability status by comparing physical activity levels and chronic disease diagnoses among these populations in the western U.S.

**Methods**

*Design*

The purpose of this study is to examine contrasting built environments and establish the relationship between physical activity and the prevalence of chronic diseases among individuals with disabilities. The specific research objectives are to: (1) compare levels of physical activity for individuals with disabilities residing in rural and urban built environments, (2) compare the physical activity of individuals with disabilities to those without disabilities in the rural environment, (3) compare prevalence of chronic diseases for individuals with disability living in rural versus urban areas, and (4) compare the prevalence of chronic diseases among individuals with and without disability in rural areas.

This observational study is both cross-sectional and ecologic. It is cross-sectional in regards to the fact that the research utilizes previously gathered and recorded data without manipulating the study environment for a specific point in time. The study is also ecologic because the units of analysis are focused on populations and place, not individuals. The method of analysis is comparable to a reputable study conducted by the Center for Smart Growth, which examined the relationship between urban sprawl, health,
and specific health-related behaviors.12

Data sets informing the analysis derive from the 2010 Rural-Urban Commuting Area codes (RUCAs) and the 2011 Centers for Disease Control and Prevention’s (CDC) Behavioral Risk Factor Surveillance System (BRFSS). Geospatial analysis utilizes zip code tabulation areas from the 2010 U.S. Census. The study also includes individuals without disabilities as a comparison population for both physical activity levels and chronic disease prevalence. Data analysis correlates geographically with the 2011 BRFSS respondents in Arizona, Nevada, Oregon, Utah, and Washington.

**Measures**

**Rural and urban**

Several of the most commonly used parameters for defining rural environments do not sufficiently provide the level of accuracy needed for this study. For example, the U.S. Census and Office of Management and Budget (OMB) both measure rural by determining what is urban. The geographic regions that are not classified as urban, by default, are rural. This focus on urban characteristics overlooks many rural communities within Census-designated urban areas or counties classified by the OMB as metropolitan. Consequently, a collaborative definition is more often used to define rural communities for research. The organizations providing this detailed classification of the built environment are the Health Resources and Service Administration’s Office of Rural Health Policy, the Washington/Wyoming/Alaska/Montana/Idaho (WWAMI) Rural Research Center, and the U.S. Department of Agriculture’s Economic Research Service (ERS) is the basis for defining the rural and urban parameters of this study. These
agencies developed RUCAs to classify subcounty areas. The categorization of counties represents additional measures of urbanization, population density, and daily commuting totals. The Federal Office of Rural Health Policy acknowledges RUCA methodology as a credible means in classifying urban and rural locations.\textsuperscript{53}

RUCA classifications utilize tracts from the U.S. Census to separate urban and rural areas at the subcounty scale. Metropolitan and micropolitan terminology from the OMB are the labels used to identify RUCA codes with the corresponding zip codes. Only BRFSS respondents that disclosed a zip code are included in the study population so as to geographically represent the findings. This demarcation of BRFSS responses makes the rural and urban comparison possible.

The RUCA classification codes include many levels of urbanization that are beyond the scope of this study (see Appendix A). As such, several RUCA classifications combine to appropriately represent the rural and urban measures used to categorize the 2011 BRFSS respondents. The rural built environment is defined using the RUCA codes for small town core (7.0, 7.1, 7.2) small town high commuting (8.0, 8.1, 8.2), small town low commuting (9.0), and rural areas (10.0, 10.1, 10.2, 10.3).

The RUCA codes used to define the urban environment are the metropolitan area core (1.0, 1.1) and metropolitan area high commuting (2.0, 2.1). A defined urban area is a critical component of this study because it serves as a comparison between built environments. Comparing areas classified as highly urban with the most rural mitigates the potential overlap of suburban environments which may exhibit qualities of both rural and urban communities.
Health behavior

Physical activity is the preventative aspect of health behavior examined in this study. The 2011 BRFSS defines physical activity as exercise or leisure-time recreation which occurs outside regular job duties. The BRFSS section regarding health behavior provides respondents with two opportunities to describe physical activities, first asking: “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?” Respondents then report the activity, frequency (times/week or times/month) and duration (hours and minutes) of the activity.

The 2008 Physical Activity Guidelines for Americans is the most widely accepted standard for determining appropriate levels of physical activity. These guidelines define the adult recommended level of physical activity as 150 minutes of moderate-intensity activity per week, or 75 minutes of vigorous-intensity activity per week. Additionally, adults should participate in two or more days a week of moderate to high intensity muscle-strengthening activities that involve all major muscle groups.

Reported frequency and duration, as well as the calculated intensity of each reported activity, determine if an individual meets the 2008 physical activity guidelines. The 2011 BRFSS Questionnaire assesses frequency (“How many times per week or per month did you take part in this activity during the past month?”) and duration (“And when you took part in this activity, for how many minutes did you usually keep at it?”) of the reported activity. The method to determine intensity comes from A Data User’s Guide to the BRFSS Physical Activity Questions: How to Assess the 2008 Physical
Activity Guidelines for Americans and is outlined in four steps below.  

- Step 1: Maximal oxygen uptake (VO₂max) helps determine the body’s capacity to use and transport oxygen during maximum exertion. Metabolic equivalents (METs) measure the rate of energy expenditure while at rest and are frequently used to determine physical activity intensity. The following formulas determine VO₂max (expressed in METs):
  
  **Men**
  
  \[
  \text{Estimated VO}_2\text{max (METs)} = \frac{60-0.55 \times \text{age in years}}{3.5}
  \]
  
  **Women**
  
  \[
  \text{Estimated VO}_2\text{max (METs)} = \frac{48-0.37 \times \text{age in years}}{3.5}
  \]
  
- Step 2: The minimum intensity for a physical activity to be vigorous is 60% of VO₂max, or 6 METs; the values required for moderate intensity physical activities is 30% of VO₂max, or 3 METs (U.S. Department of Health and Human Services, 1996).

- Step 3: Compare the MET values for each reported activity to the respondents’ MET values found in step 2, see MET value table in Appendix B. Determine if the MET values for each physical activity meet the moderate or vigorous intensity MET values for each respondent. Some activities—pilates, tai chi, weight lifting, and yoga—are not considered aerobic or are low-intensity activities (values less than 3 METs).

- Step 4: Combine the information on frequency, duration, and intensity. This will determine time spent per week in moderate and vigorous-intensity physical activities for each respondent.

To determine the physical activity level for muscle-strengthening, the following question is used in the 2011 BRFSS: “During the past month, how many times per week or per month did you do physical activities or exercise to STRENGTHEN your muscles? Do NOT count aerobic activities like walking, running, or bicycling. Count activities using your own body weight like yoga, sit-ups or push-ups and those using weight
machines, free weights, or elastic bands.” If the individual can report at least two times per week, he or she meets the requirement for muscle-strengthening.

Upon calculating the reported physical activity, respondents are classified into six levels of physical activity using the data from the 2011 BRFSS Questionnaire and the 2008 Physical Activity Guidelines.55,56

1. Inactive
2. Insufficiently active
3. Active
4. Highly active
5. Meets muscle-strengthening guidelines
6. Meets aerobic and muscle-strengthening guidelines

For ease of ranking survey participant responses and to provide more accurate statistical analysis, this study further classified the physical activity levels. The new levels used in this research areas outlined below:

1. Inactive; insufficiently active
2. Active
3. Highly active
4. Meets aerobic (active or highly active) and muscle strengthening guidelines

Health status

Chronic diseases are central to understanding the health status focus of this study due to their known relation to physical inactivity.3,15-19 In correspondence to the chronic diseases documented in the 2011 BRFSS Questionnaire, the following health measures are used: two weight-related measures (body mass index (BMI) and obesity), hypertension, diabetes, coronary heart disease (CHD), and mental wellbeing (depression, major depression, dysthymia, or minor depression).

The BRFSS questions: “About how much do you weigh without shoes?” and
“About how tall are you without shoes?” provide the necessary numbers for BMI calculations and determining obesity. BMI is calculated by weight in kilograms divided by height in meters squared. As weight and height obtained in the BRFSS is self-reported, overweight participants often underestimate their weight, while all participants tend to overestimate their height. Consequently, obesity percentages from this study may be lower than research that measures height and weight in person. The BMI number for each respondent is ranked to define obesity through standard measures as follows:

- **a. BMI is >= 40** Morbidly obese
- **b. BMI is >= 30 < Obese**
- **c. BMI is >= 25 < 30** Overweight
- **d. BMI is >= < 25** Idea weight
- **e. BMI is < 19** Underweight

Hypertension, diabetes, and coronary heart disease are recorded if the respondent answers in the affirmative to the question: “Has a doctor, nurse, or other health profession EVER told you that you had *(chronic disease)*?” For hypertension and diabetes, the responses are categorized by the following measures: 1=Yes, 2=Borderline, or 3=No. The responses to questions regarding coronary heart disease and mental wellbeing are ranked as 1=Yes and 2=No.

**Disability**

Disability status for this study was determined by a ‘yes’ response to at least one of the following BRFSS core questions: “Are you limited in any activities because of physical, mental, or emotional problems?” or “Do you now have any health problem that requires you to use special equipment, such as a cane, a wheelchair, a special bed, or a special telephone?” This designation for disability follows the guidelines found in
Sample

The sample population includes select participants of the 2011 BRFSS who reside in the western states of Arizona, Nevada, Oregon, Utah, and Washington and are between 18-64 years of age. Adjusting the sample to exclude the elderly reduces the confounding effects of health conditions associated with advanced age. While the investigation explores the impact of the rural built environment on individuals with disabilities specifically, samples from other demographics and built environments are also quantified to provide the basis for comparison. For example, individuals without disabilities living in both rural and urban areas are included in the data set. Similarly, persons with disabilities living in the urban-defined regions provide additional insight regarding a similar population residing in a contrasting built environment.

Analysis

The purpose of this study is to quantify the health status of the population with disabilities, compare reported levels of physical activity, and analyze the likely correlation of the built environment on the aforementioned factors. The exact research objectives are fourfold.

1. Compare levels of physical activity for individuals with disabilities residing in the rural or urban built environments,

2. Compare the physical activity of individuals with disabilities to those without disabilities in the rural built environment,

3. Compare the prevalence of chronic diseases for individuals with disability living in rural versus urban environments, and
4. Compare the prevalence of chronic diseases among individuals with and without disability in rural areas.

This study conducts independent-samples $t$ tests to compare the health status between individuals with and without disabilities to determine the disparities that may result from the conditions of the rural environment. Disability status and the rural or urban environment are the two grouping variables used to organize the four research objectives. The test variable compares the health element (physical activity levels and the prevalence of chronic diseases) for each grouping variable.

The independent-samples $t$ test accounts for variances in population size. This is particularly relevant due to the study’s focus on regions with drastically different population counts and that individuals with disability represent a minority group. The moderate to large size of each sample group increases the $p$ value validity as it accounts for both the normal and non-normal distributions in the sample. The resulting statistical correlation of the independent-samples $t$ tests, combined with the existing body of knowledge, assist in identifying likely disparities between health behavior and status for the sample population.

Additionally, descriptive frequencies of the data provide further insight into differences for persons with disabilities in the rural communities. These frequencies help explain and clarify the results of the independent-samples $t$ tests. Characteristics of key demographics, scrutiny of the data parameters, and summary percentages for substantiated factors are among the descriptive frequencies explored.
Results

For Arizona, Nevada, Oregon, Utah, and Washington, the 2011 BRFSS interviewed 37,850 by landline and 6,070 by cell phone. Including partially completed surveys, the average response rate across these states is 72.67%; dropping to a 44.67% response rate for complete interviews. Excluding individuals over the age of 64 for this study, the population sample draws from an extensive 33,801 responses. The rural base sample comprises 11.4% \( (n = 3,848) \) of that total, while the urban population constitutes 72.9% \( (n = 24,630) \), see Figure 2-2. Surveyed individuals with disability in these states total 8,932 (26.4%); while those without a disability amount to 24,869 (73.6%) of the sample.
Objective 1: Physical activity for individuals with disability in rural versus urban built environments.

An independent samples $t$ test was conducted to evaluate the hypothesis that physical activity levels for individuals with disabilities are lower in rural built environments than the urban comparison. The test was significant, $t(1617.382) = -2.696$, $p = 0.007$, and supports the research hypothesis. Findings support the notion that individuals with disabilities in rural environments engaged in less physical activity ($M = 1.92$, $SD = 1.149$) on average than those residing in urban locations ($M = 2.02$, $SD = 1.149$).
The 95% confidence interval for the difference in means has a range from -0.173 to -0.027. Although the independent sample t test is significant, the effect size ($d = 0.1$) suggests that the difference between rural and urban environment can only account for a small portion of the variation in physical activity.

**Objective 2:** Physical activity in rural environments for individuals with and without disability.

An independent-samples t test was conducted to evaluate the hypothesis that physical activity levels for individuals with a disability are lower than individuals without a disability in rural environments. The test was significant, $t(2243.968) = -6.039$, $p=0.000$, and the results confirm the research hypothesis. Individuals with disabilities in rural environments engaged in less physical activity ($M = 1.92, SD = 1.149$) on average than those without a disability residing in similar locations ($M = 2.17, SD = 1.2$). The 95% confidence interval for the difference in means ranges from -0.329 to -0.167. As with the findings of objective 1, the effect size ($d = 0.2$) suggests that the difference between physical activity levels accounts for a small amount of the physical activity discrepancy.

**Objective 3:** Chronic disease prevalence for individuals with disability in rural versus urban built environments.

An independent-samples t test was conducted to evaluate the hypothesis that chronic disease prevalence is higher among individuals with a disability in the rural environment than the comparable demographic in an urban setting. The independent samples t tests for hypertension ($t(1361.327) = -1.399, p = 0.162$), coronary heart disease
mental wellbeing \((t(1592.398) = 1.901, p = 0.057)\), diabetes \((t(7336) = -0.265, p = 0.059)\), and obesity \((t(7136) = -0.746, p = 0.456)\) were not significant. Individuals with disabilities in rural environments had a nearly identical prevalence of these chronic diseases as those in urban environments: hypertension (Rural, \(M = 2.23, SD = 0.993\); Urban, \(M = 2.14, SD = 0.983\)), coronary heart disease (Rural, \(M = 1.94, SD = 0.245\); Urban, \(M = 1.94, SD = 0.235\)), mental wellbeing (Rural, \(M = 1.59, SD = 0.491\); Urban, \(M = 1.56, SD = 0.496\)), diabetes (Rural, \(M = 2.68, SD = 0.718\); Urban, \(M = 2.69, SD = 0.713\)), and obesity (Rural, \(M = 2.75, SD = 0.971\); Urban, \(M = 2.78, SD = 0.98\)) are counter to the research hypothesis. The 95% confidence interval for the hypertension difference in means ranges from -0.117 to 0.02; for coronary heart disease, -0.02 to 0.01; mental wellbeing, -0.001 to 0.061; diabetes, -0.051 to 0.039; and obesity, -0.087 to 0.039. The effect sizes (hypertension \(d = 0.06\); coronary heart disease \(d = 0.02\); mental wellbeing \(d = 0.06\); diabetes \(d = 0.01\); obesity \(d = 0.03\)) suggest that the difference between individuals with a disability in rural and urban environments accounts for a small change in the prevalence of chronic disease among the population.

**Objective 4:** Chronic disease prevalence in the rural built environment for individuals with and without disability.

An independent-samples \(t\) test was conducted to evaluate the hypothesis that chronic disease prevalence is higher among individuals with a disability than those without in the rural built environment. The tests for hypertension \((t(1639.297) = -10.821, p = 0.00)\), coronary heart disease \((t(1384.532) = -6.248, p = 0.00)\), mental wellbeing \((t(1722.614) = -14.931, p = 0.00)\), diabetes \((t(1615.477) = -7.802, p = 0.00)\), and obesity
\((t(1948.528) = -7.568, p = 0.00)\) were highly significant. The results for hypertension (Disability, \(M = 2.10, SD = 0.993\); No disability, \(M = 2.49, SD = 0.863\)), coronary heart disease (Disability, \(M = 1.94, SD = 0.125\); No disability, \(M = 1.98, SD = 0.125\)), mental wellbeing (Disability, \(M = 1.59, SD = 0.491\); No disability, \(M = 1.84, SD = 0.371\)), diabetes (Disability, \(M = 2.68, SD = 0.718\); No disability, \(M = 2.86, SD = 0.493\)), and obesity (Disability, \(M = 2.75, SD = 0.971\); No disability, \(M = 3.01, SD = 0.902\)) strongly support the research objective hypothesis. The 95% confidence interval for the hypertension difference in means ranges from -0.470 to -0.326; coronary heart disease, -0.063 to -0.033; mental wellbeing, -0.274 to -0.211; diabetes, -0.228 to -0.137; and obesity, -0.326 to -0.192. The effect sizes for most health factors (hypertension \(d = 0.4\); mental wellbeing \(d = 0.5\); diabetes \(d = 0.3\); obesity \(d = 0.3\)) suggest that the difference between individuals with and without disabilities in the rural environment accounts for a moderate amount of the change in chronic disease prevalence. The effect size for coronary heart disease \((d = 0.2)\) suggests a smaller correlation between chronic disease prevalence among individuals with or without a disability rural environments.

**Discussion**

Given the proxy measure used to define rural built environments, the results provide a narrow understanding of the relationship in question and should only be interpreted knowing the specific set of parameters used to define the area and population of interest. Myriad organizations define rural environments across a broad spectrum ranging from quantitative measures to subjective characteristics.\(^{53,62}\) The parameters to
define rural communities in this study are substantiated and valid, but further research should seek to determine if alternative rural definitions yield varying results.

RUCA codes are an effective, recognized means of defining rural populations—providing a more tailored description than the U.S. Census or OMB definitions—and account for population density, urbanization, and daily commuting. As an approved means of obtaining rural funding, they are deemed appropriate for research and standardized rural classification. Still, RUCA zip codes represent an approximation, albeit highly detailed. Commuting times and distances stem from the population center of a zip code. For large zip code areas this may distort the classification of rural and urban, particularly for those living on the fringe.

The small effect sizes reported in this study also prompt further examination to more accurately express the relationship between physical activity, chronic disease, and the built environment. Although the results of each research objective provide varying degrees of statistical significance, the built environment alone cannot fully depict the multifaceted relationship between a population’s participation in physical activity, chronic disease prevalence, and disability. However, a closer examination of each independent-samples t test and evaluation of descriptive frequencies reaffirms existing research and substantiates the importance of evaluating the barriers to healthy behaviors among the population with disabilities.

Research objectives 1 and 2 evaluate the relationship between physical activity and the built environment among individuals with disabilities. Both objectives indicate statistical significance, respectively \( p = 0.007 \) and \( p = 0.000 \). Research objectives 3 and 4
examine the prevalence of chronic disease in relation to the built environment for the sample population of individuals with disability in Arizona, Nevada, Oregon, Utah and Washington. While the results of objective 3 lack statistical significance regarding the correlation of chronic diseases and urban and rural environments, objective 4 outcomes demonstrate a very significant correlation between chronic disease and disability status among rural inhabitants.

**Objective 1:** Physical activity for individuals with disability in rural versus urban built environments.

The independent-samples $t$ test points to a significant correlation ($p = 0.007$) between reported physical activity levels and the built environment among individuals with disabilities in the selected western states. Individuals with disabilities in rural environments engaged in less physical activity ($M = 1.99, SD = 1.11$) on average than those residing in urban locations ($M = 2.17, SD = 1.18$). This supports the assumption that people with disabilities have fewer opportunities and locations to participate in physical activity in the rural environment.

The 2011 BRFSS asked respondents two questions regarding the type of physical activities in which they participated. In rural environments, 41.3% (722 of 1,148) of individuals with disability in rural environments reported a second activity, compared to 44.0% (2,772 of 6,303) in urban areas. Individuals in urban environments participated in a broader array of activities than those in rural areas (see Appendix C for table). Although walking is by far the most common form of physical activity for both groups, there is a higher diversity of activity reported among those residing in urban locations ($n = 48$) than
those in rural areas \((n = 32)\). A difference of sixteen self-reported activities suggests the rural sample may be afforded a lower diversity of activity or access to activities due to their surroundings.

Lower physical activity levels among individuals with disability in rural or urban communities can likely be attributed to similar barriers, namely neighborhood design and convenient access to recreation facilities and parks.\(^{63,64}\) In rural environments, increased distance between amenities isolates physical activity,\(^{65}\) leading to lower visibility of opportunities for exercise and, consequently, others engaging in exercise. High visibility and the aesthetic of these amenities, and people utilizing them, prompt higher rates of physical activity.\(^{66}\) Distance and other barriers, both physical and mental, are compounded for individuals with disabilities,\(^{47}\) and necessitates an evaluation regarding how the rural built environment impacts physical activity levels among individuals with and without disability in rural populations.

**Objective 2**: Physical activity in rural environments for individuals with and without disability.

As anticipated, individuals with disability participate in less physical activity \((M = 1.92, SD = 1.149)\) than those without a disability \((M = 2.17, SD = 1.2)\) in rural environments. The statistical significance \((p = 0.000)\) indicates a strong relationship between disability status and level of physical activity in rural areas. As a comparison, urban adults with a disability engage in less physical activity \((M = 2.43, SD = 1.284)\) compared to adults without a disability \((M = 2.59, SD = 1.278)\). The difference between means is greater in rural environments for individuals with and without disability \((0.25)\).
versus the urban population (0.16).

The likely explanation for the larger gap includes compounded barriers to physical activity in the rural environment for persons with disability due to inaccessibility and decreased opportunity. Disconnected pedestrian ways are often more prevalent in rural communities as are poor signage and coarse pathway textures. These design considerations discriminate against certain individuals and prevent use of areas programmed for physical activity. Consequently, with fewer allotted locations to engage in physical activity, inaccessibility restricts individuals faced with mobility, vision, or psychological disorders. The statistical significance of objective 1 adds further depth to the relationship between disability and physical activity in the rural environment.

Accessibility and the availability of opportunities are common barriers to physical activity, particularly for individuals with disability. Although the independent-samples $t$ test does not clarify the specific obstacles, the results verify that rural environments cause participation in physical activity to be more challenging. Goenka and Andersen studied physical activity and the built environment across five continents and concluded that the following aspects increased physical activity: public parks within walking distance (0-5 km from residence), higher density of public transport, higher residential density, and higher numbers of pedestrian accessible intersections. That description is counter to the built environment of most rural areas and, with limited resources, these communities are often unable to ensure widespread accessibility throughout characteristically low residential densities. Visibility of others engaging in physical activity and social support are known factors that promote individual engagement in physical activity and are less
prevalent in rural settings. Similarly, increased distance to parks and recreational facilities in small communities adds time and financial costs to leisure time physical activity that is not as evident in urban environments.65

An independent-samples $t$ test comparing individuals without disabilities in rural and urban environments yields the same significant correlation ($p = 0.000$) between physical activity and location. The independent-samples $t$ tests for each group, individuals with and without disabilities in rural or urban locations, confirm the research hypothesis and support previous findings that indicate rural adults participate in less physical activity.68 Urban respondents with a disability reported a broader range of activities ($n = 68$), compared to the rural responses ($n = 45$). As indicated in research objective 1, the population with disability living in rural environments the fewest opportunities, perceived or otherwise, to meet the recommended amounts of physical activity.

To further understand the relationship between the built environment and physical activity levels, Table 2-2 displays the descriptive frequencies of physical activity levels among each group. These frequencies provide a simple comparison between groups and can be interpreted knowing the statistical significance. Individuals with disabilities report higher rates of inactivity, particularly those in rural environments who report 4.1% higher levels of inactivity. Furthermore, the frequencies indicate the rural population with disabilities has the lowest percentage of individuals meeting both the aerobic and muscle-strengthening guidelines of any group.
### Table 2-2

**Physical Activity Levels by Population Percentage**

<table>
<thead>
<tr>
<th>Respondent</th>
<th>Physical activity levels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inactive</td>
</tr>
<tr>
<td>Rural</td>
<td></td>
</tr>
<tr>
<td>Disability</td>
<td>56.2</td>
</tr>
<tr>
<td>No disability</td>
<td>45.8</td>
</tr>
<tr>
<td>Urban</td>
<td></td>
</tr>
<tr>
<td>Disability</td>
<td>52.1</td>
</tr>
<tr>
<td>No disability</td>
<td>45.8</td>
</tr>
</tbody>
</table>

*aParticipant information was gathered from the 2011 Utah BRFSS data, excluding responses for individuals under 18 or over 64. The numbers presented are the valid percent of each variable.

*bPhysical activity levels were determined as described in the methods section of this narrative.

**Objective 3:** Chronic disease prevalence for individuals with disability in rural versus urban built environments.

Although contrary to the research hypothesis, the results of objective 3 present important information. The hypothesis projected that rural populations with disability would report a higher prevalence of hypertension, coronary heart disease, diabetes, and obesity while mental wellbeing would decrease. However, the independent-samples *t* test did not show statistical significance when comparing chronic disease among individuals with disability in urban and rural environments.

The effect sizes (hypertension *d* = 0.06; coronary heart disease *d* = 0.02; mental wellbeing *d* = 0.06; diabetes *d* = 0.01; obesity *d* = 0.03) suggest that the difference between individuals with a disability in rural and urban environments accounts for a small change in the prevalence of chronic disease among the population. These numbers,
combined with the independent-samples t test, suggest that a single factor cannot establish a significant relationship between chronic disease and the built environment for populations with disability. Specifically, the built environment alone does not account for the increased prevalence of chronic disease among individuals with disability.

As substantiated by objective 1, rural individuals with disability report lower rates of physical activity when contrasted against those in urban communities. Research confirms that lower exercise rates are likely to increase the prevalence of chronic disease in a population. This information targets a significant correlation between chronic disease and physical activity. However, the fact that rural populations with disability in Arizona, Nevada, Oregon, Utah and Washington did not manifest significantly higher rates of chronic disease posits a disconnect between the role of the built environment regarding health status. The independent samples t tests for the previous two objectives prove a correlation, although with small effect sizes, between physical activity and the built environment. Those small effect sizes likely compound when relating the built environment to the prevalence of chronic disease in a population.

These results highlight that the factors relating the built environment to manifestations of chronic disease in a population are multifaceted. Evaluating the built environment continuum, including suburban communities not included in this study, may indicate areas where rural and urban communities are both disadvantaged. Future research should evaluate the additional links complicating the relationship between chronic disease and the built environment for individuals with disability. The independent-samples t test does not specifically evaluate and quantify individuals
that exhibit multiple chronic diseases. Additional investigation of the 2011 BRFSS data indicates that 4.4% \( (n = 50) \) of individuals with disability among rural populations have four chronic diseases, compared to a slightly lower frequency of 4.0% \( (n = 255) \) in urban built environments. With minimal statistical difference between the two groups in this research objective, the comparisons in Table 2-3 add depth to the relation between health status, disability and the built environment. Those individuals with disability in rural communities exhibiting two or more chronic diseases comprise 43.4% \( (n = 499) \) of the population, 2.4% more than the comparable demographic in the urban environment.

**Objective 4:** Chronic disease prevalence in the rural built environment for individuals with and without disability.

The results of objective 4 indicate high statistical significance between chronic disease and disability status in the rural built environment: hypertension \( (p = 0.00) \), coronary heart disease \( (p = 0.00) \), mental wellbeing \( (p = 0.00) \), diabetes \( (p = 0.00) \), and

<table>
<thead>
<tr>
<th>Built environment</th>
<th>Number of diseases per individual ( b )</th>
<th>( 0 )</th>
<th>( 1 )</th>
<th>( 2 )</th>
<th>( 3 )</th>
<th>( 4 )</th>
<th>( 5 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural</td>
<td>Frequency</td>
<td>290</td>
<td>359</td>
<td>291</td>
<td>146</td>
<td>50</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Valid percent</td>
<td>25.3</td>
<td>31.3</td>
<td>25.3</td>
<td>12.7</td>
<td>4.4</td>
<td>1.0</td>
</tr>
<tr>
<td>Urban</td>
<td>Frequency</td>
<td>1645</td>
<td>2073</td>
<td>1526</td>
<td>761</td>
<td>255</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>Valid percent</td>
<td>26.1</td>
<td>32.9</td>
<td>24.2</td>
<td>12.1</td>
<td>4.0</td>
<td>0.7</td>
</tr>
</tbody>
</table>

\( a \) Participant information was gathered from the 2011 Utah BRFSS data, excluding responses for individuals under 18 or over 64.

\( b \) Chronic disease was counted only if the respondent answered yes (hypertension, coronary heart disease, mental wellbeing, and diabetes) and if BMI was \( \geq 30 \).
obesity \((p = 0.00)\). Descriptive frequencies of the rural environment highlight that 49.6% of individuals without disability report one or more chronic disease, compared to 74.7% of individuals with disability. The high significance supports the hypothesis that individuals with disability in rural communities exhibit a greater risk for chronic disease when compared to those without a disability.

An additional independent-samples \(t\) test for individuals with and without disabilities in urban areas also yielded high statistical significance \((p = 0.000)\) for the five chronic diseases under investigation. The result of both tests verifies that higher manifestations of chronic disease correspond directly to disability status, regardless of location. This confirms existing research that chronic diseases are more prevalent among persons with disability.73,74

However, an unanticipated result shows that the differences between the mean values of urban individuals with and without disability are often marginally greater than the mean difference of the rural population, see Table 2-4. This suggests that the prevalence of chronic disease is not necessarily compounded for populations with disability in relation to the built environment. Higher overall rates of chronic disease among individuals with disability,75 regardless of location, may account for the similar prevalence in both environments. This validates the small effect size finding and results of research objective 3, suggesting the relationship of chronic diseases and rural environments involves additional variables beyond disability status.

Hypertension, diabetes, and obesity are the health risks reported more frequently for both rural groups, Table 2-4. Variables closer to 1 indicate higher diagnoses rates in
Table 2-4

*Mean Comparison of Chronic Disease Prevalence Among All Individuals*[^a]

<table>
<thead>
<tr>
<th>Chronic disease</th>
<th>Built environment</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rural</td>
<td>Urban</td>
<td></td>
</tr>
<tr>
<td>Hypertension[^b]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disability</td>
<td>2.10</td>
<td>2.14</td>
<td></td>
</tr>
<tr>
<td>No disability</td>
<td>2.49</td>
<td>2.56</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>0.39</td>
<td>0.42</td>
<td></td>
</tr>
<tr>
<td>Coronary heart disease[^c]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disability</td>
<td>1.94</td>
<td>1.94</td>
<td></td>
</tr>
<tr>
<td>No disability</td>
<td>1.98</td>
<td>1.99</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>0.04</td>
<td>0.05</td>
<td></td>
</tr>
<tr>
<td>Mental wellbeing[^d]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disability</td>
<td>1.59</td>
<td>1.56</td>
<td></td>
</tr>
<tr>
<td>No disability</td>
<td>1.84</td>
<td>1.83</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>0.25</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td>Diabetes[^e]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disability</td>
<td>2.68</td>
<td>2.69</td>
<td></td>
</tr>
<tr>
<td>No disability</td>
<td>2.86</td>
<td>2.89</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>0.18</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>Obesity[^f]</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disability</td>
<td>2.75</td>
<td>2.78</td>
<td></td>
</tr>
<tr>
<td>No disability</td>
<td>3.01</td>
<td>3.14</td>
<td></td>
</tr>
<tr>
<td>Difference</td>
<td>0.26</td>
<td>0.36</td>
<td></td>
</tr>
</tbody>
</table>

[^a]: Participant information was gathered from the 2011 Utah BRFSS data, excluding responses for individuals under 18 or over 64.
[^b]: Hypertension means are derived from the following scale: 1-Yes, 2-Borderline, 3-No.
[^c]: Coronary heart disease means are derived from: 1-Yes, 2-No.
[^d]: Mental Wellbeing means are derived from being diagnosed with a depressive disorder: 1-Yes, 2-No.
[^e]: Diabetes means are derived from the following scale: 1-Yes, 2-Borderline, 3-No.
[^f]: Obesity means are derived from: 1-Morbidly, 2-Obese, 3-Overweight, 4-Ideal Weight, 5-Underweight.

the population. Descriptive frequencies report 44.9% (*n* = 436) of the rural population with disability have hypertension, compared to 42.1% (*n* = 2124) of urban individuals with disability; 14.9% (*n* = 169) have diabetes, compared to 14.7% (*n* = 912); and 42.9%
(n = 472) have a BMI ≥ 30, compared to 39.7% (n = 2,505). Globally hypertension is the deadliest yet most preventable cause of morbidity and mortality, accounting for one in six deaths in the U.S.\textsuperscript{76} Awareness, treatment, and prevention education are frequently low in rural communities.\textsuperscript{76} Lower reported rates of physical activity in rural environments are likely to account for a higher prevalence of hypertension, type II diabetes, and obesity among individuals with disability.\textsuperscript{77,78}

**Conclusion**

In the western U.S., many of the participants of the 2011 BRFSS survey did not meet the recommended amount of physical activity (see Figure 2-3), thus increasing individual risk for chronic disease. The results of this study confirm the impact of the built environment on a community’s propensity for physical activity and that communities with lower rates of physical activity exhibit higher diagnoses of chronic disease. Independent-samples $t$ tests, however, did not prove an overwhelming significance directly relating higher rates of chronic disease to the built environment. Although research documents that the chronic diseases plaguing the U.S. are preventable through physical activity, additional factors beyond the built environment correlate these variables and warrant further research.

Features of the built environment have bearing on an individual’s propensity to engage in physical activity with populations residing in rural built environments being the least likely to meet the recommended amounts of exercise. Inaccessibility and the inconvenience of viable opportunities for physical activity are among the most common
barriers. Individuals with disability in rural communities reported a 4.1% higher level of inactivity than those in urban environments; and 10.4% higher inactivity than those without a disability in rural communities. Further data analysis and descriptive frequencies indicate the rural population with disabilities has the lowest percentage of individuals meeting both the aerobic and muscle-strengthening guidelines of any of the demographics summarized in this study.

Persons with disability in both rural and urban communities exhibit higher diagnoses of chronic diseases, particularly: hypertension, coronary heart disease,
diabetes, and obesity with an impact of mental wellbeing. The hypothesis that individuals with disability in rural built environments would exhibit significantly higher rates of chronic disease was not found to be statistically significant. This indicates the built environment is likely just one of a myriad of factors that impact the prevalence of chronic diseases often correlated with physical activity.

However, diagnoses for individuals with disability in rural communities with two or more chronic diseases comprise 43.4% ($n = 499$) of the demographic; 2.4% more than the comparable population in the urban environment. This information complicates the findings surrounding the impact of the built environment on chronic disease prevalence for persons with disability.

This research can supplement the dialogue between professionals creating the various built environments in which we live. Communities with limited opportunities for physical activity can be made aware of the barriers fostering sedentary lifestyles. Increasing knowledge and awareness regarding the ability of our surroundings to encourage or inhibit physical activity may lead to the promotion of public health as a critical topic within design and planning professions. Further research should explore additional components of the rural environment that complicate the health status of individuals with disability.

References


CHAPTER 3

DISABILITY AND ITS RELATION TO PHYSICAL ACTIVITY FOR RURAL COMMUNITIES IN THE WESTERN UNITED STATES

Abstract

Minimizing barriers to physical activity is a high priority due to its beneficial effect regarding the compounding health problems associated with obesity. An individual’s propensity to engage in physical activity is, in part, impacted by his or her most frequented surroundings and built environment. In general, populations residing in rural environments are less likely to meet the recommended amounts of activity. The demographic of individuals with disability often face increased barriers to physical activity than those without a disability. The impact of the rural built environment on physical activity is, therefore, likely compounded for individuals with disabilities. This study compares the relationship between rates of physical activity among individuals with disabilities in rural versus urban communities in the western U.S. The four research objectives are: (1) rural and urban physical activity comparison for the highest disability classification; (2) rural and urban physical activity comparison for individuals with disability using equipment; (3) rural and urban physical activity comparison for individuals with disability resulting from physical, mental, or emotional impairments; and (4) rural and urban physical activity comparison for individuals not reporting disability.

The study found high statistical significance for the rural and urban physical

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2 Chapter 3 was coauthored by Nicholas Tanner and Keith Christensen for future journal submission.
activity comparison for individuals with disability resulting from physical, mental, or emotional impairments. The lack of significance for the three remaining objectives indicates a complex relationship between disability classifications and physical activity that cannot be explained through a single variable.

**Introduction**

Existing research indicates a strong association between the built environment and physical activity. Healthy, active communities provide both physical and social environments that support wellbeing (Gray, Zimmerman, & Rimmer, 2012). Such communities are described as having convenient recreational opportunities and a culture of physical activity in the neighborhood (Hoehner, Ivy, Brennan-Ramirez, Handy, & Brownson, 2007). These statements indicate the widespread influence of the built environment on promoting exercise and altering societal norms for participation in physical activity through increased visibility.

Reviewing a decade of literature on this association, Heath et al. (2006) compiled case studies of community-scale designs and land use policies that led to an increase of physical activity in various communities. Some of the most effective strategies to promote physical activity included the availability of walking and biking trails, residential proximity to recreation areas, sidewalk continuity, and pedestrian scaled amenities. Within urban planning, some research suggests that incorporating smart growth planning principles shifts the perspective from vehicular to pedestrian movement, yielding an environment that better accommodates physical activity (Durand, Andalib,
The promotion of physical activity is an escalating national priority for public health officials and others (Haskell et al., 2007). Professional organizations for landscape architects, architects, urban planners and engineers are working together to provide resources to perpetuate the implementation of healthy and accessible communities. This urgency stems from the established fact that physical inactivity increases risk for chronic diseases, including non-insulin-dependent diabetes, coronary heart disease, obesity, hypertension, colon cancer, osteoarthritis, osteoporosis, and cardiovascular disease (Ewing, Schmid, Killingsworth, Zlot, & Raudenbush, 2003; Schoenborn & Stommel, 2011). Physical inactivity accounts for roughly 300,000 premature deaths annually, behind only tobacco-related fatalities among the preventable causes of death in the U.S. (McGinnis & Foege, 1993). Globally, chronic diseases account for two thirds (36 million) of the worldwide death count (World Health Organization, 2011).

Because physical activity is one of several methods to reduce risk of chronic diseases and conditions, low levels of physical activity in the U.S. remain a high concern. Unfortunately, less than half of the adult population meets the recommended amounts of physical activity (Pratt, Macera, & Blanton, 1999; Troiano et al., 2008). This means the majority of Americans are at increased risk for chronic disease and premature mortality despite knowledge of the benefits of exercise (Physical Activity Guidelines Advisory Committee, 2008). Targeting barriers created by the built environment could lead to improved levels of physical activity. The need for information and academic interest on this topic of research has never been greater (Day & Cardinal, 2007; Sallis et al., 2009).
Obstacles preventing exercise may be greatest for persons with disability. Limited opportunities for physical activity result in a verifiable disadvantage for this demographic (Rimmer, Riley, Wang, Rauworth, & Jukowski, 2004). The construct of the built environment affects the ability of persons with disabilities to be physically active and socially integrated into their community (World Health Organization, 2001). Furthermore, members of this demographic are more likely to encounter mental barriers to physical activity than individuals without disabilities (Spivok, Gauvin, & Brodeur, 2008).

The introduction of the Americans with Disability Act (ADA) in 1990 was, in part, an attempt to mitigate these discrepancies. However, unsuccessful implementations of ADA regulations continue to hinder equal participation, particularly in areas with limited funding (Spivok, Gauvin, & Brodeur, 2007). Universal design and aspects of smart growth policies share comparable goals to ADA regulations. These promote the philosophy that designing for a limited ability level promotes wellbeing for the entire population (Durand et al., 2011). Planning with the intent to accommodate diverse functional abilities should decrease barriers to traditional exercise and other forms of activity for all (Crews & Zavotka, 2006).

Although pertinent literature has investigated trends related to physical activity among individuals with disabilities, few studies have assessed its correlation to the built environment for this group. Much of the research concerning people with disabilities focuses on secondary conditions resulting from the disability, creating a knowledge gap regarding preventative health care (Diab & Johnston, 2004). Because of this academic
void in the literature, this study seeks to understand the connection between physical activity and disability. Furthermore, limited studies have classified disability levels to better evaluate the association to the built environment. The objective of this paper is to evaluate how the built environment impacts physical activity levels for varying categories of disability in the western U.S., namely Arizona, Nevada, Oregon, Utah, and Washington.

**Methods**

**Design**

The intent of this paper is to determine the extent to which the built environment impacts physical activity for individuals with disability. The population comparisons are derived from responses to the 2011 BRFSS disability questions and the relationship between physical activity levels and the extremes of the built environment. The built environment, as specified in this study, compares the differences exhibited by individuals in urban and rural classified communities.

The study is cross-sectional and utilizes previously recorded data without manipulating the study environment for the duration in which the data was obtained. The study is also ecologic because the primary units for the analysis focus on populations and geographic areas, not individuals (Sallis, Bauman, & Pratt, 1998). It is loosely based on a study developed by the Center for Smart Growth, which examined the relationship between urban sprawl, health, and physical activity (Ewing et al., 2003).

The paper analyzes data produced by the 2010 Rural-Urban Commuting Area
codes (RUCAs), and the 2011 Center for Disease Control and Prevention’s (CDC) Behavioral Risk Factor Surveillance System (BRFSS). The geographic area targeted by the data analysis correlates with the BRFSS respondents in the states of Arizona, Nevada Oregon, Utah and Washington.

Measures

Rural and urban. Two government agencies offer generic parameters commonly utilized to define rural areas and populations (Defining the Rural Population, n.d.). First, the Office of Management and Budget (OMB) assigns rural designation at the county scale. The OMB classifies counties as metropolitan (containing an urban core of 50,000 or more residents), micropolitan (containing an urban core with a population between 10,000-50,000), or neither. In this instance, rural locations are assumed by the geographic areas beyond the prescribed stipulations above. The second rural description derives from the U.S. Census Bureau and identifies two types of urban areas: urbanized areas containing 50,000 people or more; urban clusters containing a population between 2,500 and 50,000. By default, all undefined areas and clusters are determined to be rural.

The problem with utilizing such definitions for this study is spatial exactness. Identifying the rural environment by what is not urban overlooks many rural populations residing within an OMB classified metropolitan county as well as Census designated urban cores that exhibit rural qualities (What is Rural, 2013). These predetermined definitions do not provide the specificity needed to identify rural environments for the scope of this study.

In response to the two broad definitions described above, the Health Resources
and Service Administration’s Office of Rural Health Policy, the Washington/Wyoming/Alaska/Montana/Idaho (WWAMI) Rural Research Center, and the U.S. Department of Agriculture’s Economic Research Service (ERS) developed RUCAs to classify subcounty areas which represent urbanization, population density, and daily commuting. The Federal Office of Rural Health Policy accepts RUCAs methodology as a means of determining rural eligibility for their programs (What is Rural, 2013).

RUCA utilizes Census tracts to delineate components of urban and rural areas at the subcounty scale. OMB metropolitan and micropolitan terminology is used to label RUCA codes and correspond to zip codes for further geographic representation. Combining the BRFSS survey responses with the respective RUCA classification provides the foundation for comparison between rural and urban populations. The RUCA classification system contains 10 primary codes and 21 secondary. The classification codes represent the RUCA labels utilized in conjunction with the results of the 2011 BRFSS (see Appendix A).

For this study, rural is defined using the RUCA codes for small town core (7.0, 7.1, 7.2) small town high commuting (8.0, 8.1, 8.2), small town low commuting (9.0), and rural areas (10.0, 10.1, 10.2, 10.3). Comparing the most urban built environment with the most rural provides a distinct contrast and eliminates the overlap of potentially confounding variables exhibited in suburban communities. The RUCA codes used to define the urban environment are the metropolitan area core (1.0, 1.1) and metropolitan area high commuting (2.0, 2.1).

**Physical activity.** Physical activity is the preventative health behavior studied in
this paper. The 2011 BRFSS defines physical activity as exercise or leisure-time recreation which occurs outside regular job duties (Centers for Disease Control and Prevention [CDC], 2008). The 2011 BRFSS permits respondents with two chances to report physical activity, asking: “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?” The respondents then report the activities, frequency (times/week or times/month) and duration (hours and minutes).

The most notable standard for determining sufficient physical activity originates from the 2008 Physical Activity Guidelines for Americans (PAGAC, 2008). To meet the aerobic requirements for sufficient physical activity, an adult must participate in 150 minutes of moderate-intensity activity per week, or 75 minutes of vigorous-intensity activity per week (CDC, 2008; PAGAC, 2008). Adults should also participate in two or more days a week of moderate to high intensity muscle-strengthening activities that involve each of the major muscle groups (PAGAC, 2008).

The 2011 BRFSS monitors frequency and duration, and provides a method for calculating the intensity of a set list of activities. These factors are used to determine if the intensity of an activity for each individual is sufficient to meet the guidelines. The 2011 BRFSS assesses frequency with the question: “How many times per week or per month did you take part in this activity during the past month?” The following question determines activity duration for each respondent, “And when you took part in this activity, for how many minutes did you usually keep at it?” The method to determine intensity comes from A Data User’s Guide to the BRFSS Physical Activity Questions:
How to Assess the 2008 Physical Activity Guidelines for Americans and is outlined below (CDC, n.d.).

Step 1: Maximal oxygen uptake (VO$_{2\text{max}}$) helps determine the body’s capacity to use and transport oxygen during maximum exertion. Metabolic equivalents (METs) measure the rate of energy expenditure while at rest and are frequently used to determine physical activity intensity. The following formulas determine VO$_{2\text{max}}$ (expressed in METs):

**Men**

Estimated VO$_{2\text{max}}$(METs) = \( \frac{60-0.55 \cdot \text{age in years}}{3.5} \)

**Women**

Estimated VO$_{2\text{max}}$(METs) = \( \frac{48-0.37 \cdot \text{age in years}}{3.5} \)

Step 2: The minimum intensity for a physical activity to be vigorous is 60% of VO$_{2\text{max}}$, or 6 METs; the values required for moderate intensity physical activities is 30% of VO$_{2\text{max}}$, or 3 METs (U.S. Department of Health and Human Services, 1996).

Step 3: Compare the MET values for each reported activity (see Appendix B) to the respondents’ MET values found in step 2. Determine if the MET values for each physical activity meet the moderate or vigorous intensity MET values for each respondent. Some activities (pilates, tai chi, weight lifting, and yoga) are not considered aerobic or are low-intensity activities (values less than 3 METs).

Step 4: Combine the information on frequency, duration, and intensity. This will determine time spent per week in moderate and vigorous-intensity physical activities for each respondent.

To determine the physical activity level for muscle-strengthening, the following question is used: “During the past month, how many times per week or per month did you do physical activities or exercise to STRENGTHEN your muscles? Do NOT count aerobic activities like walking, running, or bicycling. Count activities using your own body weight like yoga, sit-ups or push-ups and those using weight machines, free
“weights, or elastic bands.” If the response is at least two times per week, individual meets the requirement for muscle-strengthening.

Respondents are then classified into four levels of physical activity using the data from the 2011 BRFSS Questionnaire and the 2008 Physical Activity Guidelines (CDC, 2008, PAGAC, 2008).

1. Inactive
2. Insufficiently active
3. Active
4. Highly active
5. Meets muscle-strengthening guidelines
6. Meets aerobic and muscle-strengthening guidelines

For ease of ranking and statistical analysis, the physical activity levels are further classified as the following:

1. Inactive; insufficiently active
2. Active
3. Highly active
4. Meets aerobic (active or highly active) and muscle strengthening guidelines

**Disability.** The standard protocol for determining disability when using BRFSS data is a ‘yes’ response to either of the disability questions in the core portion of the survey (Christensen, Holt, & Wilson, 2010; Rimmer, 2007; Strine, Kroenke, & Dhingra, 2009; U.S. Department of Health and Human Services, 1999; Wolf, Armour, & Campbell, 2008). The two questions are: “Are you limited in any activities because of physical, mental, or emotional problems?” or “Do you now have any health problem that requires you to use special equipment, such as a cane, a wheelchair, a special bed, or a special telephone?”

However, this standard achieves a limited scope regarding disability research.
Individuals can only be categorized as having a disability or not. To better assess the relation of physical activity and the built environment, this paper determines disability using four categories derived from the 2011 BRFSS data set (CDC, 2011):

1. No to both questions  
2. Yes to limitations caused by physical, mental, or emotional problems  
3. Yes to requiring use of special equipment for assistance  
4. Yes to both questions

Sample

The study population includes individuals who are between 18-64 years of age, residing in the following states: Arizona, Nevada, Oregon, Utah, and Washington. This reduces the confounding effects of health conditions associated with advanced age. While the question of the study is to understand the impact of the built environment on individuals with disabilities, samples from other demographics are needed. Individuals without disabilities are used as a comparison. Analyzing persons with similar disabilities residing in urban versus rural built environments provides the basis for comparison to evaluate the impact of the built environment. These criteria investigate the relationship of individuals with disabilities, physical activity, and the built environment.

Analysis

The focus of this paper is to determine the extent to which the built environment impacts physical activity for individuals with disability. The four disability categories are the foundation for comparing physical activity levels and the built environment.

The specific comparisons of this study are fourfold.

1. rural and urban physical activity comparison for the highest disability
classification,

2. rural and urban physical activity comparison for individuals with disability using equipment,

3. rural and urban physical activity comparison for individuals with disability resulting from physical, mental, or emotional impairments, and

4. rural and urban physical activity comparison for individuals not reporting disability.

This study conducts independent-samples \( t \) tests to compare physical activity levels between categories of disability to determine the disparities that may exist. The study tests for a simple correlation using an independent-samples \( t \) test between levels of physical activity for persons with disabilities and the rural environment. The result of this study has potential to further develop rural health initiatives for individuals with disability, specifically those related to accessibility.

The independent-samples \( t \) test accounts for variances in population size. This is important due to the focus on individuals with disability and that they represent a minority of both rural and urban demographics. Similarly, the moderate to large size of each sample increases \( p \) value validity, accounting for both normal and nonnormal distributions in the sample. The resulting correlation between health and the built environment for this vulnerable population will be extrapolated based on the existing body of knowledge to identify the cause of health behavior and status differences between populations.

To compare persons with and without disabilities in the built environment, descriptive frequencies provide additional insight into the results of the independent-samples \( t \) tests. Demographic characteristics, scrutiny of survey data, and percentages for
health and environment factors are among the descriptive frequencies evaluated.

**Results**

For Arizona, Nevada, Oregon, Utah, and Washington, the 2011 BRFSS interviewed 37,850 by landline and 6,070 by cell phone. Including partially completed surveys the average response rate across these states is 72.67% and dropping to a 44.67% response rate for complete interviews. Excluding individuals over the age of 64 for this study, the population sample draws from 33,801 responses. The rural base sample includes 11.4% \((n = 3,848)\) and the urban population consists of 72.9\% \((n = 24,630)\).

Surveyed individuals who answered yes to both disability questions total 5.6\% \((n = 1,882)\); individuals who report a disability requiring special equipment total 0.8\% \((n = 254)\); persons who are limited because of physical mental, or emotional impairments comprise 20.2\% \((n = 6,834)\) of the sample; and those who answered no to both disability questions total 67.0\% \((n = 22,644)\).

**Comparison 1:** Rural and urban physical activity comparison for the highest disability classification.

An independent-samples \(t\) test was conducted to evaluate the hypothesis that persons reporting higher disability in rural built environments are less likely to meet the physical activity guidelines than the urban comparison. However, the test was not significant \(t(1557) = 0.165, p=0.869\). Individuals reporting higher disabilities in rural environments engaged in more physical activity \((M = 1.77, SD = 1.143)\) on average than those residing in urban locations \((M = 1.75, SD = 1.119)\). The 95\% confidence interval
for the difference in means ranges from -0.138 to 0.163. The effect size \((d = 0.01)\) suggests that the difference between rural and urban environment accounts for a minimal amount of the change in physical activity.

**Comparison 2:** Rural and urban physical activity comparison for individuals with disability using equipment.

An independent-samples \(t\) test was conducted to evaluate the hypothesis that persons with a disability requiring use of special equipment in rural built environments are less likely to meet the physical activity guidelines than the urban comparison. The test was not significant, \(t(212) = -0.215, p = 0.830\). However, the results support the hypothesis, indicating that individuals with disabilities in rural environments engaged in less physical activity \((M = 1.85, SD = 1.099)\) on average than those residing in urban locations \((M = 1.90, SD = 1.183)\). The 95% confidence interval for the difference in means ranges from -0.052 to 0.241. The effect size \((d = -0.04)\) suggests that the difference between physical activity levels accounts for a fraction of the change in physical activity.

**Comparison 3:** Rural and urban physical activity comparison for individuals with disability resulting from physical, mental, or emotional impairments.

An independent-samples \(t\) test was conducted to evaluate the hypothesis that persons with a disability resulting from physical, mental, or emotional impairments in rural built environments are less likely to meet the physical activity guidelines than the urban comparison. The test was significant, \(t(1120.181) = -3.037, p = 0.002\). The results support the hypothesis, indicating that individuals with disabilities in rural environments
engaged in less physical activity ($M = 1.97$, $SD = 1.148$) on average than those residing in urban locations ($M = 2.10$, $SD = 1.190$). The 95% confidence interval for the difference in means ranges from -0.213 to -0.046. The effect size ($d = -0.11$) suggests that the difference between physical activity levels accounts for a small portion of the change in physical activity.

**Comparison 4:** Rural and urban physical activity comparison for individuals not reporting disability.

An independent-samples $t$ test was conducted to evaluate the hypothesis that persons without disability in the rural built environments are not as likely to meet the physical activity guidelines when compared to the urban comparison. The test was not significant for $t(19184) = 0.121$, $p = 0.130$. The result, however, supports the hypothesis that individuals without disabilities in rural environments engaged in less physical activity ($M = 2.24$, $SD = 1.201$) on average than those residing in urban locations ($M = 2.28$, $SD = 1.218$). The 95% confidence interval for the difference in means ranges from -0.091 to 0.012. Although the test is significant, the effect size ($d = -0.03$) suggests that the difference between rural and urban environment accounts for a small amount of the change in physical activity.

**Discussion**

Some limitations exist regarding the results of the study. The method used to categorize ability levels only superficially distinguishes disability and is limited by the scope investigated in the survey. With only two questions in the core section of the 2011
BRFSS, the means of obtaining additional insight into this variable are limited. Additional studies should expand the data set to include state added modules that may include specific details regarding an individual’s disability status.

Additionally, the proxy measure used to define rural built environments provides a finite scope as to the complex relationship under investigation. The results, therefore, should be interpreted knowing the limitations originating from the research parameters used to define the geographic areas. The general standards for defining rural communities vary across a broad spectrum of quantitative measures and subjective characteristics that complicate accuracy (Defining the Rural Population, n.d.; What is Rural, 2013).

RUCA codes are an effective, recognized means of defining rural populations and account for a more accurate population density, urbanization, and daily commuting than other means of defining rural populations. A concern, however, is that RUCA zip codes represent an approximation, albeit highly detailed, and provide a relative depiction of rural communities. Commuting times are the approximation variable and distances stem from the population center of a zip code. For large zip code areas this may distort the classification of rural and urban communities, particularly for those persons living on the fringe.

The small effect sizes and minimal statistical significance reported in this study also prompt further examination to more accurately express the relationship between physical activity and the built environment for persons with disability. Although the results of each research comparison provide varying degrees of statistical significance and effect size, the built environment alone cannot accurately explain the complex
relationship between a population’s participation in physical activity and degree of disability. In addition to the built environment, other factors such as cultural norms, time constraints, pre-existing health conditions, physician advice, awareness of opportunity, and self-efficacy impact an individual’s propensity to be physically active (Schutzer & Graves, 2004).

To some degree, the built environment has a differing impact on varying levels of disability. However, the built environment is neither solely responsible for increasing participation in physical activity nor does it procure all the barriers. This results of this study conclude that there is a weak statistical correlation between physical activity and classifications of disability when comparing those living in the most urban and rural locations. Table 3-1 summarizes the descriptive frequencies for the study population by disability classification. The small sample size for the rural population in some instances limits the accuracy of the data due to its impact on effect size.

Of the four research comparisons, three did not yield statistical significance. This, in part, dismisses the hypothesis that a strong correlation exists between levels of

Table 3-1

Survey Sample Populations

<table>
<thead>
<tr>
<th>Disability levelsa</th>
<th>Yes to both</th>
<th>Uses equipment</th>
<th>Physical, mental, or emotional</th>
<th>No disability reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ruralb (N)</td>
<td>258</td>
<td>27</td>
<td>865</td>
<td>2,500</td>
</tr>
<tr>
<td>Urbanb (N)</td>
<td>1,301</td>
<td>187</td>
<td>4,829</td>
<td>16,686</td>
</tr>
</tbody>
</table>

Note. Participant information was gathered from the 2011 Utah BRFSS data, excluding responses for individuals under 18 or over 64.

a See the Methods section for a description of the disability levels used in this study

b See the Methods section for a description of rural and urban classification of the built environment
disability and participation in physical activity. Or more specifically, levels of disability are not impacted differently by the built environment. The statistical significance for people exhibiting the highest disability classification, those who rely on equipment, and those who did not report a disability the statistical findings are, respectively, $p = 0.869$, $p = 0.830$, and $p = 0.130$, see Table 3-2 for the comparisons.

Additionally, each of these research objectives report small effect sizes. This alludes that the comparison between disability and the built environment is limited in scope. Subsequent research should consider the other facets of this elaborate relationship to determine the other dominant factors that inhibit physical activity for persons with disability.

Of particular interest is the information obtained for research objective 1. The independent-samples $t$ test does not point to a significant correlation ($p = 0.869$) between reported physical activity levels and the built environment for the demographic

| Table 3-2 |

| Mean Value Comparison for Inactivity and the Built Environment |

<table>
<thead>
<tr>
<th>Disability classification$^a$</th>
<th>Yes to both</th>
<th>Uses equipment</th>
<th>Physical, mental, or emotional</th>
<th>No disability reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural disability level$^b$</td>
<td>1.77</td>
<td>1.85</td>
<td>1.97</td>
<td>2.24</td>
</tr>
<tr>
<td>Urban disability level$^b$</td>
<td>1.75</td>
<td>1.90</td>
<td>2.10</td>
<td>2.28</td>
</tr>
<tr>
<td>Significance ($p$)</td>
<td>0.372</td>
<td>0.218</td>
<td>0.002</td>
<td>0.130</td>
</tr>
</tbody>
</table>

*Note.* Participant information was gathered from the 2011 Utah BRFSS data, excluding responses for individuals under 18 or over 64.

$^a$ Disability status for this study was determined by a response to the following BRFSS core questions: “Are you limited in any activities because of physical, mental, or emotional problems?” or “Do you now have any health problem that requires you to use special equipment, such as a cane, a wheelchair, a special bed, or a special telephone?”

$^b$ See Methods section for a description of rural and urban classification of the built environment.
answering “yes” to both disability questions. Interestingly, the demographic in rural environments engaged in slightly more physical activity \((M = 1.77, SD = 1.143)\) on average than those residing in urban locations \((M = 1.75, SD = 1.119)\). This does not support the hypothesis that people ranked in this category of disability face more barriers to physical activity in the rural environment and is the only objective to report mean values contrary to the research assumptions.

The mean values for research objectives 2, 3, and 4 support the hypothesis that persons in rural environments engage in less physical activity than the comparable demographic in an urban environment. See Table 3-2 to compare values. This finding provides context and indicates some relation between the built environment and physical activity. Although these three research objectives individually did not conclude statistical significance, an independent-samples \(t\) test comparing people who answered ‘yes’ to both or either one of the disability questions yields different results.

The test was highly significant for \(t(1625.399) = -2.728, p = 0.006\). This result supports the hypothesis that rural individuals who responded affirmatively to the disability questions engaged in less physical activity \((M = 1.92, SD = 1.148)\) on average than those residing in urban locations \((M = 2.02, SD = 1.184)\). The 95% confidence interval for the difference in means ranges from -0.173 to -0.028. The small effect size \((d = -0.08)\), however, indicates why this may not have appeared on the independent-samples \(t\) test for individual comparisons between the research objectives.

Combined the three classifications for individuals with disability warrant high significance, which may be in part a result of research objective 3. The independent-
samples t test for individuals reporting limited use due to physical, mental, or emotional conditions yielded high statistical significance, \( p = 0.002 \). It is the only statistically significant research objective. The high significance of this variable may be what creates significance when combined with the other two disability classifications. Also the larger sample size of individuals in rural areas may impact the strong correlation between the two variables.

Exploring the reasons behind the high significance of this research objective may inform the complex relationship between activity, disability, and the built environment. Transportation issues, weather, negative support from caregivers, financial limitations, and inadequate awareness of exercise options are among the common barriers to physical activity (Bodde & Seo, 2009; Salmon, Owen, Crawford, Bauman, & Sallis, 2003).

**Conclusion**

In the western U.S., many of the participants of the 2011 BRFSS survey did not meet the recommended amount of physical activity, resulting in high rates of inactivity throughout the region. This research seeks to expand the current body of knowledge by exploring the correlation between physical activity by evaluating four classifications of disability based on the 2011 BRFSS survey.

Existing research confirms that features of the built environment have bearing on an individual’s propensity to engage in physical activity. The premise that populations residing in rural built environments are often the most unlikely to meet the recommended amounts of exercise is largely supported by the results. Although only those who
identified having a physical, mental, or emotional disability had a high statistical significance between physical activity and the built environment, research objectives 2 and 4 report means (M) that support the notion that rural persons engage in less exercise than those in urban communities.

Due to the lack of significance for research objectives 1, 2, and 4 we can conclude there are confounding variables that complicate physical activity engagement for individuals with disability. This mitigates the hypothesis of a strong relationship between levels of disability and participation in physical activity. Or rather, the levels of disability defined in this study are not impacted differently by the built environment. Further research should explore additional components of the rural environment that complicate the active health behaviors for individuals with disability.

References


CHAPTER 4

CONCLUSION

Summary

The intent of this thesis was to quantify the relationship between chronic disease and physical activity as they relate to the built environment for individuals with disability. Each element of research and the two distinct papers filtered the broad issues at hand to understand how and to what degree these measures correlate. Although both papers concluded the complexity of the relationship prompts additional research, the results provide valuable insight into the topic.

This section of the thesis briefly restates the research objectives of each paper and provides an overview of the major findings. There is also a discussion of study limitations and recommendations for future research that may contribute to a clearer understanding of the relationship of the study variables. Finally, the chapter concludes with an examination regarding how the content of this thesis has professional application to landscape architecture.

Chapter 2: Paper #1

The first paper focused on the built environment and its correlation to physical activity and chronic disease. Researching this topic led to a wealth of existing information describing how many chronic diseases can be avoided through adherence to the prescribed amounts of physical activity. Existing literature strongly supports the notion that the built environment influences an individual’s propensity to engage in
exercise and physical activity. Background research generally confirmed the initial assumptions that populations in rural environments are most often the least likely demographic to attain the recommended amounts of activity and tend to exhibit higher rates of chronic diseases such as hypertension, coronary heart disease, diabetes, obesity (Frost et al., 2010).

This paper focused on quantifying the notion that persons with disability in rural localities face increased barriers to physical activity and, by default, are at a higher risk for chronic diseases associated with sedentary lifestyles. The four research objectives defined the parameters of the independent-samples \( t \) tests utilized to determine statistical significance: (1) physical activity for individuals with disability in rural versus urban environments; (2) physical activity in rural environments for individuals with and without disability; (3) prevalence of chronic disease for individuals with disability in rural versus urban areas; and (4) prevalence of chronic disease in rural environments for individuals with and without disability. To a large extent, the results confirmed the validity of the hypothesis with statistical analysis reporting significance for three of the four research objectives 1 \((p = 0.007)\), 2 \((p = 0.000)\) and 4 \((p = 0.000\) for each chronic disease).

Although the study did not find statistical significance for objective 3, additional analysis of the data set suggests conflicting results that warrant further exploration regarding the complex relationship of the built environment to chronic disease. Of particular interest was the descriptive frequencies that indicated individuals with disability living in the most rural environments had higher rates of persons with two or more chronic diseases. The initial independent-samples \( t \) test only queried individuals
reporting at least one chronic disease. Those results found that rural populations with disability in Arizona, Nevada, Oregon, Utah, and Washington did not manifest significantly higher rates of chronic disease. The difference between the independent-samples t test and the descriptive frequencies highlights that the factors relating the built environment to manifestations of chronic disease in a population are multifaceted and should be further investigated.

Overall, this paper corroborates previous work that suggests populations residing in rural environments are not afforded the abundance of opportunities for physical activity prevalent in most urban networks. This paper also confirms the existing body of research and indicates high statistical significance relating physical activity engagement to the built environment. Furthermore, individuals with disability in rural communities face increased barriers to physical activity. Concerted effort to explore the correlation of the built environment and chronic disease for persons with disability is encouraged to more fully comprehend the factors at play.

**Chapter 3: Paper #2**

To build upon the statistical significance determined in Chapter 2, the second paper concentrates on physical activity and disability. Minimizing barriers to physical activity remains a high priority in the U.S. due to its effectiveness at preventing the compounding health problems associated with a sedentary lifestyle. The paper affirms that the built environment impacts an individual’s propensity to engage in physical activity, with populations residing in rural environments being less likely to meet the recommended amounts of activity. Persons with disability often face more barriers to
physical activity compared to those without a disability (Rimmer, Riley, Wang, Rauworth, & Jukowski, 2004). The paper hypothesized that the impact of the rural built environment on physical activity would likely be compounded for individuals with disabilities.

The methods for the paper in Chapter 3 are patterned after the first study of the thesis. The paper explores the relationship between rates of physical activity among varying disability classifications in rural versus urban communities in the western U.S. utilizing four research objectives: (1) rural and urban physical activity comparison for the highest disability classification; (2) rural and urban physical activity comparison for individuals with disability using equipment; (3) rural and urban physical activity comparison for individuals with disability resulting from physical, mental, or emotional impairments; and (4) rural and urban physical activity comparison for individuals not reporting disability.

The results did not yield high significance for the hypothesis based upon the parameters of the sample populations. Objective 3 yielded high statistical significance and suggests that the built environment is of important consequence for persons with disability resulting from physical, mental, or emotional impairments. The lack of significance for the research objectives 1 ($p = 0.869$), 2 ($p = 0.830$), and 4 ($p = 0.130$) indicates that the relationship between disability classifications and physical activity is many-sided and cannot be explained solely through the lens of the built environment.
Limitations

As discussed in the individual papers, one potential limitation is in regards to the proxy measure used to define rural built environments. Although an effective and acceptable parameter for defining rural locales, RUCA codes represent a geographical estimate. The approximated commuting times and distances of 2011 RUCA codes may distort the classification of some typologies, particularly for respondents living on the fringe of a given zip code. As such, some data may have been mistakenly classified as rural or urban and slightly altered the outcome of the statistical analysis.

The small effect sizes reported in each of independent-samples t tests also prompt the need examine additional variables and smaller populations to more accurately express the relationship between physical activity, chronic disease, and the built environment. The results of each research objective examined in this thesis provide varying degrees of statistical significance, leading to the conclusion that the built environment has bearing on a population’s participation in physical activity, chronic disease prevalence, and disability but cannot fully explain the intricate relationships. Further examination of each independent-samples t test corroborates existing research and substantiates the importance of evaluating the barriers to healthy behaviors among the population with disabilities.

Lastly, the criterion used to define disability, particularly for the study parameters found in Chapter 3, was dependent entirely on self-reporting and the questions of the BRFSS survey. Little existing research ranks disability and compares the impacts of physical activity and the built environment. The unprecedented nature of defining
disability based on two questions would likely be more effective if additional information on each individual, and their specific limitations, was available.

**Recommendations**

Risk for chronic disease mortality is largely attributed to physical inactivity, tobacco use, and nutrition (Bunnell et al., 2012). This thesis explores only one aspect—physical inactivity—and an exploration comparing tobacco use and nutrition to physical activity and the built environment could determine the degree to which each variable impacts the health status of persons with disability in rural environments. Similarly, other variables beyond physical activity that relate health to the built environment are important issues needing quantified research.

Further research should explore additional components of the rural environment that complicate the health status of individuals with disability. This could include access to health care and overall awareness or perceptions of chronic disease prevention. Additional studies evaluating planning policy and accessibility design standards for rural built environments could provide relevant and practical application to professionals that may lower the barriers preventing equitable participation in physical activity.

**Conclusion**

Although some results were contrary to the hypothesis, the outcome of each paper still largely confirm the notion that persons with disability in rural environments face greater health challenges when compared to individuals with disability in urban
communities and those without disability in rural areas. Available research and the findings contained in this thesis confirm that populations residing in rural environments are less likely to meet the recommended amounts of activity and subsequently exhibit slightly higher rates of hypertension, coronary heart disease, diabetes, and obesity. Also, there is a relatively strong correlation between mental well being and the ability to participate in physical activity. Despite consistently small effect sizes and some insignificant results, the findings are of value to future research efforts and professionals in related fields.

The built environment provides a platform for understanding one of the major hurdles to increasing physical activity and exercise in the U.S. Interdisciplinary work between health and design professionals could be one component of the necessary catalyst to reduce the physical barriers to exercise. Some promising collaboration currently exists between professional organizations for landscape architects, architects, and planners that link these skill sets to those of public health officials and policy makers. As these relationships progress and become integral to the professions at large, the resulting dialogue and research will be particularly enlightening.

Design and planning professionals are often put in a position to incorporate design standards that could promote healthy living in prominent projects. Evaluations of walkable neighborhoods showing increased exercise levels and decreased rates of obesity and associated chronic diseases exist but need to be further integrated into the design process (Bunnell et al., 2012; Ewing, 2005; Frank et al., 2006; Jackson, 2003; King & Clarke, 2014). Continued research in this area will provide more quantifiable benefits and
metrics for design and planning that may broaden the grants and other funding enterprises available for development.

The specific implications of this study for landscape architecture and planning are varied. Continued emphasis on the positive effect of sensibly connected walkways, mixed-use development, and human-scaled environments may lead to higher quality developments that promote physical exercise. Studies such as this thesis continue the dialogue in hopes of decreasing automobile dependency and improving universal accessibility as a means of tackling broad health issues (Jackson, 2003). Proximity and continuity remain major features that enhance engagement in physical activity. Increased attention to these components may render useful regarding the health epidemic surrounding hypertension, heart disease, mental wellbeing, diabetes, and obesity area key health indicators (Bauer, Briss, Goodman, & Bowman, 2014; Heath et al., 2012; Sturm & Cohen, 2004).

Knowing the location of populations at an increased risk for chronic disease and discussing the various demographics that face increased barriers to physical activities will provide specific areas where targeted solutions should be explored. Designers and planners with an impact in rural communities should evaluate policies and design standards that decrease the impediments to physical activity for individuals with disability. By minimizing the barriers to physical activity for those who find it most difficult, the obstacles created by the built environment will be lessened and positively impact all members of the community.


APPENDICES
Appendix A

Primary and Secondary RUCA Codes, 2010
**Primary RUCA Codes, 2010**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Metropolitan area core: primary flow within an urbanized area (UA)</td>
</tr>
<tr>
<td>2</td>
<td>Metropolitan area high commuting: primary flow 30% or more to a UA</td>
</tr>
<tr>
<td>3</td>
<td>Metropolitan area low commuting: primary flow 10% to 30% to a UA</td>
</tr>
<tr>
<td>4</td>
<td>Micropolitan area core: primary flow within an Urban Cluster of 10,000 to 49,999 (large UC)</td>
</tr>
<tr>
<td>5</td>
<td>Micropolitan high commuting: primary flow 30% or more to a large UC</td>
</tr>
<tr>
<td>6</td>
<td>Micropolitan low commuting: primary flow 10% to 30% to a large UC</td>
</tr>
<tr>
<td>7</td>
<td>Small town core: primary flow within an Urban Cluster of 2,500 to 9,999 (small UC)</td>
</tr>
<tr>
<td>8</td>
<td>Small town high commuting: primary flow 30% or more to a small UC</td>
</tr>
<tr>
<td>9</td>
<td>Small town low commuting: primary flow 10% to 30% to a small UC</td>
</tr>
<tr>
<td>10</td>
<td>Rural areas: primary flow to a tract outside a UA or UC</td>
</tr>
<tr>
<td>99</td>
<td>Not coded: Census tract has zero population and no rural-urban identifier information</td>
</tr>
</tbody>
</table>
**Secondary RUCA Codes, 2010**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Sub-Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Metropolitan area core: primary flow within an urbanized area (UA)</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.1</td>
</tr>
<tr>
<td>2</td>
<td>Metropolitan area high commuting: primary flow 30% or more to a UA</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.1</td>
</tr>
<tr>
<td>3</td>
<td>Metropolitan area low commuting: primary flow 10% to 30% to a UA</td>
<td>3.0</td>
</tr>
<tr>
<td>4</td>
<td>Micropolitan area core: primary flow within an Urban Cluster of 10,000 to 49,999 (large UC)</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.1</td>
</tr>
<tr>
<td>5</td>
<td>Micropolitan high commuting: primary flow 30% or more to a large UC</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.1</td>
</tr>
<tr>
<td>6</td>
<td>Micropolitan low commuting: primary flow 10% to 30% to a large UC</td>
<td>6.0</td>
</tr>
<tr>
<td>7</td>
<td>Small town core: primary flow within an Urban Cluster of 2,500 to 9,999 (small UC)</td>
<td>7.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.1</td>
</tr>
<tr>
<td>8</td>
<td>Small town high commuting: primary flow 30% or more to a small UC</td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.1</td>
</tr>
<tr>
<td>9</td>
<td>Small town low commuting: primary flow 10% to 30% to a small UC</td>
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<td>10</td>
<td>Rural areas: primary flow to a tract outside a UA or UC</td>
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</tr>
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<td></td>
<td></td>
<td>10.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10.2</td>
</tr>
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</tr>
<tr>
<td>99</td>
<td>Not coded: Census tract has zero population and no rural-urban identifier information</td>
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</tbody>
</table>
Appendix B

Activity Metabolic Equivalent Values
<table>
<thead>
<tr>
<th>Activity Description</th>
<th>METs</th>
<th>Aerobic Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active gaming devices (Wii Fit, Dance Revolution)</td>
<td>3.8</td>
<td>Yes</td>
</tr>
<tr>
<td>Aerobics video or class</td>
<td>7.3</td>
<td>Yes</td>
</tr>
<tr>
<td>Backpacking</td>
<td>7.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Badminton</td>
<td>5.5</td>
<td>Yes</td>
</tr>
<tr>
<td>Basketball</td>
<td>6.5</td>
<td>Yes</td>
</tr>
<tr>
<td>Bicycling machine exercise</td>
<td>6.8</td>
<td>Yes</td>
</tr>
<tr>
<td>Bicycling machine exercise</td>
<td>6.8</td>
<td>Yes</td>
</tr>
<tr>
<td>Boating (Canoeing, rowing, kayaking, sailing for pleasure)</td>
<td>5.8</td>
<td>Yes</td>
</tr>
<tr>
<td>Bowling</td>
<td>3.8</td>
<td>Yes</td>
</tr>
<tr>
<td>Boxing</td>
<td>12.8</td>
<td>Yes</td>
</tr>
<tr>
<td>Calisthenics</td>
<td>38.</td>
<td>Yes</td>
</tr>
<tr>
<td>Canoeing/rowing in competition</td>
<td>12.5</td>
<td>Yes</td>
</tr>
<tr>
<td>Carpentry</td>
<td>3.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Dancing-ballet, ballroom, Latin, hip hop, etc.)</td>
<td>7.8</td>
<td>Yes</td>
</tr>
<tr>
<td>Elliptical/EFX machine exercise</td>
<td>5.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Fishing from river bank or boat</td>
<td>3.5</td>
<td>Yes</td>
</tr>
<tr>
<td>Frisbee</td>
<td>3.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Gardening (spading, weeding, digging, filling)</td>
<td>5.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Golf (with motorized cart)</td>
<td>3.5</td>
<td>Yes</td>
</tr>
<tr>
<td>Golf (without motorized cart)</td>
<td>4.3</td>
<td>Yes</td>
</tr>
<tr>
<td>Handball</td>
<td>12.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Hiking--cross-country</td>
<td>6.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Hockey</td>
<td>8.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Horseback riding</td>
<td>5.5</td>
<td>Yes</td>
</tr>
<tr>
<td>Hunting large game--deer, elk</td>
<td>6.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Hunting small game--quail</td>
<td>5.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Inline skating</td>
<td>9.8</td>
<td>Yes</td>
</tr>
<tr>
<td>Jogging</td>
<td>7.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Lacrosse</td>
<td>8.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Mowing lawn</td>
<td>5.5</td>
<td>Yes</td>
</tr>
<tr>
<td>Paddleball</td>
<td>6.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Painting/papering house</td>
<td>3.3</td>
<td>Yes</td>
</tr>
<tr>
<td>Pilates</td>
<td>3.0</td>
<td>No</td>
</tr>
<tr>
<td>Racquetball</td>
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<td>Yes</td>
</tr>
<tr>
<td>Raking lawn</td>
<td>3.8</td>
<td>Yes</td>
</tr>
<tr>
<td>Running</td>
<td>6.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Rock climbing</td>
<td>8.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Rope skipping</td>
<td>11.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Rowing machine exercise</td>
<td>7.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Activity Description</td>
<td>METs</td>
<td>Aerobic Activity</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>------</td>
<td>------------------</td>
</tr>
<tr>
<td>Rugby</td>
<td>6.3</td>
<td>Yes</td>
</tr>
<tr>
<td>Scuba diving</td>
<td>7.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Skateboarding</td>
<td>5.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Skating--ice or roller</td>
<td>7.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Sledding, tobogginning</td>
<td>7.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Snorkeling</td>
<td>5.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Snow blowing</td>
<td>2.5</td>
<td>Yes</td>
</tr>
<tr>
<td>Snow shoveling by hand</td>
<td>5.3</td>
<td>Yes</td>
</tr>
<tr>
<td>Snow skiing</td>
<td>7.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Snowshoeing</td>
<td>5.3</td>
<td>Yes</td>
</tr>
<tr>
<td>Soccer</td>
<td>7.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Softball/baseball</td>
<td>5.0</td>
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</tr>
<tr>
<td>Squash</td>
<td>7.3</td>
<td>Yes</td>
</tr>
<tr>
<td>Stair climbing/Stairmaster</td>
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</tr>
<tr>
<td>Stream fishing in waders</td>
<td>6.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Surfing</td>
<td>3.0</td>
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</tr>
<tr>
<td>Swimming</td>
<td>6.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Swimming in laps</td>
<td>5.8</td>
<td>Yes</td>
</tr>
<tr>
<td>Table tennis</td>
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<td>Yes</td>
</tr>
<tr>
<td>Tai Chi</td>
<td>4.0</td>
<td>No</td>
</tr>
<tr>
<td>Tennis</td>
<td>7.3</td>
<td>Yes</td>
</tr>
<tr>
<td>Touch football</td>
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</tr>
<tr>
<td>Volleyball</td>
<td>3.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Walking</td>
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</tr>
<tr>
<td>Waterskiing</td>
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<td>Yes</td>
</tr>
<tr>
<td>Weight lifting</td>
<td>3.5</td>
<td>No</td>
</tr>
<tr>
<td>Wrestling</td>
<td>6.0</td>
<td>Yes</td>
</tr>
<tr>
<td>Yoga</td>
<td>2.5</td>
<td>No</td>
</tr>
<tr>
<td>Other____</td>
<td></td>
<td></td>
</tr>
<tr>
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Appendix C

Reported Activities for Individuals with Disability
Table C-1

*Reported Activities for Individuals with a Disability*\(^a\)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Valid percent</th>
<th>Urban disability</th>
<th>Rural disability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active gaming devices</td>
<td></td>
<td>.2</td>
<td>.1</td>
</tr>
<tr>
<td>Aerobics video or class</td>
<td></td>
<td>1.9</td>
<td>.8</td>
</tr>
<tr>
<td>Basketball</td>
<td></td>
<td>.6</td>
<td>.8</td>
</tr>
<tr>
<td>Bicycling exercise machine</td>
<td></td>
<td>2.5</td>
<td>2.9</td>
</tr>
<tr>
<td>Bicycling</td>
<td></td>
<td>3.4</td>
<td>2.5</td>
</tr>
<tr>
<td>Boating</td>
<td></td>
<td>.1</td>
<td>--</td>
</tr>
<tr>
<td>Bowling</td>
<td></td>
<td>.2</td>
<td>--</td>
</tr>
<tr>
<td>Calisthenics</td>
<td></td>
<td>1.1</td>
<td>.7</td>
</tr>
<tr>
<td>Canoeing/ rowing-in competition</td>
<td></td>
<td>.0</td>
<td>--</td>
</tr>
<tr>
<td>Carpentry</td>
<td></td>
<td>.0</td>
<td>--</td>
</tr>
<tr>
<td>Dancing-ballet, ballroom, Latin, hip-hop</td>
<td></td>
<td>.8</td>
<td>.6</td>
</tr>
<tr>
<td>Elliptical/ EFX machine</td>
<td></td>
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<td>1.1</td>
</tr>
<tr>
<td>Fishing from riverbank or boat</td>
<td></td>
<td>.1</td>
<td>.3</td>
</tr>
<tr>
<td>Frisbee</td>
<td></td>
<td>.0</td>
<td>--</td>
</tr>
<tr>
<td>Gardening</td>
<td></td>
<td>8.2</td>
<td>9.7</td>
</tr>
<tr>
<td>Golf (w/ motorized cart)</td>
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<td>.6</td>
<td>1.0</td>
</tr>
<tr>
<td>Golf (w/out motorized cart)</td>
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<td>.4</td>
<td>.4</td>
</tr>
<tr>
<td>Hiking-cross-country</td>
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<td>2.5</td>
</tr>
<tr>
<td>Hockey</td>
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<td>.0</td>
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</tr>
<tr>
<td>Horseback riding</td>
<td></td>
<td>.2</td>
<td>.6</td>
</tr>
<tr>
<td>Jogging</td>
<td></td>
<td>.6</td>
<td>.4</td>
</tr>
<tr>
<td>Lacrosse</td>
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</tr>
<tr>
<td>Mountain climbing</td>
<td></td>
<td>.0</td>
<td>--</td>
</tr>
<tr>
<td>Mowing lawn</td>
<td></td>
<td>.1</td>
<td>.4</td>
</tr>
<tr>
<td>Painting/ papering house</td>
<td></td>
<td>.0</td>
<td>.1</td>
</tr>
<tr>
<td>Pilates</td>
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<tr>
<td>Racquetball</td>
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<tr>
<td>Running</td>
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<td>3.2</td>
<td>2.6</td>
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<td>Rock climbing</td>
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<tr>
<td>Rope skipping</td>
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</tr>
<tr>
<td>Rowing machine exercise</td>
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<tr>
<td>Skating -ice or roller</td>
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<td>0</td>
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</tr>
<tr>
<td>Snow shoveling by hand</td>
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<td>0</td>
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*(table continues)*
<table>
<thead>
<tr>
<th>Activity</th>
<th>Valid percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Urban disability</td>
</tr>
<tr>
<td>Snow skiing</td>
<td>.3</td>
</tr>
<tr>
<td>Soccer</td>
<td>.2</td>
</tr>
<tr>
<td>Softball/ baseball</td>
<td>.1</td>
</tr>
<tr>
<td>Stair climbing/ stair master</td>
<td>.3</td>
</tr>
<tr>
<td>Surfing</td>
<td>.0</td>
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<tr>
<td>Swimming</td>
<td>1.3</td>
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<td>Swimming in laps</td>
<td>.8</td>
</tr>
<tr>
<td>Table tennis</td>
<td>.0</td>
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<tr>
<td>Tai Chi</td>
<td>.1</td>
</tr>
<tr>
<td>Tennis</td>
<td>.2</td>
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<td>Volleyball</td>
<td>.1</td>
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<tr>
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<tr>
<td>Weightlifting</td>
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<tr>
<td>Yoga</td>
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<td>Other</td>
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<tr>
<td>Total</td>
<td>100.0</td>
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<tr>
<td>Don’t know/ Not sure</td>
<td>--</td>
</tr>
<tr>
<td>Refused</td>
<td>--</td>
</tr>
</tbody>
</table>

*Note: Values represented as “0” represent one individual in the study population reported the activity.*

a Participant information was gathered from the 2011 Utah BRFSS data, excluding responses for individuals under 18 or over 64. The frequencies shown above represent the answers provided by all individuals with disability living the urban built environment.