Spring 5-2019

# ASSESSING THE IMPACT OF ENVIRONMENTAL FACTORS ON SEDENTARY BEHAVIOR

BRANDY BAKER
*UTHealth School of Public Health*

# ASSESSING THE IMPACT OF ENVIRONMENTAL FACTORS ON SEDENTARY BEHAVIOR

by

BRANDY BAKER, BS, MPH

APPROVED:

BELINDA REININGER, DRPH

BELINDA REININGER, DRPH

MINJAE LEE, PHD

CLINT PINION, DRPH

VANESSA SCHICK, PHD

DEAN, THE UNIVERSITY OF TEXAS
SCHOOL OF PUBLIC HEALTH

DEDICATION

To God and my family

# ASSESSING THE IMPACT OF ENVIRONMENTAL FACTORS ON SEDENTARY BEHAVIOR

by

BRANDY NICOLE BAKER

BS, Eastern Kentucky University, 2008

MPH, Eastern Kentucky University, 2010

Presented to the Faculty of The University of Texas

School of Public Health

in Partial Fulfillment

of the Requirements

for the Degree of

DOCTOR OF PUBLIC HEALTH

THE UNIVERSITY OF TEXAS
SCHOOL OF PUBLIC HEALTH
Houston, Texas
May, 2019

# PREFACE

I come from a family that encourages you to go as far as you can and accomplish whatever goals you set your mind to. We are all in professions that help people in one form or another and I wanted to continue that tradition. Acquiring a doctorate in any field is a noble ambition and many people in my family serve in a medical capacity. I wanted to do something different. I wanted to work with people to help change the world. Change can be accomplished one person at a time, but I wanted to see what would happen if you could change the disparities entire populations experience. So here I am…ready to make the world a better place.

# ACKNOWLEDGEMENTS

Completion of this dissertation would not have been possible without the substantial amount of support and tough love I have received during this process. I would like to sincerely thank my committee chair and advisor, Dr. Belinda Reininger, for all her work on this project. She not only allowed me to use her data but was also extremely patient with me throughout the years with the topic changes, delays, and tears. She stayed with me through committee and advisor changes and remained positive. Though tough, I have appreciated her candor and leadership throughout the writing process.

Dr. MinJae Lee and Dr. Vanessa Schick were valuable members of my committee. They may have been late additions when I was scrambling to find committee members, but, they too, have provided wonderful incite and suggestions. Statistics was never my strong suit, but Dr. Lee has been instrumental in explaining what additions and why I need them to build a stronger case. Dr. Schick really stressed the importance of continuing to link my dissertation topic and explanations throughout the chapters. They helped me strengthen my methods and build a solid foundation.

I would like to thank Dr. Clint Pinion for being a part of my committee. Not living in Texas has had its drawbacks. Being able to meet with a knowledgeable faculty member—within a two-hour drive—has set my mind at ease more often than I care to admit. He has met with me several times and has always been patient and understanding with the barrage of questions hurdled his way about the dissertation process. He guided me and my sanity with calm winds in my otherwise circuitous dissertation journey.

Special thanks go to Dr. Enmanuel Chavarria and Dr. James Klyza. Dr. Chavarria served as my external reviewer for my dissertation defense. He probably provided the toughest feedback but remained positive and supportive throughout our communication. I really appreciated the time and effort he put into editing my document. Dr. Klyza stood with me for the analysis portion of the dissertation. He helped me navigate the statistical waters of SAS with numerous meetings and resiliently steered through the bombardment of emails and questions with humor and understanding.

Above all, I would like to thank my family for all the behind the scenes work that salvaged all vestiges of sanity. They sailed through oceans muddled with desolation and misery as expertly as they would the seas peppered with triumph. Quite often, I could be found brooding in a corner, ready to throw my hands up. My family remained steady; never shying away from the fog, just coursing through in quiet acceptance and some tough love.

Without all of you, this dissertation would not have been completed. I am sincerely thankful for the opportunity I have been given to work with each of you. This journey has been long and taxing, but it provided me with knowledge and skills I can take with me into my career in public health. Thank you for everything.

# ASSESSING THE IMPACT OF ENVIRONMENTAL FACTORS ON SEDENTARY BEHAVIOR

Brandy Nicole Baker, BS, MPH, DrPH
The University of Texas
School of Public Health, 2019

Dissertation Chair: Belinda Reininger, DRPH

**Objectives**

Mexican Americans are burdened with many of the same noncommunicable diseases present in sedentary populations. Those living on the Texas/Mexico border have higher rates of obesity and diabetes than others in the nation. Sedentary behavior and perceptions of the environment have not been well studied among Mexican Americans, especially when examining education, gender and age.

**Study Design**

Sample was drawn from the Cameron County Hispanic Cohort (CCHC) where participants were randomly selected and completed a survey to report sedentary behavior and perceptions of the environment among other examinations. The participants' initial visit with the CCHC was included in the analysis.

**Methods**

Descriptive statistics and logistic regression tested the effect of protective and risk factors on sedentary lifestyle. Age, gender, and education were examined as effect

modifiers.  Using Kingdon's window theory, a policy brief on H.R. 228—Increase Transportation Alternatives Act of 2019 was developed to disseminate results.

**Results**

The overall adjusted logistic regression model demonstrated that each unit increase in protective environmental factors, years of education, and being female lowered the odds of being sedentary.  For each unit increase in age and risk environmental factors, sedentary behavior increased.

**Conclusions**

In an adjusted model, the environmental protective and risk factors had a measurable effect on the odds of being sedentary.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

# SEDENTARY BEHAVIOR

## Background

Many studies suggest that a lack of transportation, sidewalks, streetlights and other environmental amenities pose barriers to active living in all populations, resulting in less than optimal long-term mobility and numerous health repercussions (Beard et al., 2009; Owen et al., 2010; Botticello et al., 2015; Clarke & George, 2005). Moreover, nearly half of all adults aged 45 years or more have mobility issues that are often compounded by environmental factors (Altman & Bernstein, 2008; Rosenburg et al, 2012). While these studies begin to describe a relationship between the built environment and sedentary behavior, the extent of this relationship and its impact needs to be explored further. The work in the current document strives to: cultivate a more comprehensive understanding of the relationship between specific environmental factors and sedentary behavior. This understanding will provide actionable data that can inform public policy now and into the future.

Some of the biggest health issues affecting our communities today often stem from a larger epidemic that is affecting every country, social status, and age without prejudice—sedentary behavior (Bloom et al., 2011). For those living chronically sedentary lifestyles, resulting health issues include a wide range of non-communicable diseases: obesity (Pate et al, 2008; Wu et al., 2017; Radwan et al., 2018), cardiovascular disease (Wu et al., 2017; Falck et al., 2017: Nooijen et al, 2019), type 2 diabetes (Falck et al, 2017; Wu et al., 2017; Diaz et al., 2017), cancer (Conroy et al, 2013; Siddique et al., 2015), impaired psychological health (Nooijen et

al., 2019), risk of cognitive impairment and decreased cognitive function (Pate et al, 2008; Wu et al., 2017; Falck et al, 2017; Nooijen et al, 2019), decreased quality of life (Bloom et al., 2011), all-cause mortality (Pate, 2008; Wu et al., 2017), and reduced longevity (Pate et al, 2008). These illnesses/disorders affect positive community participation by prolonging disability and driving more people under the poverty line (Bloom et al., 2011).

Furthermore, non-communicable diseases associated with sedentary lifestyle pose an economic threat to communities, often leading to decreased productivity (e.g. quality of work, absence rates) (Bloom et al., 2011), increased strain on family resources (Bloom et al., 2011), and increased disease-specific health service demand (Radwan et al., 2018). Together, these outcomes threaten community growth, development, and amplify social inequalities (Bloom et al., 2011).

With this health crisis in perspective, reducing sedentary behaviors represents an important step toward strengthening communities (Bloom et al., 2011). Existing literature strongly supports the societal benefits of exercise (Owen et al., 2010; Ruegsegger & Booth, 2018), justifying ongoing efforts to keep communities active. However, a bigger question remains: How do a given community's *environmental* aspects influence the prevalence of sedentary behavior?

By 2050, the United States is expected to have a Hispanic population of 30% (Fisher-Hoch et al., 2012). Among Hispanics, the largest ethnically distinct subgroup is the Mexican-American population (Fisher-Hoch et al., 2012). Mexican-Americans are at high risk for non-communicable diseases (e.g. obesity, diabetes,

cardiovascular disease) and those living on the Texas and Mexico border have higher rates of diabetes, obesity, and hypertension than in other areas in the nation (Fisher-Hoch et al., 2012). Obesity rates in Mexican-Americans on the U.S. border, for instance, are 50% compared to the national rate in Mexican Americans of 39.3% (Fisher-Hoch et al., 2012). Cameron County, Texas located on the Mexico border, has some of the poorest communities in the U.S. with low high school graduation rates and low incomes amongst their predominantly Mexican-American population (Fisher-Hoch et al., 2012). Sedentary behavior (which is independent of physical activity) could be one factor contributing to the prevalence of non-communicable disease in the Mexican American population as it shares many of the same disease outcomes. The question remains as to whether environmental factors can impact sedentary behaviors in Mexican-Americans on the Texas/Mexico border.

As it stands, existing scholarship in the field of public health falls short on understanding how specific environmental factors influence sedentary behavior. Therefore, the motivation behind the current study is to examine how environmental factors impact sedentary behavior by: sorting those factors into two categories (e.g. protective or risk); analyzing their impact on sedentary behavior; and proposing recommendations to researchers and policy makers to decrease barriers in the environment.

## Review of Existing Scholarship

An adapted socio-ecologic framework guided review of the literature (Hafoka, 2017; Sallis et al., 2006). We focused on the following constructs: individual, social, built, and policy environmental levels (Figure 1). By focusing on the individual, social, and built environments, researchers can find and define connections or relationships that suggest the need for systemic change that would encourage policy makers to act and implement the necessary adjustments to community landscapes.

To mitigate the lack of research on sedentary behavior's relationship with the built environment, we must consider certain established metrics for evaluating societal wellbeing: livability; sustainability; motivations for choosing residential locations; types of community spaces available. Considering these metrics, several key themes emerge in the existing literature, supporting the need to further examine the relationship of sedentary behaviors and the built environment.

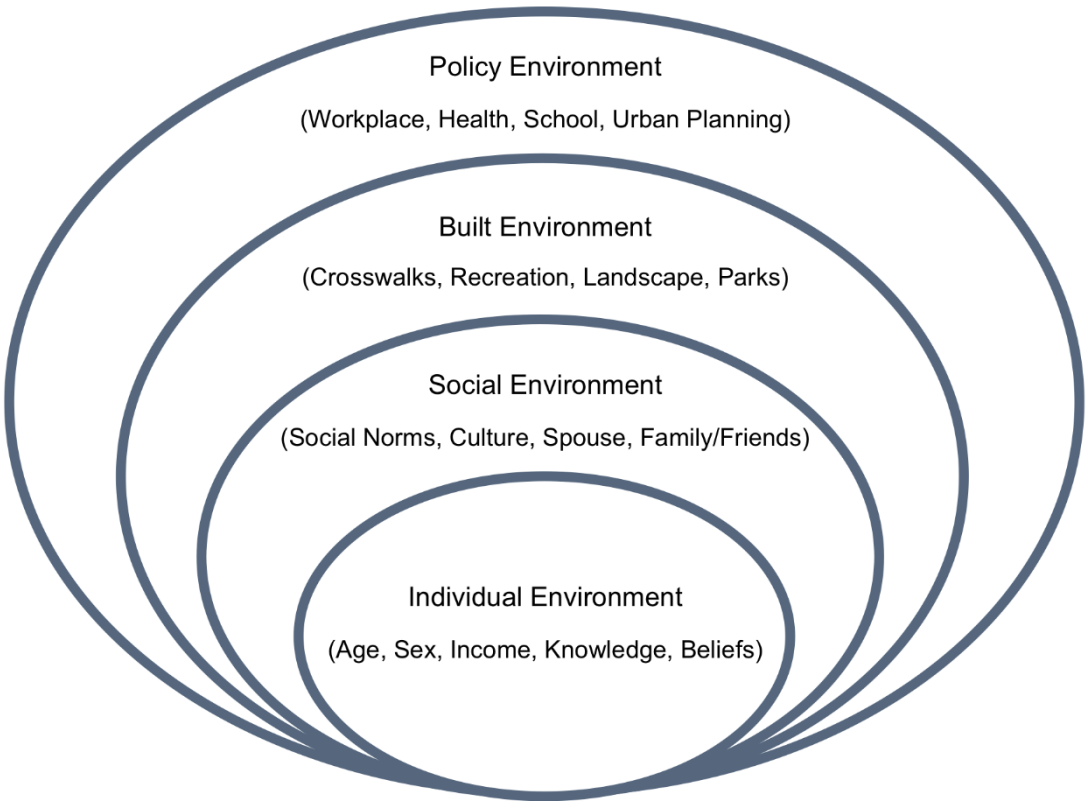


**Figure 1. Socio-ecologic model**
Modified by Hafoka (2017) from a previous version listed in Sallis et al (2006).

Using the framework exhibited in Figure 1, the following themes are listed from characteristics of the microsystem (individual environment) to the macro system (Policy):

* Understanding Sedentary Behavior (Individual Environment)

* Physical Inactivity (Individual Environment)

* Demographic Influences on Sedentary Behavior (Individual Environment)

* Social Participation (Social environment)

* Safety (Social environment)

* Livability versus Sustainability (Built environment)

* Built Environment (Built environment)

* The Role of Policy (Policy Environment)

**Understanding sedentary behavior**

Sedentary behavior is independent of physical activity and involves the expenditure of little to no energy during waking activities (Han et al., 2017). Sedentary behavior encourages prolonged time sitting, reclining, or lying down (i.e. video games, reading, listening, watching TV, using a computer) (Han et al., 2017). Physical activity differs, as it results in improved physical fitness and increased energy expenditure involving activities or behaviors that encourage human movement (Han et al., 2017). According to Han and colleagues (2017), this separation implies that even when the recommendation for moderate-intensity physical activity of at least 150 minutes (preferably not accomplished in one event) is met, that an active individual can still be sedentary. Physical activity and sedentary behavior have an inverse relationship where engagement in sedentary behavior times indicate how likely that same individual is willing to participate in physical activity (Han et al., 2017). These implications are considered controversial and Han and colleagues (2017) recommend further study of physical activity and sedentary behavior because much of this relationship remains unclear. For the purpose of this study, sedentary behavior is studied as the inverse of physical activity.

According to Wu et al. (2017), sedentary behavior—defined in their study as use of screen-based media (e.g. television, using computer/smartphones, playing video games)—also contributes to delayed cognitive development, decreased academic achievement among youth, decreased physical and mental health and decreased psychosocial well-being. In studying the effects of sedentary behaviors on health-related quality of life (HRQoL), longer sedentary times (i.e. greater than 2 hours a day) had a negative impact on HRQoL among children/adolescents (Wu et al., 2017). Researchers estimated the negative effect would continue to rise as sedentary times continue to increase (Wu et al., 2017). Recommended next steps in research include examining other causal mechanisms because the variables examined (i.e. weight status, age, sex, and socioeconomic characteristics) did not affect the relationship between HRQoL and physical activity (Wu et al., 2017).

**Physical Inactivity**

While physical inactivity and sedentary behaviors are not exactly the same constructs, they are related. Over the last decades, physical inactivity increased globally to one in five adults leading predominantly inactive lives (Koohsari et al., 2018). The World Health Organization (WHO) recently indicated that the fourth leading risk factor of global mortality was physical inactivity, accounting for an annual death toll of 3.2 million and 5.8% of all deaths worldwide (Vuori et al, 2010).

Studies show empirical evidence that suggests insufficient physical activity contributes to premature mortality, and increases the occurrence of non-

communicable diseases, such as obesity, coronary heart disease, cardiovascular disease, and impaired mental health (Smith et al., 2017; Ellis et al, 2018; Wu et al., 2017). Sedentary behaviors are noticeably becoming a pressing public health concern in adults as well as children (Flegal et al., 2010; Rodriguez et all, 2011).

Koohsari et al. (2018) state that the built environment's role in supporting active behavior should be recognized. As expressed in literature (Owen et al., 2010; Ruegsegger & Booth, 2018), health benefits of physical activity include a 47% reduction in mortality. Addressing environmental barriers to active living may also substantially improve health outcomes in the general population (Smith et al., 2017; Ellis et al, 2018). Furthermore, results from physical activity studies listed above suggest individual motivation (which is habitual in nature), may not be solely responsible for determining barriers to active living (Koohsari et al., 2018). This implies environmental factors play a major role in defining and limiting active behaviors but the extent of that role needs to be studied further (Koohsari et al., 2018).

**Demographic Influences on Sedentary Behavior.**

***Mexican American Population.*** In a 2016 study, a Mexican-American population was examined to determine if obesity rates and acculturation were mediated by physical activity levels/sedentary behavior (Murillo et al., 2016). Obesity prevalence is higher among Hispanics than among non-Hispanic Whites and non-Hispanic Blacks, with obesity rates in Hispanic children/adolescents at 26%

and adults at 47% (McDonald et al., 2018). Studies involving racial and ethnic groups have reported large disparities in the prevalence of obesity (Murillo et al., 2016). In foreign-born Mexican-Americans, obesity rates are believed to have been influenced by changes in physical activity as these individuals adapted to the U.S. beliefs, attitudes, and culture (Murillo et al., 2016). Murillo and colleagues (2016) found that sedentary behavior accounted for 40.7-57.1% of the total effect, and was the strongest mediator of the association between obesity and acculturation in foreign-born Mexican-Americans who had lived in the US for at least ten years. It was speculated this was due to less occupational physical activity as employment opportunities, other than manual labor, increased with acculturation (Murillo et al., 2016). The increase in sedentary times was also suspected to be a result of the type of occupation and transportation activity as socioeconomic status increased over time (Murillo et al., 2016). Murillo and colleagues (2016) emphasized that literature supported their findings of an increased prevalence of sedentary behaviors resulting in a greater risk of obesity and that further research should be conducted on the Mexican-American population and sedentary behaviors.

***Age.*** Focusing on the built environment—specifically to understand how it enables or hinders activity—is crucial with the increasing median age worldwide (Ellis et al., 2018). Subsequently, research should focus on understanding environmental factors and their relationship with active living. A strong collinearity exists between active lifestyle and social participation; thus, many barriers to active living are barriers to social participation (Levesseur et al., 2017).

Recent studies found insufficient evidence for sedentary behavior determinants for children in the following domains: physical environmental; social & cultural; behavioral; psychological, cognitive & emotional; and demographic & biological (Hidding et al., 2017). The few relevant studies that focused directly on children examined determinants only once and focused on screen time as the major indicator of sedentary behavior (Hidding et al., 2017). Hidding and colleagues (2017) stated that many studies were implemented without specifically exploring determinants designed for children and only concern characteristics of the children that do not address the motivations behind sedentary behavior. For effective intervention design, engagement in sedentary behavior has to be assessed using motivational and contextual reasons, not just characteristics of the population (Hidding et al., 2017). In the social & cultural domain, as well as the physical/environmental domain, Hidding and colleagues (2017) study on children and their parents found several important determinants for sedentary behavior. One of the most important of those, affecting both children and their parents, was “I sit because I can work/play better that way” (Hidding et al., 2017). Other reasons included: children feeling like they have to sit--it is the norm--or having no one to play with. However, there was very little feedback on the demographic and biological domain (Hidding et al., 2017). Hidding and colleagues (2017) explicitly noted the lack of response on the demographic and biological domain because previous studies extensively discuss this domain. Weather conditions (e.g. hot temperatures, rain, coldness) and safety were potential determinants of sedentary behavior, as

indicated by children in the study (Hidding et al., 2017). Many of the statements relating to sedentary behavior in the school environment indicated that the activities children participate in could be done while sitting; thus, if schools have classrooms that are more conducive to physical activities or active behaviors, children may spend less time being sedentary (Hidding et al., 2017).

Literature also falls short on identifying sedentary behavior determinants in older adults (Shaw et al., 2017). Due to a limited number of studies utilizing socio-ecological determinants of sedentary behavior, Shaw and colleagues (2017) investigated how neighborhood/social environmental factors impacted the percentage of sedentary behavior in older adults, averaged over seven days. Few of these studies (citing only three at the time of their study) quantitatively investigated the importance of specific aspects in a social and environmental context among older adults (Shaw et al., 2017). Shaw and colleagues (2017) used five categories to classify the independent variables: “objective neighborhood, subjective neighborhood, social support, social participation, and home environment measures.” Findings suggested an association between age and increased sedentary behavior, where average sedentary time comprised 65-80% of an older adult’s waking day (Shaw et al., 2017). Increased sedentary time was also associated with crime rates across all cohorts even after adjusting for socioeconomic demographic factors (Shaw et al., 2017). Depending on how researchers measure activity within different aspects of the environment, the results can vary for different groups (e.g. crime impacts older adults more so than younger adults) (Shaw et al.,

2017). Though disputed, people in the earlier period of old age (i.e. between 65-74), known as the Third Age, may experience a greater sense of freedom or agency to pursue leisure activities; this is possibly due to the restrictions and constraints of employment no longer being relevant, while not being subject to the degree of infirmity or poverty that older ages experience (Shaw et al., 2017). The Third Age and newly retired may be the most susceptible to interventions intended to reduce sedentary behavior, because the social and physical environment play a more influential role in their lives (Shaw et al., 2017).

Ellis and colleagues (2018) state that shifts in demographic profiles can have significant implications for changes in policy fields (i.e. transport, planning, housing, etc.). For example, an elderly demographic may considerably impact health and social care; policies should then be reevaluated or developed based on the projected impact of that population change (Ellis et al., 2018). Koohsari et al. (2018) indicated the occurrence of "super-aged" societies—a society where people aged 65 or older make up more than 20% of total population—is increasing around the world. The increasing prevalence of super-aged societies supports the need for more research on reducing barriers to activity in the environment, thereby allowing people to remain independent for as long as possible. By 2050, it is expected that the population of people aged 60 years or older will double compared to 2017; likewise, those aged 80 years and older will triple to an estimated 392 million worldwide (Koohsari et al., 2018; Ellis et al., 2018). Longevity will increasingly strain public

health budgets and services in the years to come and likely cause significant social transformation (Ellis et al., 2018).

When conducting social participation studies in aging populations, there are benefits and concerns for choosing rural or urban settings; understanding the strengths and limitations of both can help make the study's output more relevant for community planners. Levasseur et al. (2017) found that rural areas were able to implement small-scale plans for age friendly communities faster, yet had to contend with poor infrastructure and larger distances between participants. Urban areas, on the other hand, were initially slower to develop appropriate changes but could leverage existing infrastructures and processes to more easily accommodate larger-scale projects (Levasseur et al., 2017).

The World Health Organization declared 2020-2030 to be the "Decade of Healthy Aging"—which not only depends on the absence of illness—but in the ability of people to fully pursue worthwhile ends, as mobility and/or functional impairment increases with age (Ellis et al., 2018). Maintaining physical activity while aging is described as active aging. However, the relationship between physical activity, personal motivation and environmental factors is complex: while physical *activity* may interest older adults, physical *function* may deter activity (Ellis et al., 2018; Koohsari et al., 2018). Thus, it becomes important to look at environmental factors as functional determinants of active aging (Koohsari et al., 2018).

***Socioeconomic level.*** A study of adolescents in a range of high-to-low-income countries showed that the relationship between sedentary behavior and SES

was dependent on the overall income-level of the country itself (Mielke et al., 2016). Overall, results suggest an inverse relationship between sedentary behavior and socio-economic level—especially in higher-income countries (Mielke et al., 2016). However, in low-and-middle income countries, there was a positive association between SES and sedentary behavior (Mielke et al., 2016).

Another study evaluated the relationship of sedentary behavior and social economic position in Community-dwelling adults aged around 79, 83, and 64 years (Shaw et al., 2017). In a study of older adults in Scotland, a strong association between social disadvantage and increased sedentary time was found (Shaw et al., 2017). More socially disadvantaged participants spent 6.5% (95% CI 0.3 to 12.7) more of their waking time sedentary, than those in higher socio-economic positions (Shaw et al., 2017).

A recent study in France, showed that higher physical activity/sedentary behavior was actually higher in low socio-economic cohorts, because the majority of physical activity was job-dependent (Omorou et al., 2016). In other words, the lower classes are more active because their job demands it—not because they're willingly more active. These findings suggest that getting people more active may require different intervention strategies for different SES classes (Omorou et al., 2016).

Using a convenience sample of low-income Mexican-Americans living on the New Mexico/Mexico border, one study found that Hispanic youths spend more time, than other youths, in sedentary activities as it relates to screen time (McDonald et al., 2018). McDonald and colleagues (2018) recommended more strategies in

addressing obesity and sedentary behaviors need to be tested with Hispanic populations as well as other minority populations.

***Education.*** The relationship between education--a key health determinant--and sedentary behavior has proven to be complicated (Kantomaa et al., 2016). Some studies report positive association with sedentary times while others observed no association (Kantomaa et al., 2016). The type of sedentary behavior, like computer time, becomes more common in highly educated people but viewing TV decreases within that same educated population (Kantomaa et al., 2016). Daily commuting, recreational activities, and the workplace have seen a decrease in physical activity demand and an increase in sitting due to a rapid development in communication, transportation, and most importantly, modern technology (Albawardi et al., 2017). Albawardi and colleagues (2017) found education level to be a significant predictor, on workdays, for sedentary behavior, predicting sitting time to increase as education level increases by 55 minutes per day. Kantomaa and colleagues (2016) also suggested that office workers, who are usually highly educated people, spend more time sedentary during work hours when compared to other occupational groups. The increase in sedentary behavior may be due to the available occupations for higher education levels, which require longer sitting times (Albawardi et al., 2017). A study using Finnish adults found higher incidences of sedentary time and lack of light physical activity during weekdays in those with high education levels, but high moderate-to-vigorous physical activity during the entire week (Kantomaa et al., 2016). The increased levels of moderate-to-vigorous

physical activity, motivation, health knowledge, attitudes, etc. could be accounted for by educational differences (Kantomaa et al, 2016). Kantomaa and colleagues (2016) suggest modifying messages to reduce sedentary behavior in specific ways based on educational groups (e.g. standing at desks, promote movement by restructuring office layouts). Sedentary behavior, in these studies, is focused around occupational instances and demonstrates a need for more research on other determinants of sedentary behavior.

**Social Participation.**

Public policy, with strategic land use (e.g. health services, locations encouraging social interaction, supermarket), can promote independence, social participation, and health (Levasseur et al., 2011). In 2014, Levesseur et al. defined social participation as an individual's personal and environmental interactions with others through involvement in community activities. Social participation is associated with many health and quality of life outcomes such as mortality, morbidity, hospitalization, and functional autonomy (Levasseur et al., 2017). However, participation has to be accomplished by the individual and not by proxy (i.e. caretakers) for benefits such as mobility and cognitive function to be evident (Levesseur et al., 2017). The type of community and the number of available lifestyle options do affect independence level and community integration (Levasseur et al., 2014), which will be reviewed in a subsequent theme.

Levasseur and colleagues (2011) noted the need for community design interventions to improve independence (e.g. modifications to communities for age friendly accessibility). Certain defining features (e.g. affordable transportation, housing, activities) in an age friendly community (Levasseur et al., 2017) could also be useful when planning for active living, regardless of age. Maintaining independence—at least in terms of physical capacity—impacts a person's ability to stay in their own home and continue living in accordance with established social networks (Ellis et al., 2018). This helps sustain their local economic contributions and allows for less reliance on health and social services (Ellis et al., 2018). Greater social participation was associated with greater perceived proximity to neighborhood resources and lower levels of disability in men and women (Levasseur et al., 2011). Greater social participation was also noted in the male population for those with little to no disability when compared the rest of the study population.

To understand the dynamics of social engagement in individuals with functional limitations, data on affluence and residential stability are possibly needed (Beard et al., 2009). Based on data from the 2000 U.S. Census, a high prevalence of physical disability and disability outside the home was associated with low socioeconomic status, instability, negative street characteristics, high levels of crime, and higher proportions of black residents (Beard et al., 2009). These findings failed to account for degree of physical limitation, due to use of self-reported data, and possible risk of social selection. The aforementioned barriers may be due to the individuals living with disabilities coming from a minority background or, as a result

of the disability, lost income and were forced to move to disadvantaged neighborhoods (Beard et al., 2009).

Understanding the relationship between sedentary lifestyle and mobility issues reveals a deeper connection to matters of social engagement, and, therefore, community participation. Using mobility limitations and the disablement process to analyze social engagement across the stages of disability throughout an individual's lifespan was an innovative approach by Rosso et al. in 2013. Social engagement was highest—whether inside or outside the home—amongst those with higher mobility, and participation was lowest with the presence of a disability (Rosso et al., 2013). Interestingly, the study concluded that communication to friends or family through phone or internet was, in fact, lower with decreased levels of mobility (Rosso et al., 2013). Thus, if decreased mobility is an effect of a sedentary lifestyle, then social engagement as whole (including phone, text and internet communication) could be negatively impacted.

**Safety.**

Ellis and colleagues (2018) found walking and physical activity to be negatively associated with aesthetically disruptive features (e.g. litter, vandalism, and decay) while positively associated with pedestrian infrastructure (e.g. safety, lighting, green space, and recreational facilities). In disadvantaged neighborhoods—such as those located in rural and inner-city areas—higher poverty rates,

deteriorating/substandard housing, and increased crime fears constrain independence and deter walkability (Clarke & George, 2005).

While studying residential security and its effects on interpersonal interaction, a 2011 study discovered that residential security had no effect on individuals who did *not* have difficulty walking; however, the presence of residential security *did* have a significant effect on people who have trouble walking 2-3 blocks (Clarke et al., 2011). This suggests—among individuals with mobility limitations—the fear of walking is strongly associated with decreased interpersonal interaction (Clarke et al., 2011). When safety was not an issue, racial/gender differences—as well as level of cognitive function—determined frequency of interaction between people with mobility issues (Clarke et al., 2011). These findings were based on a set of narrow self-reported measurements on participation in a geographically defined urban population, so future studies should incorporate this concept in more social settings (e.g. rural, suburban) and environments to evaluate the relationship between impairment and social interactions (Clarke et al., 2011).

**Livability Versus Sustainability.**

Separating livability from sustainability, Ruth & Franklin (2014) developed the "first principles" of livability by examining how population demands interact with the physical and biological characteristics of the environment. Livability refers to the fundamental or immutable characteristics that shape the environment socially, economically, physically, and biologically; sustainability deals with the long-term

viability of urban infrastructure but lacks a fixed definition (Ruth & Franklin, 2014). Though separate concepts, livability and sustainability are interdependent; both define the threshold in which a population can thrive, but both are also subject to the pressures of that same population (Ruth & Franklin, 2014).

Changes in livability come slow, with long-lived institutions (e.g., culture, values, education) and infrastructure (e.g. green space, water/energy, roads and sidewalks) often resisting change. Discontent/deterioration then becomes the catalyst for improvement, increasing potential for a more sustainable community (Ruth & Franklin, 2014). It's important to note these studies focused more on life stage and characteristics within the environment instead of socioeconomic level or race. Socioeconomic status has been associated with physical activity levels and should be studied further (Ellis et al., 2018).

Livability has a human component where a community is deemed livable based on life stage, geographic variation, and the tendency for people to self-sort (Ruth & Franklin, 2014). Life stage, in this sense, involves the needs and preferences of different age groups; geographic variation encompasses different population compositions that look for specific characteristics, which varies from community to community (Ruth & Franklin, 2014). Additionally, individuals tend to sort themselves into locations that share their interests and values (i.e. deemed livable), based on preferences for community features and life stage (Ruth & Franklin, 2014).

Due to the absence of clear guidelines for the sustainability of a community, unforeseen circumstances can drastically impact community planning (Ruth & Franklin, 2014). Implementation of these plans often becomes difficult because the future is uncertain and community planners can only hope to prevent damage from events such as natural disasters (e.g. earthquakes, hurricanes, and wildfire) so much (Ruth & Franklin, 2014). By contrast, livability focuses on existing standards (e.g., building codes, zoning) that may vary from city to city but elicits societal accountability (Ruth & Franklin, 2014). For instance, people are accountable for not following laws and regulations concerning food, shelter, security, etc. This is not the case with sustainability since there is no universally accepted definition (Ruth & Franklin, 2014).

This approach to sustainability and livability is significant because—in addition to being innovative—it addresses the relationships and interactions between livability and environment by modifying the conceptualization of livability, as defined above. Prior to research conducted by Ruth & Franklin (2014), livability was not examined as a dynamic variable. Human behaviors and interactions are subject to society, life stage, and the environment and further research was recommended to include additional studies on urban environment and its effect on people with disabilities (Ruth & Franklin, 2014); this could be instrumental in helping policy makers assess societal implications and invest in more relevant infrastructure.

When determining health and wellbeing as it relates to livability, it is important to understand that not all neighborhood characteristics (e.g., sidewalks, crosswalks,

traffic lights) are uniform (Rosso et al., 2013). For instance, these characteristics are instrumental for accessibility within a community and some populations, such as aging populations, may have a greater need for safe passage between amenities. However, having amenity diversity (e.g. parks, grocery stores, hospitals, restaurants, museums) is negatively correlated with community participation in people with mobility issues (Rosso et al., 2013), leading to an increase in sedentary behavior—possibly due to inaccessible routes between locations. It is also important to note that Rosso and colleagues (2013) found no significant associations between community participation and amenity diversity among participants who never left home or for those who travelled outside the neighborhood often. Other limitations included zip-code reliance and neighborhood boundaries defined by census tracts—though these did help categorize diversity by tiers (Rosso et al., 2013). Next steps in research could include an exhaustive study to determine directionality of the amenity/inaccessibility relationship (Rosso et al, 2013).

Structural barriers (e.g. lack of ramps, streetlights, poorly maintained sidewalks) also exacerbate inaccessibility within the community, increasing the gap between functional capacity (i.e. what they are physically capable of doing) and ability to carry out intrinsic activities of daily living (IADL) like working and leisure activities (Clarke & George, 2005). Housing density (i.e. property proximity) did not affect IADLs, but for participants with declining physical health in limited-land-mix communities, results showed a greater influence on IADLs (Clarke & George, 2005). Notwithstanding the need for greater empirical evidence on structural and individual-

level variables, planning for accessibility and diversity in today's communities may assist in reducing and preventing future disabilities (Clark & George, 2005).

In 2011, Rosso and colleagues conducted research on transportation systems, land use patterns, and urban design to see if/how they can negatively/positively impact disability and functional limitations. Rosso et al. (2011) found socially disadvantaged (e.g. racially/culturally stigmatized) subpopulations are more vulnerable to environmental factors like crime and public safety. Based on these findings, they distinguished capacity from function because they saw a marked distinction in how these affect disability/restrictions, thus proving the need to assess each construct independently (Rosso et al., 2011). Further research should investigate causal associations between changes in the built environment and incident mobility restrictions among vulnerable subpopulations (Rosso et al., 2011).

Based on a study of older adults, Levasseur, Desrosiers & St-Cyr Tribble (2008) identified a relationship between quality of life, participatory satisfaction, and perceived obstacles based on activity level. If social support and adaptability receive more consideration during community planning stages (e.g. coordination of health service, prevention programs, policies, and planning for activity limitations/competence levels), the reduction of obstacles could increase activity levels in older adults (Levasseur et al., 2008). This suggests a need to examine adaptability, and its impact on sedentary behavior among various age groups and types of disabilities encountered by various groups.

Plouffe and Kalache (2010) analyzed data gathered from older adults, people who provided direct care to older adults, and providers of services to older adults in thirty-three cities in twenty-two countries around the world. The purpose of Plouffe and Kalache's study was to examine recurring themes in desirable communities within these cities to help plan a better age-friendly environment. The themes Plouffe and Kalache (2010) uncovered helped develop a reference/checklist for assessing current strengths and gaps in emerging age-friendly communities during community planning stages. There were no systematic differences other than a longer listing of positive, age-friendly features (e.g. wheel-chair accessible, non-slip pavement) and services in developed countries compared to developing ones (Plouffe & Kalache, 2010).

**Built Environment.**

Literature is limited on the topic of built environment and its interaction effects (Clarke & George, 2005; Van Sluijs et al., 2008; Cooper et al., 2010; Rosenberg et al., 2012; Botticello et al., 2015) especially across different age ranges (Rodriguez et al., 2012). Existing studies in this area focus on physical independence and social integration (Botticello et al., 2015; Ellis et al., 2018), amenity diversity and proximity (Levasseur et al., 2011; Rosso et al., 2013; Botticello et al., 2014), and perceived health (Botticello et al., 2015). The available literature focuses on populations with disabilities or mobility issues (Rosso et al., 2011), as well as physical activity and participant perceptions of barriers (Rosenberg et al., 2012). Though the topic of

interest in the current study is on sedentary behavior, it is important to understand previous research conducted on the built environment's effect on community participation. These findings prove more research is necessary on all ages, mobility levels, and neighborhoods.

Botticello and colleagues (2014) examined the relationship between social integration and physical independence. Physical independence consisted of mobility, occupation, impairment severity, assistance; social integration encompassed types of communities, land use, amenity diversity and whether there was open space (e.g. parks). The study concluded that physical activity positively correlated with open space (Botticello et al., 2014). While the study population was representative of spinal cord injuries, generalizability was limited due to a majority of participants of White, non-Hispanic background (Botticello et al., 2014).

Previous studies often did not translate across the spectrum of disability due to their exclusive focus on populations with late-life disability, illustrating the importance of studying populations outside of the elderly demographic (Botticello et al., 2014). The approach of Botticello and colleagues (2014) was innovative because the study concentrated on people at various stages of life and was more inclusive of younger populations experiencing mobility related barriers of their own.

Boticello et al. (2014) found a correlation with the number/types of amenities within a community and a lower incidence of community participation. This was possibly due to inaccessibility issues—e.g., a dense proliferation of retail venues in a given community often presents challenges in terms of accessibility. While their

study focused on disabled adults with a single impairment, researchers were able to utilize community-specific Geographic Information System (GIS) data as a lens through which to draw conclusions about the participation of the population in question (Botticello et al., 2014).

In 2015, Botticello et al. found participants were more likely to report poor perceived health in mixed land use communities with small amounts of open space. However, characteristics like background, impairment severity, and socioeconomic status mitigated this relationship of perceived health and open space. To increase generalizability, future research warrants a focus on what role the built environment—specifically the availability and accessibility of resources—plays in long-term health and wellbeing in people with spinal cord injuries in other locations. Future research must anticipate and address the diversity of experiences and needs in populations living with disabilities, as well as social condition, and community risk factors affecting rehabilitation (Botticello et al., 2015).

Studying how the built environment impacts inclusion/participation relevant to midlife and older adults, Rosenberg and colleagues (2013) encountered a range of physical barriers/facilitators. These barriers and facilitators centered around the impact on general mobility and the ability to reach destinations. For example, curb ramps, parking, aesthetics, lighting, weather, street crossings, sidewalks, amenities, traffic, walking paths, and safety all played roles in the likelihood of mobility (Rosenberg et al., 2013). This approach highlighted the importance of examining neighborhood barriers from the individual's perspective.

The Americans with Disability Act Standards for Accessible Design (United States, 2010) allows for enforcement of regulations on accessibility-related designs in both new and existing structures. However, this focus on ramps, railings, etc. remains narrow. Perceptions of barriers located in the built environment could be the logical answer to the question of what is keeping people sedentary. By viewing neighborhoods and communities in a more holistic light, policy makers can utilize the environment to facilitate activity (Rodriguez et al., 2012)

As levels of physical capacity rise and fall with age and health, the importance of building an enabling environment cannot be overstated. Though road infrastructure may be important for certain types of physical activity, well-connected, pedestrian-oriented street design (e.g. transit stops, crossing signals, and quality sidewalks), mixed land use (e.g. retail, commercial, and residential homes) can encourage non-motorized travel, such as walking and cycling. Using GPS and accelerometers to measure moderate-to-vigorous-intensity physical activity (MVPA), Rodriguez et al. (2011) discovered that activity-enabling environmental factors positively impacted MVPA in bouts of at least ten minutes. Findings by Koohsari et al. (2018)—which suggest that the *perception* of positive neighborhood attributes are required for an active lifestyle—also support the idea that certain favorable environmental factors are a prerequisite to active living.

There is evidence to suggest that the level of diversity in a given environment also impacts physical activity. Clarke & George (2005) found decreases in diversity exacerbate the gap between functional capacity and the ability to carry out desired

activities, triggering an increase in car dependence. Conversely, car dependence could possibly affect neighborhood design (e.g. lack of safe sidewalks and accessible public transit), thus continuing a cycle of disablement (Clarke & George, 2005). Clark & George (2005) also found that environments with limited land-use mixtures inhibit independence in both older adults and those with functional limitations. This is due to both groups' greater dependence on the instrumental activities of daily living (e.g. traveling alone on buses, grocery shopping, preparing meals, etc.) and their dependence on certain aspects of the local environment (Clarke & George, 2005).

Though there have been a relatively small number of studies identifying the role of the built environment and physical activity in children/adolescents, there is a need for greater focus on where they live, play, and attend school (Cooper et al., 2010; Van Sluijs et al., 2008; Rodriguez et al., 2011; Tester, 2009). The presence of parks, recreational facilities, and plots of green space has been positively associated with walking and MVPA in children and adolescents (Rodriguez et al., 2011); this further supports the need for the built environment to address the needs of the entire community and its inhabitants, regardless of age.

According to Smith et al. (2017), general improvements in the built environment (e.g. quality parks, playgrounds and updated transportation infrastructure) can have a markedly positive impact on children and adults alike. Their study went on to list a range of other improvements that showed promise for increasing active transport:

Multiple streetscape components for walking or cycling (including two or more of: crosswalk and sidewalk improvements, improved and covered bike parking, installation of traffic calming features (e.g. raised platforms, zebra crossings) and parking bays; creating safe places to walk); bike boulevard/lane installations; new greenways; traffic free bridges and boardwalks; installation of fitness playground equipment; multiple park renovations (including two or more of: new equipment, walking tracks, fencing, landscaping, surfaces, lights); removal of park/playground seating; retrofitting existing spaces into pocket parks; temporary road closures and play equipment; access to and availability of public transport; higher residential, destination, and recreation density; increased street connectivity; and increase land use mix." (Smith et al., 2017).

**The Role of Policy.**

According to WHO, the world is about to experience an unprecedented boom in the elderly population. This demographic shift will exponentially increase the burden on the healthcare industry (Ellis et al., 2018), possibly outpacing modern medicine's capacity for treatment. Thus, more effective prevention of late-life disability will be a crucial factor in managing this transition. Successful prevention begins with informed community intervention, originating in the field of public health.

Addressing this challenge will depend on the seamless cooperation of public health researchers and policymakers at all stages of intervention (Vuori et al., 2010; Smith et al., 2017). Working hand in hand, researchers and policymakers can

actively manage the intervention process from end to end, ensuring that actions are relevant and timely. Effective prevention comes from effective cooperation, born of a mutually recognized need and its importance to the community. Appropriately preparing for an increase in the elderly population will yield positive results for society as whole, independent of age.

By building more activity-enabling environments, individual health, function, and independence will be positively impacted in a more holistic way, throughout the community (Clarke & George, 2005). This holds especially true for older individuals, for whom environmental factors often pose the greatest barriers to active living (Koohsari et al., 2018). Sedentary lifestyle is often seen as the most prevalent—and manageable—obstacle to healthy aging.

As it relates to active living, public policy not only sets a standard, but also is—in itself—a form of prevention. Current gaps in research are, in some part, attributed to lack of collaboration between disciplines, intervention evaluation, quality research cost, and lack of political involvement from the beginning (Smith et al., 2017; Vuori et al, 2010). Building physical activity into public policy at all levels enables better planning and proper resource management for developing community environments that support individuals in their endeavors to be more physically active and less sedentary (Vuori et al., 2010).

Previous studies recommend involving research professionals from a spectrum of disciplines (e.g. policy actors, statutory agencies, frontline health and social services, transport, urban planners, development professionals, sport

sciences, experts in gerontology and geography, etc.) (Koohsari et al., 2018). Including key stakeholders—who are better able to use the results of the studies and disseminate the information (translating the results to policy) (Ellis et al., 2018)—would positively impact health expenditures and long-term care by reducing disability later in life and further reducing the burden on the medical field.

Policymakers will benefit from direct involvement beginning in the early the planning stages; their input can inform the approach to disseminating results and communicating within the community (Ellis et al., 2018). Throughout every stage of the intervention process, seamless collaboration is key.

One example of a task requiring diverse collaboration, is determining how to "build, retrofit, and sustain activity-friendly built environments" in urban areas where populations have declined, and the prevalence of abandoned spaces has increased (Smith et al., 2017). Koohsari and colleagues (2018) discussed the notion of the "shrinking city"—an urban area that has experienced economic transformations and symptomatic structural crisis due to large population losses for two or more years and has a minimum of 10,000 residents.

Using cities like these as a baseline can provide researchers and policymakers with a nearly clean slate (Koohsari et al., 2018), from which to jointly affect positive change in urban settings where it is needed most. Better facilities and larger parks, historically, have been easier in suburban communities than urban ones (Wolch et al., 2011; Rodriguez et al, 2011), so focusing on "shrinking cities"

may provide unique opportunities to study the effects of the built environment and subsequently drive meaningful improvement.

**Summary of review of existing literature.**

Collectively, the studies explored here have strength in their varied approaches to illustrating the interdependence of livability, sustainability, the built environment, and the prevalence of sedentary behavior. Accessibility, population characteristics, and environmental characteristics consistently impacted mobility, which could explain recent increases in sedentary behavior. For instance, the Rosenberg study (2012) participants indicated that time allotted by crossing signals was too short with participants' use of assistive devices. These participants were afraid of tripping/falling because they felt pressured to move too quickly, given the insufficient crossing time (Rosenberg et al., 2012). A fear of falling and feeling unsafe when traversing crosswalks, sidewalks, or uneven pavement would have a negative impact on engaging in physical activity outside the home (Rosenberg et al., 2012).

However, several gaps emerged. These include: the need to gather more in-depth knowledge on participation outcomes; indicators of physical and emotional health in the disabled population (e.g. assistive technology use, transportation access); quality of the neighborhood (Botticello et al., 2014) as well as others previously discussed throughout the themes in this review. There were not many

studies that examined how populations—especially within different age ranges—viewed environmental barriers (Clarke & George, 2005; Van Sluijs et al., 2008; Cooper et al., 2010; Rosenberg et al., 2012; Rodriguez et al., 2015; Botticello et al., 2015), and that holds true today. This necessitates a concerted effort to study other populations across the age spectrum in order to drive generalizability, furthering the notion that all people would benefit from addressing environmental factors.

Given the strengths and weaknesses in existing literature, researchers should work to define barriers in the environment—including perceived (e.g., safety), physical (e.g. built environment), or institutional (e.g. policy). Clearly defining the environmental barriers will allow policymakers and neighborhood planners to more efficiently address and resolve common themes in inaccessibility. Counteracting challenges in inaccessibility will allow people to move more freely and independently within their communities, regardless of life stage or level of disability/impairment.

Hidding and colleagues (2017) stated that many studies were implemented without specifically exploring determinants/motivations behind sedentary behavior. Engagement in sedentary behavior has to be assessed using motivational and contextual reasons for effective interventions (Hidding et al., 2017). Depending on how researchers measure activity within different aspects of the environment, the results can vary for different age groups (Shaw et al., 2017). For children, decreases in sedentary behavior in the school environment could be a result of classrooms that are more conducive to physical activities (Hidding et al., 2017). For older adults—who can spend as much as 80% of their waking time sedentary—

specific aspects in a social and environmental context could be more influential (Shaw et al., 2017) and should be studied further.

In low-and-middle income countries, there was a positive association between socioeconomic status and sedentary behavior (Mielke et al., 2016). Some studies showed a strong association between social disadvantage and increased sedentary time where more socially disadvantaged participants spent 6.5% more of their waking time sedentary (Shaw et al., 2017). Other studies show higher physical activity as well as high sedentary times in low socioeconomic cohorts but suspected this was due to job-dependent physical activity (Omorou et al., 2016). Low socioeconomic levels may be positively associated with high sedentary times (Shaw et al., 2017; Omorou et al., 2016) but high education was also associated with high sedentary times during work (Kantomaa et al., 2016). The type of sedentary behavior, like computer time versus TV, became more important to distinguish because occupations available to highly educated people may require spending more time sedentary during work hours (Kantomaa et al., 2016; Albawardi et al., 2017). High incidences of sedentary times during the workweek and high incidences of moderate-to-vigorous physical activity during the entire week were found in higher educated groups (Kantomaa et al., 2016). Educational differences could account for the increased levels of moderate-to-vigorous physical activity, motivation, health knowledge, attitudes, etc. (Kantomaa et al, 2016). Sedentary behavior, in these studies, is focused around occupational instances and demonstrates a need for more research on other determinants of sedentary behavior.

Some of the poorest communities in the U.S., with low incomes and low high school graduation rates, are found in Cameron County, Texas along the U.S and Mexico border (Fisher-Hoch et al., 2017). Having a predominantly Mexican-American population, Cameron County has a high prevalence of non-communicable diseases (e.g. obesity, diabetes, cardiovascular disease) shared by sedentary behavior (Fisher-Hoch et al., 2012; Ellis et al., 2018). Importantly, sedentary behavior (e.g. little to no energy expenditure) is independent of physical activity (e.g. energy expenditure in activities/behaviors that encourage movement) (Han et al., 2017). Murillo and colleagues (2016) found that sedentary behavior was the strongest mediator between obesity and acculturation in foreign-born Mexican-Americans. It was speculated this was due to less occupational physical activity as employment opportunities, other than manual labor, increased (Murillo et al., 2016). In foreign-born Mexican-Americans, obesity rates are believed to have been influenced by changes in physical activity as these individuals adapted to the US beliefs, attitudes, and culture (Murillo et al., 2016). Murillo and colleagues (2016) as well as McDonald and colleagues (2018) emphasized that further research should be conducted on the Mexican-American population or other minority populations with sedentary behaviors.

**Specific Aims**

"Community" is more than simply a place where people live. It is a universal social construct that influences, shapes, and defines the human experience at a

fundamental level. It is dynamic. It is subjective. And for those forced to live a sedentary lifestyle, it is often out of reach. While we understand the lack of community participation has a marked impact on someone's social/psychological wellbeing, we do not fully understand the causes: very few studies have sought to identify—and understand—the specific factors within the environment that impact sedentary behavior.

To understand the root causes of sedentary behavior we must begin at the most fundamental level: the physical landscape itself—specifically, the built environment. Thus, the goal of this research is to investigate whether barriers in the physical environment present a verifiable—and ultimately correctable—hindrance to community participation in sedentary populations while controlling for age, gender and education levels amongst a Mexican American population. Reviewing existing literature on issues of livability, sustainability, and social participation identified a range of generalizable factors that supported this hypothesis. The literature review covered studies noting how what was known and not known regarding difference by demographic characteristics.

* Research Question: How do environmental factors impact sedentary behavior?

* Research Aim: To assess the impact of environmental protective and risk factors on sedentary behavior.

* Research Hypothesis: Environmental factors significantly affect the odds of a sedentary lifestyle.

* Research Objective 1: To identify the environmental factors—characterized as protective or risk—significantly associated with sedentary behavior among a Mexican American population.
* Research Objective 2: To analyze protective and risk factors in the environment and their association with sedentary behavior while controlling for age, education, and gender among a Mexican American population.
* Research Objective 3: To develop a policy brief for policy makers using a current bill that would improve pedestrian infrastructure and reduce sedentary behavior.

This study represents an effort to dimensionalize the association between the environment and sedentary behaviors. As such, it can therefore pave the way for systemic policy change to affect a greater incidence of community participation. Ultimately, by building communities more conducive to active living, everyone will experience a positive impact; this can, in turn, serve as a preventative measure, allowing more people to remain active throughout their lives.

## METHODS

Viewed through the lens of the previously described socioecological framework, the interaction between environmental factors and sedentary behavior manifests in various dimensions, corresponding to the strata set forth in the model. Perspectives in the literature review pertain mainly to the “personal” and “social” strata, positing strong evidence that decreasing sedentary behavior drives positive outcomes in terms of individual health (Smith et al., 2017; Ellis et al, 2018) and

social participation (Levasseur et al., 2011; Rosso et al., 2013; Levasseur et al., 2017; Ellis et al., 2018). In an effort to drive a more comprehensive understanding of the sedentary/environment relationship, the methodology of this study focuses more directly on the "environmental" stratum of the socioecological framework. Age and education (in the "individual" stratum) are examined as effect modifiers and feelings of safety (in the "social" stratum) are also investigated. Ultimately, the goal of this study is to equip those in the health promotion field with a multi-faceted—and therefore versatile—perspective of the sedentary/environmental relationship, to help them coordinate relevant and effective reform, with the ability to be tailored to the specific needs of a given community.

## Quantitative Analysis

Using a quantitative approach, this study examined the potential association between environmental factors and sedentary behaviors, based on survey results from the initial study. There were three primary objectives in evaluation of this data: characterizing types of environmental factors as protective or risk; analyzing the impact of these factors on sedentary behavior; and proposing recommendations for future research and application.

### Primary study.

The sample for this study was drawn for the Cameron County Hispanic Cohort that began in 2004 in Cameron County, Texas in order to characterize the

extent and risk factors associated with diabetes and obesity in south Texas (Fisher-Hoch et al., 2010; Fisher-Hoch et al., 2012). There are over 4700 participants who are randomly selected by household using a two-stage stratified sampling frame from US census tracts and blocks in three cities along the Texas / Mexico border (Fisher-Hoch et al., 2010; Heredia, Lee, & Reininger, 2017). Fisher-Hoch et al. (2012) assessed social, medical, and economic factors associated with the prevalence of some common chronic diseases (i.e. diabetes, hypertension, and hypercholesterolemia) in the Mexican American population. All household members over the 18 are asked to participate in the Cohort. Clinical staff highly trained in Good Clinical Practice, enrolled and collected data on socioeconomic, educational, and personal data, family medical history, and informed consent from the participants (Fisher-Hoch et al., 2012). While the participants are recruited from their homes, the data collection visit is done at a clinical research center. The visit includes questionnaires and extensive clinical measures. Participants of the cohort study are also followed every five years. For this dissertation study if there were multiple measures on a single person, only the initial visit was included in the data analysis.

The original study contained a multitude of survey questions relevant to the current study and implied a relationship between several variables. This study seeks to explore the relationship between environmental factors and the prevalence of sedentary behavior.

**Data acquisition.**

The acquisition of the data involved using an encrypted external hard drive on which to save the data file. This hard drive was stored in a combination box and locked in an office safe where no one had access to it. The data was de-identified before it was transferred to the hard drive eliminating the chance of endangering privacy and therefore preserving anonymity for participants. The hard drive was removed from the lock box/safe solely for the purposes of analyzing the data and generating the statistical reports. When this study concluded, the data file was deleted from the hard drive.

**Data analysis program.**

SAS 9.4 (SAS Institute, Cary, NC), a statistical software program that is used to perform statistical data analysis was used to take applicable data sets from CCHC, organize and analyze them.

**Data preparation and merging.**

Data from the Cameron County Hispanic Cohort was examined to identify the demographic and other study variables to produce an analytic dataset base on the RRID variable. RRID was a unique participant ID for the CCHC data and was collected for all versions of the study. Most of the variables in the original study had no relevance to the current study and observations were excluded due to lack of relevance, duplications, missing values, or text in the cells. The number of visits

ranged from one to fifteen. Because all participants had an initial visit and to prevent duplicate data on any individual, visit numbers greater than one were excluded. After eliminating all the unnecessary variables, we were left with 3,966 observations. See Figure 2 below.

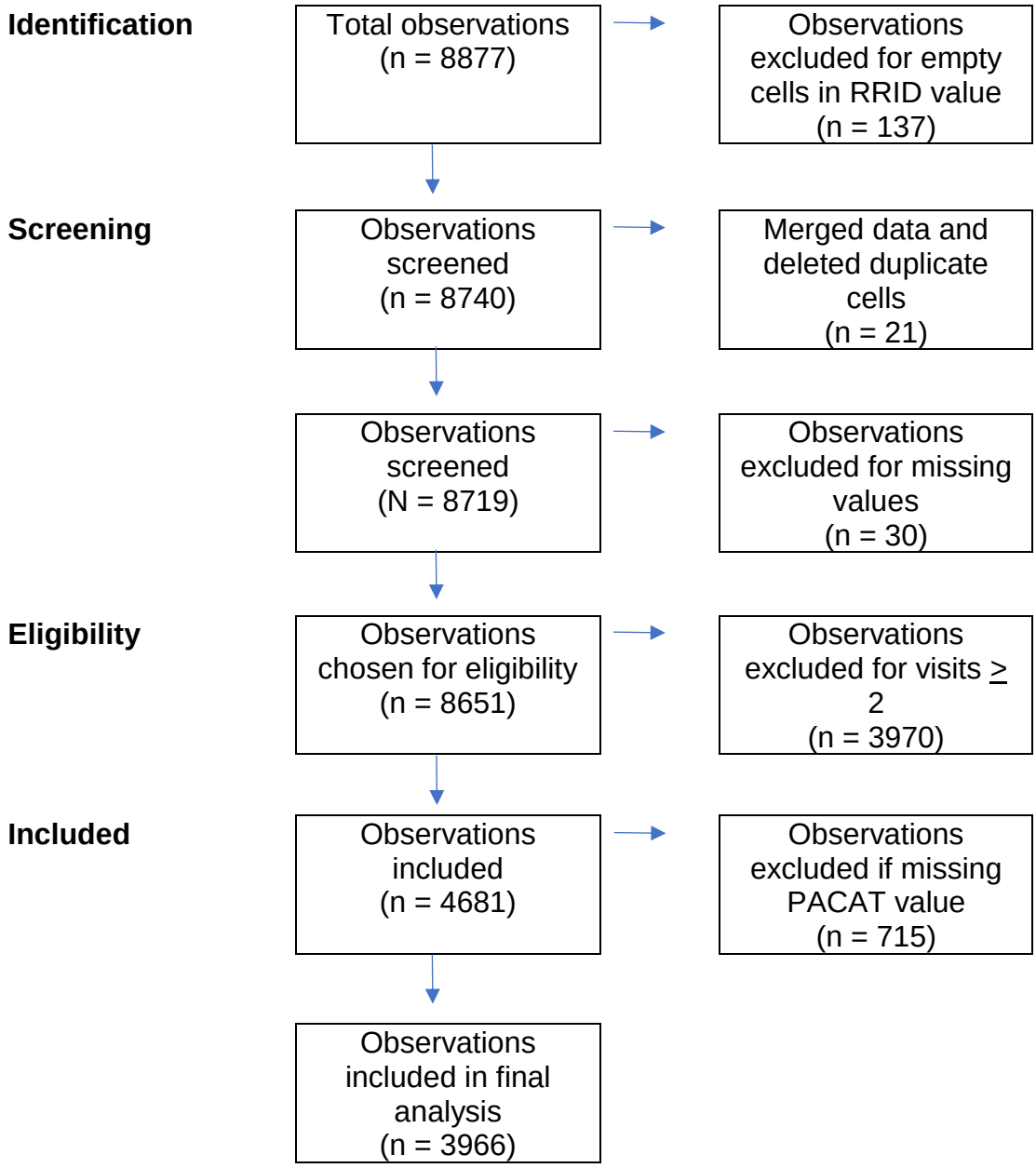

**Figure 2. Stem tree of observation exclusion**

### Scales and Variables.

Surveyed respondents were coded as sedentary or non-sedentary based on self-identified data on the physical activity category variable (PACAT). **PACAT** was developed using the U.S. Department of Health and Human Services' (2018) physical activity guidelines for high, moderate, low, and sedentary activity. Where high activity reported was $\geq$ 1500 MET minutes per week; moderate activity reported was 600-1499 MET minutes per week; low activity reported was 1-599 MET minutes per week; and sedentary activity reported was 0 MET minutes per week. Sedentary, in the current study, was operationalized as those who self-identified as sedentary. Non-sedentary was operationalized as those who identified as high, low, or moderate for physical activity. Variables were strategically chosen in an effort to evaluate an association between the occurrence of sedentary behavior (dependent variable) and a higher incidence of challenging environmental factors (independent variables). As a dependent variable, sedentary behavior is strongly associated with overall activity levels; thus, it can be seen as categorical expression of a respondents' level of active living. As the incidence of environmental barriers increase, respondents' sedentary behavior frequency will, theoretically, increase—thus supporting the hypothesis that the built environment acts as a primary limiting factor of outdoor activity and increases sedentary behavior.

The Abbreviated Neighborhood Environment Scale (Cerin et al., 2006), the St. Louis Scale (Brownson et al., 2004), and the International Prevalence Study (IPS) on physical activity (Bauman et al., 2009) were adapted to assess perceived factors in the social (i.e. crime, traffic, safety) and built environment (i.e. crosswalks, sidewalks, shops). For the purpose of the original study, these scales were modified to consider the built environment and social factors relevant to low income Mexican Americans on the Texas and Mexico border. The reliability and validity of these scales were evaluated and discussed elsewhere (Brownson et al., 2004; Cerin et al., 2006; Bauman et al., 2009). All independent variables found in the current study derived from these scales with only one variable (CRIMED_N: crime rates in the neighborhood during the day make it unsafe to walk) not included in the analysis. CRIMED_N was eliminated during the backwards elimination on the saturated model but all other environmental variables were included in the final analysis.

All independent variables were separated into two categories, each expressing a key dimension in how environmental factors affect community members, either positively (protective) or negatively (risk) in the context of supporting active behaviors. These categories cover a range of potential barriers to activity—both tangible (e.g., sidewalks) and perceived (e.g., safety). Dependent variables pertaining to sedentary behavior, where respondents were coded either yes or no, are compared against both independent variables. Demographic variables included in analysis were gender (1 = Male, 2 = Female), years of education, and age to determine interaction effects.

**Data Analysis.**

The current study conducted a secondary analysis on data gathered from the CCHC. Descriptive analysis was performed as the comparative means of continuous variables between the outcome variables in sedentary, which were coded 1 = Yes and 2 = No. The predictor variables consisted of environmental factors that were analyzed individually during research objective one where they were categorized as risk or protective. Univariate analysis (i.e. Chi-square test for categorical variables and T-test for continuous variables) was performed on each environmental variable and demographic characteristics to determine whether their associations with sedentary behavior existed (See Table 1). A multivariable logistic regression model was conducted to explain the relationship between the risk and protective environmental factors and whether participants identified as sedentary after controlling for other potential confounders. Backward elimination was performed while building multivariable model using an *a priori* alpha level of 0.05 in order to control for Type I error (false positives). Age, gender, education, and gender were included as potential confounders but weight was excluded when no statistical significance was found. By making a four-category variable PACAT (the sedentary variable) into a binary variable (i.e. Yes or No), and in using maximum likelihood estimation, it was determined a test for goodness of fit was necessary to perform. To evaluate whether the model fit was acceptable, Hosmer and Lemeshow (2000) goodness-of-fit test was performed on the final model, which included age

and education. The Shieh-O'Brien approximation was used to estimate the logistic regression model power, in order to control for Type II error (false-negatives).

**RO1: To identify the environmental factors—characterized as protective or risk—significantly associated with sedentary behavior among a Mexican American population.**

To address research objective one, univariate analysis was conducted between each of the individual environmental factors (independent variables) and sedentary behavior (dependent variable) separately. Chi square test was chosen to determine if there was an association between the two variables. The degrees of freedom were set at 1 with a significance level of 0.05 for each of the independent variables. Findings in literature were then used to determine whether environmental factors were separated into risk or protective factors in relation to sedentary behavior.

**RO2: To analyze protective and risk factors in the environment and their association with sedentary behavior while controlling for age, education, and gender among a Mexican American population.**

To address research objective two, logistical regression was used to analyze the effect of environmental factors labelled below as protective or risk on sedentary behavior. Age, gender, education, and gender were then introduced to determine if any significant effects occurred with the previous results. The degrees of freedom were set at 1 with a significance level of 0.05 for each of the independent variables.

***Protective environmental factors.***

Positive Environmental Factors (Numerical) = WALKBU_N + WALK15_N + SIDEHO_N + SIDEMN_N + FREERE_N + STRTLG_N + CRSSWL_N + PPLEXE_N

Variables used were conducive to outdoor activity, within the community, that could decrease sedentary behavior and were recommended for analysis across all versions of the survey. Where WALKBU_N = Many shops, stores, markets or other places to buy things I need are within easy walking distance of your home; WALK15_N = Is the bus stop within a 15-minute walk from your home; SIDEHO_N = There are sidewalks on most of the streets in your neighborhood; SIDEMN_N = The sidewalks in your neighborhood are well maintained (consider cracks, evenness); FREERE_N = Your neighborhood has several free or low cost recreation facilities, such as parks, walking trails, bike paths, recreation centers, playgrounds, public swimming pools, etc.; STRTLG_N = Your neighborhood streets are well lit at night; CRSSWL_N = There are crosswalks and pedestrian signals to help walkers cross busy streets in your neighborhood. PPLEXE_N = You see many people being physically active in your neighborhood, doing things like walking, jogging, cycling, or playing sports and active games.

***Risk environmental factors*.**

Risk Environmental Factors (Numerical) = TRAFFI_N + HIGHCR_N + DOGUN_N + DOGUNR_N

Variables used were those that presented challenges within the community making it unsafe to walk or participate in physical activity outdoors and increase sedentary behavior. Variables were recommended for analysis across all versions of the survey. Where TRAFFI_N = There is so much traffic on the streets that it makes it difficult or unpleasant to walk in your neighborhood; HIGHCR_N = There is a high crime rate in your neighborhood; DOGUNW_N = The problem with unattended (stray) dogs in your neighborhood makes it difficult or unsafe to go on walks; DOGUNR_N = The problem with unattended/stray dogs in your neighborhood makes it difficult or unsafe to use its free or low cost recreation facilities.

***Final Model.***

Logit $P(X) = \alpha + \beta_1(\text{Protective Environmental Factors}) + \beta_2(\text{Risk Environmental Factors}) + \beta_3\text{Age} + \beta_4\text{Education} + \beta_5\text{Gender}$

or

$$\text{Probability(Sedentary)} = (1 / (1+e^{-(\alpha + \beta 1(\text{Protective Environmental Factors}) + \beta 2(\text{Risk Environmental Factors}) + \beta 3\text{Age} + \beta 4\text{Education} + \beta 5\text{Gender})}$$

Where Outcome = Sedentary $_{(1,2)}$: Sedentary lifestyle (1= Yes, 2 = No); Protective Environmental Factors = Sum of protective factors against a sedentary lifestyle with a continuous covariate adjustment; Risk Environmental Factors = Sum of risk factors for a sedentary lifestyle with a continuous covariate adjustment; $\alpha$ = Intercept constant.

**RO3: To develop a policy brief for policy makers using a current bill that would improve pedestrian infrastructure and reduce sedentary behavior.**

No statistical methods were used to address research objective three. However, a policy brief will be included in the results section. Kingdon's window theory was used as a framework to develop the policy brief. Problem, Policy, and Politics were the three streams that comprise Kingdon's window theory. Sedentary behavior (problem stream) comprises the main issue/problem that needs to be addressed. H.R. 228 Increase Transportation Alternatives Act of 2019 is a bill (policy stream) focused on rerouting funds to areas under heavy construction that would increase pathways and public transportation facilities for bicycle and pedestrian travelers. These improvements have been shown to reduce sedentary behavior. The politician knows the political climate (Politics stream) and can help navigate the government avenues to spread awareness and gain support for the bill. Having all three converge into the "window" of opportunity is theoretically what allows bills to pass. Sedentary behavior is a public health problem. A solution was available in the form of H.R. 228. The only stream left to address was the political one so the policy brief was developed.

**Human subjects and safety considerations.**

The original research data was collected for the project, Evaluation of a Media Campaign and The Challenge-RGV with approval by the Institutional Review Board at the University of Texas Health Science Center School of Public Health at

Brownsville (HSC-SPH-05-0488). Current research, a secondary analysis, was approved by the University of Texas Health Science Center School of Public Health at Houston Committee for the Protection of Human Subjects (HSC-SPH-18-1071). Human subjects training and a manuscript, data, and specimen sharing proposal form were completed in order to use the data. Human subjects training was provided by Collaborative Institutional Training Initiative (CITI), the course for group one biomedical researchers and key personnel (Record ID 30579786) was completed to comply with CCHC IRB requirements. Completion of a second course, group two for social and behavioral researchers and key personnel (Record ID 28151348) was completed for the initial proposal submission. Additional forms for informed consent were not necessary for the current study because forms collected since 2004 included permission to use de-identified data for future studies (Fisher-Hoch et al., 2010).

## RESULTS

The results section is organized numerically by research objective. Research objective one results contain information on the association of individual environmental factors with sedentary behavior using univariate analysis. This analysis was necessary to assess whether significant associations exists independently of the other variables. Variables were then sorted into protective or risk categories to address the next objective. Research objective two is addressed by combining the environmental factors that are risk into one logistical regression

equation, protective factors into another equation, and analyzing the effect collectively (protective or risk) on sedentary behavior. Age, education, and gender were added to assess the impact on protective and risk factors.

## Model Results

### RO1: To identify the environmental factors—characterized as protective or risk—significantly associated with sedentary behavior among a Mexican American population.

To examine research objective one, univariate analysis was conducted between each of the individual environmental factors (independent variables) and sedentary behavior (dependent variable) separately. Table 1 shows the chi square results for individual environmental variables and sedentary behavior.

**Table 1: Univariate Analysis of Environmental Factors and Sedentary Behavior**

| Environmental Factor | | Sedentary Yes n (%) | Sedentary No n (%) | P value |
|---|---|---|---|---|
| Many shops, stores, etc. are within easy walking distance from home | Yes | 1216 (54.92%) | 1008 (57.53%) | 0.100 |
| There is a bus stop within 15-minute walk from home | Yes | 1670 (75.43%) | 1311 (74.83%) | 0.664 |
| There are sidewalks on most of the streets in your neighborhood | Yes | 1493 (67.43%) | 1186 (67.69%) | 0.862 |
| The sidewalks in your neighborhood are well maintained | Yes | 1428 (64.50%) | 1148 (65.53%) | 0.501 |
| Your neighborhood has several free or low-cost recreation facilities | Yes | 1422 (64.23%) | 1224 (69.86%) | <0.0002 |
| Your neighborhood streets are well lit at night | Yes | 1606 (72.45%) | 1329 (75.86%) | 0.018 |
| There are crosswalks & pedestrian signals to help walkers cross busy streets | Yes | 1219 (55.06%) | 1041 (59.42%) | 0.006 |
| You see many people being physically active in your neighborhood | Yes | 1457 (65.81%) | 1277 (72.89%) | <0.0001 |
| Problem with unattended dogs makes it difficult or unsafe to go for walks | Yes | 860 (38.84%) | 630 (35.96%) | 0.063 |
| Problem with unattended dogs makes it difficult to use free/low cost rec facilities | Yes | 643 (29.04%) | 432 (24.66%) | 0.002 |
| There is so much traffic on the streets that it makes it difficult or unpleasant to walk | Yes | 861 (39.19%) | 579 (33.10%) | <0.0001 |
| There is a high crime rate in your neighborhood | Yes | 486 (22.43%) | 315 (18.49%) | 0.003 |

According to the results of the chi square tests, having shops (p= 0.100) and bus stops (p= 0.664) within walking distance of 15 minutes of participant's homes were not significantly associated with sedentary behavior. Having sidewalks (p=0.862), well maintained (p=0.501) or not, also had no significant association with sedentary behavior. Problems with unattended dogs making it difficult or unsafe to go for walks (p=0.063) was close but not significant at the 0.05 level. Test failed to reject the null hypotheses due to no statistical significance for these variables and sedentary behavior at the 0.05 level.

There were significant associations with access to free or low-cost recreation facilities (p<0.0002), well-lit streets at night (p=0.018), and crosswalks at busy streets (p=0.006). The most significant associations were from seeing other people being physically active in the neighborhood (p<0.0001) and heavy traffic making it difficult to walk (p<0.0001). Use of recreation facilities had a significant association with sedentary behavior when unattended or stray dogs were present (p=0.002). High neighborhood crime rates (p=0.003) was significantly associated with sedentary behavior. Test rejected the null hypotheses due to statistical significance for these variables and sedentary behavior at the 0.05 level.

**RO2: To analyze protective and risk factors in the environment and their association with sedentary behavior while controlling for age, education, and gender among a Mexican American population.**

To examine the second research objective, environmental factors were separated into protective and risk based on whether they were protective of an

active lifestyle (non-sedentary) or at risk of increasing sedentary behavior. Table 2 illustrates the median and interquartile range of environmental factors (protective and risk), age, years of education, and gender stratified by sedentary and non-sedentary identification.

**Table 2: Environmental factors and demographic characteristics stratified as sedentary and non-sedentary.**

| Variable* | Total | Sedentary 2147 (56%) | Non-Sedentary 1698 (44%) | P value |
|---|---|---|---|---|
| **Protective Factors, Mean (SD)** | 5.95(2.04) | 5.88 (2.07) | 6.04 (2.00) | 0.0120 |
| **Risk Factors, Mean (SD)** | 0.57 (0.69) | 0.62 (0.70) | 0.51 (0.67) | <0.0001 |
| **Age, Mean (SD)** | 43.93 (16.30) | 45.46 (26.30) | 41.99 (16.10) | <0.0001 |
| **Years of Education, Mean (SD)** | 10.98 (5.38) | 10.31 (5.25) | 11.82 (5.42) | <0.0001 |
| **Female, n (%)** | 2553 (64.37%) | 1469 (66.35%) | 1084 (66.87%) | <0.0001 |

*t-test was used for continuous variables and Chi-square test for a categorical variable.

The mean participant “Protective Environmental Factors” were higher for non-sedentary (5.88) than sedentary (6.04). In addition, the mean participant “Risk Environmental Factors” were lower for non-sedentary (0.51) than sedentary (0.62). Age increased and years of education decreased in those that identified themselves as sedentary compared to those who did not identify as sedentary. The mean age for sedentary group was slightly higher at 45 than for the non-sedentary group which

was 42. The mean for years of education was higher in the non-sedentary group with 12 years as opposed to the sedentary group which showed a median of 10 years of education. Female participants made up 64% of the total population and showed marginal differences between those identified as sedentary compared to those who were not. For these reasons, further investigation with hypothesis testing were thought to be warranted to determine if these differences are significant.

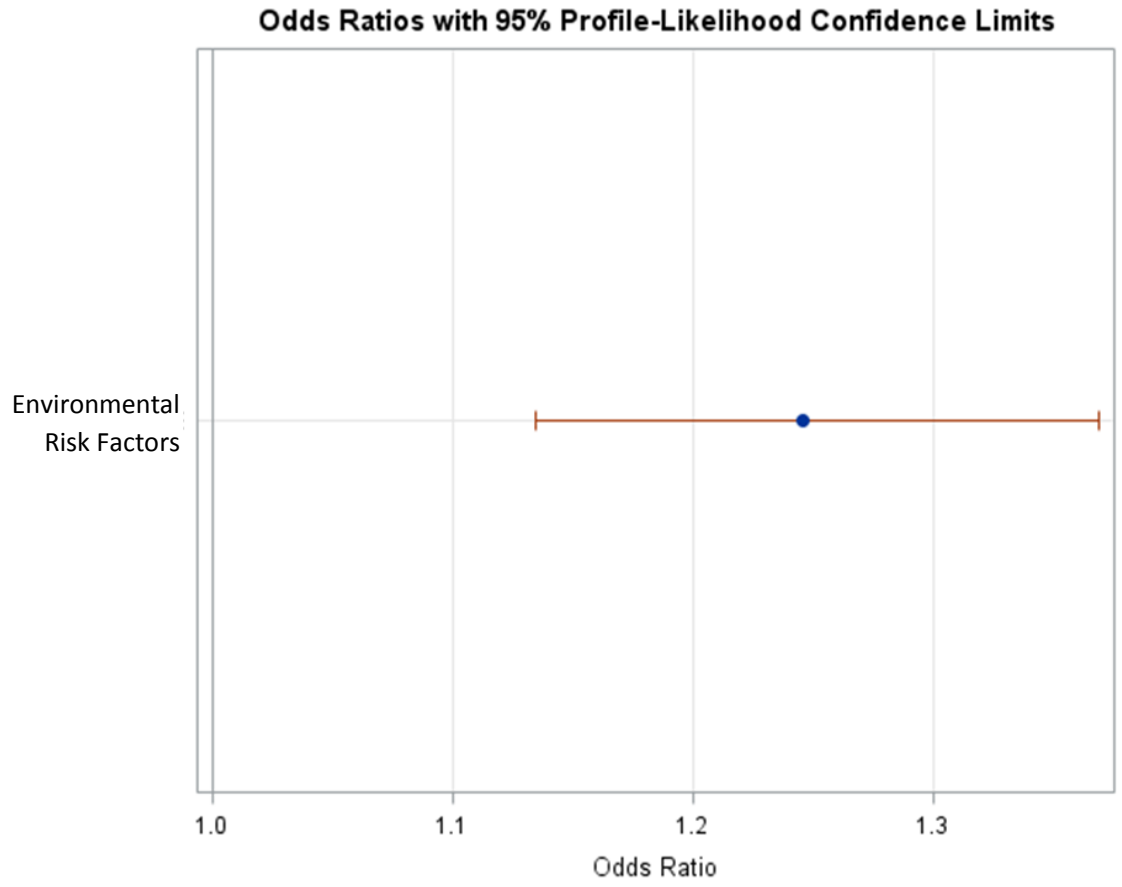


**Figure 3: Univariable effect of environmental risk factors on sedentary behavior.**

**Table 3: Univariable Association Between Risk Factors and Sedentary Behavior.**

| Variable | Unadjusted OR (95% CI) | P value |
|---|---|---|
| **Risk** | 1.246 (1.134, 1.369) | <0.0001 |

Environmental risk factors had a significant univariable association with sedentary behaviors. The odds of being sedentary increased by 24.6% in the presence of the environmental risk factors (OR = 1.246; 95% CI 1.134, 1.369).

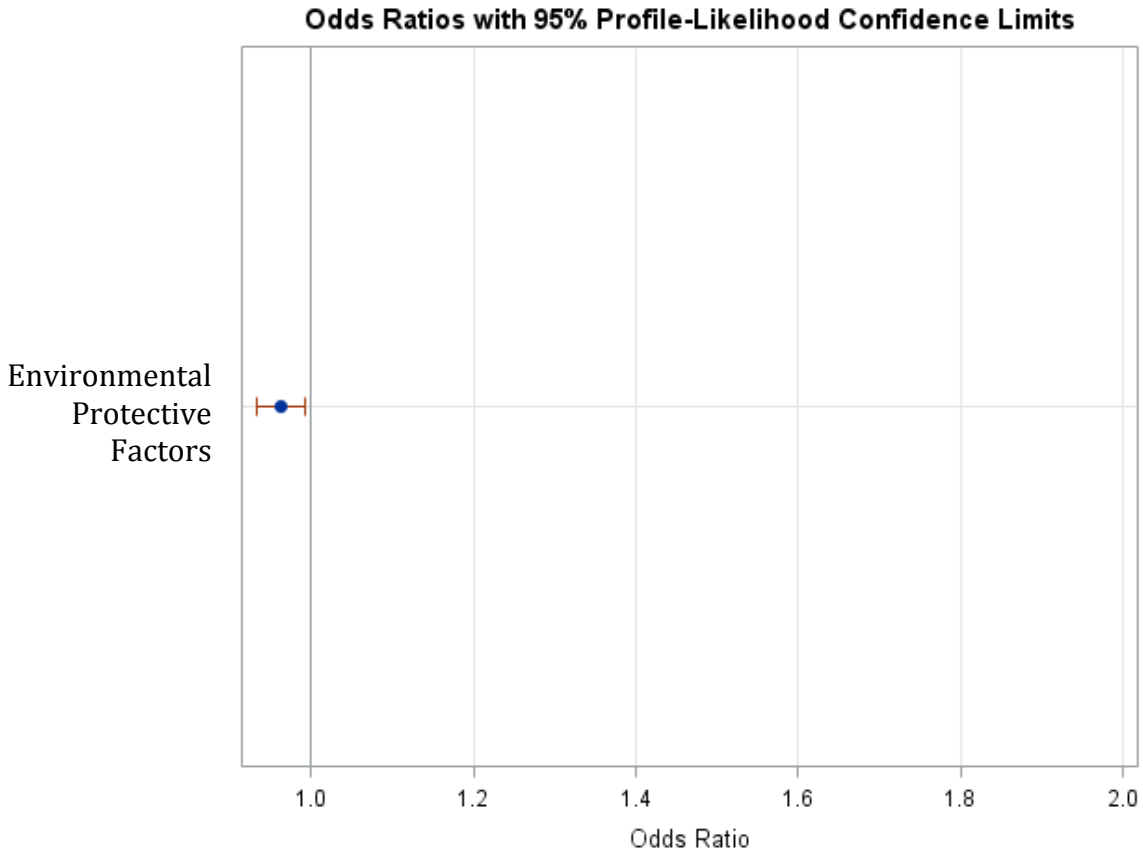

**Figure 4: Univariable effect of environmental protective factors on sedentary behavior.**

**Table 4: Univariable association Between protective factors and sedentary behavior.**

| Variable | Unadjusted OR (95% CI) | P value |
|---|---|---|
| **Protective** | 0.961 (0.932, 0.991) | 0.012 |

Environmental protective factors had a significant univariable association with sedentary behaviors. The odds of being sedentary decreased by 3.9% in the presence of the environmental protective factors (OR = 0.961; 95% CI 0.932, 0.991).

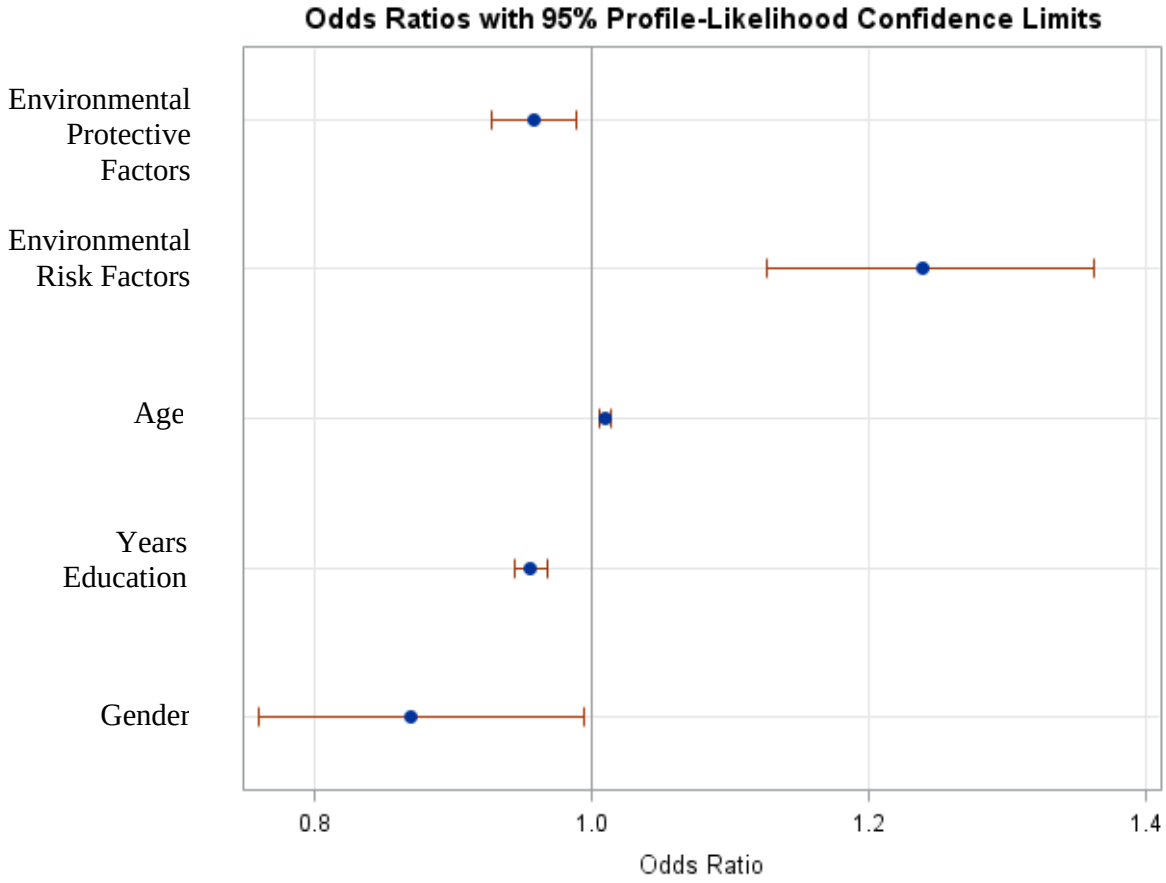


**Figure 5: Multivariable effect of environmental factors on sedentary behavior after controlling for other variables.**

**Table 5: Association of protective and risk factors with sedentary behavior based on a multivariable logistic regression model after controlling for other variables.**

| Variable | Adjusted OR (95% CI) | P value |
|---|---|---|
| **Protective** | 0.958 (0.928,0.989) | 0.0077 |
| **Risk** | 1.239 (1.126,1.363) | <0.0001 |
| **Age (year)** | 1.010 (1.006,1.014) | <0.0001 |
| **Years Education** | 0.956 (0.944,0.968) | <0.0001 |
| **Female Gender** | 0.868 (0.759,0.994) | 0.0406 |

The overall adjusted logistic regression model results after adjusting for age, years education, and gender were significant [$X^2$ (5, 3845) = 122.54, p <0.0001]. The model indicated that, for each unit increase in protective environmental factors, there is 4% reduction in odds of being sedentary (p-value= 0.008) (adjusted OR = 0.96; 95% CI 0.93, 0.99). Secondly, there was a 24% increase in odds of being sedentary for each unit increase in risk environmental factors (p = <0.0001) (adjusted OR = 1.24; 95% CI 1.13, 1.36). Thirdly, for each unit increase in age, there is 1% increase in odds of being sedentary (p-value <0.0001) (adjusted OR = 1.01; 95% CI 1.01, 1.01). Fourthly, for each unit increase in years of education, there is 4% reduction in odds of being sedentary (p-value <0.0001) (adjusted OR = 0.96; 95% CI 0.94, 0.97). Lastly, for gender, there is 13% reduction in odds of being sedentary (p-value =0.0406) (adjusted OR = 0.87; 95% CI 0.76, 0.99) with females being more protective and less sedentary. The Hosmer Lemeshow Goodness-of-Fit

Test failed to reject the $H_0$ of the observed matching the expected, indicating that this model had adequate fit ($p = 0.12$). In conclusion, the Shieh-O'Brien approximation estimated the logistic regression model power to range from 51.3% to 71.8%, in order to control for type II error (false-negatives).

**RO3: To develop a policy brief for policy makers using a current bill that would improve pedestrian infrastructure and reduce sedentary behavior.**

To address research objective three, a policy brief was written.

***Policy brief: Working with roadblocks: Build sustainable communities that support active lifestyles.***

In recent years, the prevalence of sedentary behavior has seen a marked increase around the world (Koohsari et al., 2018). Defined as any period of continuous inactivity (e.g., sitting, laying down, playing video games, etc.) greater than 2 hours, the proliferation of sedentary behavior has had disastrous effects on global health (Wu et al., 2017); increases in obesity, type 2 diabetes, heart disease and all-cause mortality have been closely linked to increases in sedentary behavior (Smith et al., 2017; Ellis et al., 2018). In fact, the World Health Organization suggests, with 1 in 5 adults predominantly inactive, that sedentary behavior may be responsible for 5.8% of all deaths, worldwide. Globally, this accounts for 3.2 million deaths (Vuori et al., 2010). Sedentary behavior also poses an economic threat through decreased company productivity, increased strain on family resources, and

increased disease specific health service demand. Taking this into consideration, it is clear that today's epidemic of inactivity represents one of the most widespread health threats of the 21st century.

*Enabling active lifestyle.*

Research shows that leading an active lifestyle (i.e., the inverse of sedentary behavior) drives positive health outcomes for all populations and reduces late-life health issues that threaten to over-burden healthcare institutions (Owen et al., 2010; Ruegsegger & Booth, 2018). However, until recently, little attention was given to identifying and understanding the specific societal factors that keep people sedentary (Ellis et al., 2018). To that end, recent studies suggest that key aspects of a community's "built environment" (e.g., traffic infrastructure, pedestrian infrastructure, parks/public recreation space) play a major role in keeping people sedentary or helping them stay more active (Koohsari et al., 2018).

Looking at lifestyle habits of low-income Mexican-American populations in Cameron County, Texas, the current study found that certain environmental factors—like heavy traffic, high crime, and stray dogs—greatly contributed to increased sedentary behavior. Conversely, the presence of crosswalks, public recreation facilities and the perception of a safe pedestrian environment (as evidenced by seeing others outside/active) helped decrease the prevalence of sedentary behavior in these same communities. Years of education and gender were also reported to be positively associated with decreased levels of sedentary

behavior. Female identification, compared to male, was shown to be more protective against sedentary behavior in the presence of environmental factors, age, and education. In short, there was clear, statistically significant relationship between key infrastructural factors and the prevalence of sedentary behavior.

*H.R. 228 and increasing safe pedestrian access.*

If we endeavor to actively resist this epidemic of sedentary behavior, it is *imperative* to support public policy that aims to improve the built environment along these lines. With a focus on infrastructural improvements that facilitate pedestrian mobility, one such policy is the "Increase Transportation Alternatives Act of 2019"—H.R. 228.

H.R. 228's primary intent is to mitigate transportation deficits in areas under heavy construction/repair (e.g., federal highways, railroads, etc.). However, the measures described in H.R. 228 directly support the kind of pedestrian friendly improvements that are shown to reduce sedentary behavior. Specifically, the bill suggests that grants given under the program should be used to plan, design and acquire rights-of-way, pathways, public transportation facilities and other civic improvements that facilitate access and expanded mobility to bicycle and pedestrian travelers. Furthermore, H.R. 228's grant eligibility extends to state and local governments—as well as rural areas—making it universally viable to communities throughout the United States.

While the benefits of H.R. 228 would be specific to construction-heavy areas, the resultant improvements would have a demonstrably positive impact on peoples' ability to stay active and reduce sedentary behavior. Thus, we can see the adoption of policies like H.R. 228 as a "proof of concept" that can pave the way for further legislation toward reducing sedentary behavior—and, consequently, improving health outcomes for populations around the world.

## DISCUSSION

The relationship of sedentary behavior and the impact of the built environment as a limiting factor is a relatively new area of study. For the current study, the hypothesis was: environmental factors significantly affect the odds of a sedentary lifestyle. Examining the built environment may explain and assist in addressing the increased prevalence of sedentary behavior. To determine whether a relationship exists between environmental factors and sedentary behaviors, three objectives were devised. The first objective was to determine if the environmental factors individually had significant associations with sedentary behavior. Chi square was performed to discover which variables, if any, had significant relationships. Several variables, such as high crime, high traffic, the presence of free or low-cost facilities, etc. had significant relationships with sedentary behavior. Through literature and results of the chi square tests, variables were separated into protective or risk environmental categories. The second objective involved analyzing each group as protective or risk with sedentary behavior. Analyzing each group

(protective or risk) with sedentary behavior would examine the overall impact of the environmental factors. The presence of protective environmental factors was significantly more likely to decrease sedentary behavior while the presence of risk environmental factors significantly increased sedentary behavior. A third objective was included to disseminate the results. A policy brief was developed to spread awareness of H.R. 228—the Increase Alternative Transportation Act of 2019—which could help decrease sedentary behavior.

To address research objective one, environmental factors impacting sedentary behavior were analyzed for significance. Having shops, stores, etc. within walking distance of participant's homes did not have a significant association with sedentary behavior. Rosso and colleagues (2013) suggested a negative correlation between amenity diversity and community participation stating this could be due to inaccessible routes. Consistent with the current findings, Rosso et al. (2013) also found that amenity diversity had no significant association with community participation in people who never left home. While community participation was not measured in the current study, the possibility of amenity diversity affecting sedentary behavior was evaluated to discover if inaccessibility was a factor. Exploring the inaccessibility relationship with amenity diversity was one of the next steps in the Rosso et al. (2013) study. Having sidewalks, whether they were well maintained or not, had no significant association with sedentary behavior. This could be more significant in aging populations as a need for safe passage or in adolescent populations for the purpose of walking to school (Rodriguez et al., 2011).

Encountering unattended/stray dogs on a walk did not have a significant association with sedentary behavior. However, participants did report feeling unsafe if unattended/stray dogs were present at the free or low-cost recreational facilities. This had a significant association with sedentary behavior, implying safety is a key factor in getting out in the community. Beard et al. (2009) suggested that the high prevalence of physical disability was associated with areas of high levels of crime. In the current study high neighborhood crime rates were significantly associated with sedentary behavior. Residents may have lost income and were then forced to move to disadvantaged neighborhoods in the study implemented by Beard and colleagues (2013). The population in the Cameron County Hispanic Cohort was predominantly low income Mexican-Americans (Fisher-Hoch et al., 2012) and, as such, is a minority, and may have resided in disadvantaged neighborhoods. Findings in this study were consistent with literature.

As far as pedestrian infrastructure, having well-lit streets at night, crosswalks, and pedestrian signals at traffic lights were significant. Rosenberg and colleagues (2012) stated that crossing signals are valuable, but populations using assistive devices may actually need more time to cross. Participants reported a significant association with heavy traffic making it difficult to walk and sedentary behavior. Increasing prevalence of crosswalks and time allotted for crossing busy streets in communities with a high elder population or people living with mobility issues and disabilities, could be beneficial for future researchers to examine.

The most significant associations were seeing other people being active in the neighborhood and access to free or low-cost recreational facilities. Ellis et al. (2018) found a positive relationship with greenspace and recreational facilities and physical activity. The current study's findings support previous research concerning factors of the built environment.

Logistical regression was conducted on each group with sedentary separately and then together to address this objective. Environmental factors were put into an equation of protective environmental factors or risk environmental factors and compared with sedentary behavior separately. The mean *protective* environmental factors were higher and the mean *risk* environmental factors were lower in the non-sedentary participants compared to sedentary participants. For those who identified as sedentary, age increased and years of education decreased. Gender was associated with non-sedentary behavior. Independently these categories implied a relationship with sedentary behavior but additional tests were conducted to determine significance.

Logistical regression was run on protective and risk equations individually to address research objective two (impact of environmental barriers). Environmental factors characterized as risk were significantly associated with being sedentary, whereas protective environmental factors were significantly associated with being non-sedentary. When factors were combined in the final model, the odds of being sedentary decreased in the presence of the environmental protective factors, gender, and years of education. Results indicated gender to be a protective factor

against sedentary behavior with females being less likely to be sedentary than their male counterparts. Male to female ratio in the sedentary and non-sedentary groups is slightly different but any bias this may have had was adjusted for in the final model. Being sedentary significantly increased in the presence of environmental *risk* factors and age. The null hypothesis was rejected in favor of this hypothesis. The overall adjusted logistic regression model results were significant. In an adjusted model, the environmental protective and risk factors had a measurable effect on the odds of being sedentary.

The results suggested that a significant relationship exists between several environmental variables, either individually or collectively, and sedentary behavior. Because age was also significantly associated with the odds of being sedentary, future research should focus on interventions in the built environment such as adding longer pedestrian signal times. Interventions are needed across the age spectrum, however. Having more longitudinal studies to evaluate populations as they age would be beneficial to see how priorities in community selection and participation change as physical capacity evolves.

**Overall Strengths and Limitations**

Further research is needed to understand the relationship between environmental variables and sedentary behavior in light of some limitations of this study. Due to the nature of the secondary analysis, one limitation would be the

survey instrument used to gather information on the participants. The questionnaire items were not readily translatable to the current study purpose due to missing elements of the socio-ecologic framework as well as missing observations. In the socio-ecologic framework, information such as personality characteristics and weather play a role in health interventions. As they were not addressed in the survey, next steps for research would be to incorporate other variables, such as these. The impact of weather could be important when looking at accessibility or furthering research on sedentary behavior. Surveys were also self-reported and subject to any bias the participants may have had. The age of the data could be considered a limitation because the interviews began in 2004. As participants cycle through life stages, different priorities may occur and only the initial visit was included.

This study assumed there was no multicollinearity between the independent variables so future research should test for this and in addition could conduct a factor analysis to examine the relationship among independent variables. Future research should also examine the independent variables as categorical variables and not continuous. While more information may be gleaned from continuous variables, categorical variables allow for non-linear relationships to be understood more easily at different levels of the independent variable. Linearity assumption between the outcome variable (i.e. sedentary behavior) and the continuous independent variables among the risk and protective factors were not checked and, therefore, is a limitation. For this study, the logit scale of sedentary behavior was

assumed to equally increase or decrease per one unit increase of risk or protective factors. Future research should examine more fully whether these assumptions should be retained in the analysis.

Lack of prior research on sedentary behavior and the environment is a limitation. Studies on sedentary behavior's effects, relationship with physical activity, and prevalence in different populations/socioeconomic levels have been conducted but not with environmental factors. The built environment has the potential to impact sedentary behaviors, as is evident by the findings in the current study. The results imply a broader range of interventions that address the influence of specific factors in the environment on sedentary behavior are necessary. Another limitation could be the fact this study is cross-sectional, but only because most studies on the topic of the built environment, are cross-sectional. More longitudinal studies are necessary to further examine the built environment's impact on people as they cycle through different life stages. CCHC data updates every five years with information from participants' follow up interviews so the information may be available to reevaluate and analyze as a longitudinal study.

The relationships found here—even circumstantially—would suggest the need for a more direct focus on this subject. The results of this study could be used by policy makers, or community developers, to address and hopefully eliminate commonly found barriers in the built environment. Moreover, conducting secondary research provided several additional advantages: access to a larger population; an institutionally funded database; and a wide range of variables to consider.

There were few studies that evaluated the impact of the built environment on low income Mexican-Americans at the time of this study. The findings here contribute to literature by showing sedentary behaviors in low socioeconomic populations can be impacted by environmental factors, perhaps even more so when including age and education. In literature, education level was associated with high sedentary behaviors; occupations for highly educated people were more likely to require a high prevalence of sedentary time during the workday (Kantomaa et al., 2016). In the current study, education decreased the likelihood of sedentary behaviors in a low-income, low-high-school-graduation-rate population in the presence of protective environmental factors. This implies that the physical neighborhood environment plays a larger role in motivations for sedentary behavior than previously believed. Moreover, age in a low SES population like the Mexican-American participants in this study, increased sedentary behavior and indicated there may be different concerns (i.e. crime, stray dogs) than higher SES populations. Older adults had not been studied extensively concerning the built environment and sedentary behavior and should be a focus in future research. Results may be generalized to other low-income communities but more research is needed to generalize to all populations.

Schule et al (2015) recommended using neighborhood level socioeconomic status (SES) in built environment studies to identify vulnerable population groups. Koohsari et al (2018) found people with low SES have less walkable built environment attributes and found to have lower levels of activity during leisure time

than those with high SES. Using low-income Hispanic Americans covers two of the recommended suggestions by involving a minority population that resides in a lower SES neighborhood. The CCHC dataset was very large and has been continuously conducted since 2004. This institutionally funded study provided access to a much larger population than a smaller study, suggesting the sample size (n=3966) is a strength. Typically, the number of participants in research ranged from 200-500 though the smallest sample found was 35 due to its qualitative nature. Two-stage random sampling techniques were used to recruit the original study participants so generalizability is possible. Though there were a relatively small amount of studies on built environment and sedentary behavior, the access to the literature through the library system within the University of Texas School of Public Health should be considered a strength of the study. Many databases were readily available which made the few related articles that were found, accessible. While this study supported findings from other studies on the built environment, sedentary behavior, or participation in activity, it also generated new insights on an existing data set. The variables were collected with a different purpose but the relationship between the environmental factors and sedentary behavior is still relevant.

Suggestions for future research include additional studies on adolescents—specifically adolescent females, as they prefer and participate in different physical activities than adolescent boys (Koohsari et al., 2018). Overall, research on children and older adults was also lacking (Smith et al., 2017) and input from these two populations could shed light on issues not faced by the population in between. Determining where certain groups spend

the majority of their time will also be crucial, because home neighborhoods may not be relevant in determining mobility (Rosso et al., 2013). Wu et al. (2017) stated that more longitudinal studies are needed on the effect of the built environment because most of the existing studies are cross-sectional in nature. Any future quantitative study should focus more directly on the quality of the built environment and its relationship to physical activity—not just the existence of attributes. Longitudinal studies would be beneficial to see how active lifestyles impact people as they age, and whether aging in place decreases the burden in certain social programs.

## CONCLUSION

The increasing elderly population will inevitably lead to a strain on resources, health services, and amplify social inequalities (Bloom et al., 2011; Radwan et al., 2018). Planning for and addressing these challenges beforehand could decrease expenditures in health and long-term care (Clarke & George, 2005).

Research shows that active lifestyle unequivocally drives positive health outcomes for aging populations—positive health outcomes that will offset the burden on an already overworked healthcare system. Moreover, "Active Aging" not only yields healthier, happier, longer-lived communities, but also helps reduce the economic impact of geriatric dependency on community resources (Bloom et al., 2011). However, time is of the essence: predictions include a population growth, from a 2017 estimate, to double for people over age 60 and to triple for those over 80 (Koohsari et al., 2018; Ellis et al., 2018). The prevalence of "super-aged"

societies (defined as populations with 20% of the population over 65) is also increasing around the world (Koohsari et al., 2018).

Identifying key barriers to active living, thus, represents an important first step in moving a community forward on the active aging spectrum. By reducing physical and mental demands of a given task, disability can swiftly and markedly be reduced (Verbrugge and Jette, 1994; Clarke & George, 2005). To that end, current research suggests that factors in the built environment (e.g., sidewalks, parks, streetlights, etc.) may represent the most salient—and potentially correctable—barriers to active aging. The policy brief was an effort to raise awareness and educate policy makers on the prevalence of sedentary behavior as well as recommend a possible solution.

Sedentary behavior is becoming a global problem for all ages, social statuses, and countries (Bloom et al., 2011). Previous research fell short on understanding how specific environmental factors influence sedentary behavior. The results of the current study suggest significant relationships between sedentary behavior and several environmental factors. Therefore, many implications for policymakers, as well as researchers in the public health field, exist. Researchers can implement interventions on a number of variables found here, in a variety of settings, to address barriers in the built environment. Though age is a significant factor contributing to sedentary behavior, making a community "walkable" would benefit all ages and strengthen the community as a whole (Bloom et al., 2011).

"Community," goes beyond the academic definitions with which we typically define it; it is a direct reflection of the health, wellness and potential of the people

within it. That said, our desire to build a stronger community through the improvement of the built environment represents a direct effort to improve the human experience, at a fundamental level. It is a foundational step from which we can build a stronger, more cohesive community—in every sense of that term—from within.

## REFERENCES


Albawardi, N. M., Jradi, H., Almalki, A. A., & Al-Hazzaa, H. M. (2017). Level of Sedentary Behavior and Its Associated Factors among Saudi Women Working in Office-Based Jobs in Saudi Arabia. *International journal of environmental research and public health*, *14*(6), 659.

Altman, B., & Bernstein, A. (2008). Disability and health in the United States, 2001–2005. Hyattsville, MD: National Center for Health Statistics.

Bauman, A., Bull, F., Chey, T., Craig, C. L., Ainsworth, B. E., Sallis, J. F., … IPS Group (2009). The International Prevalence Study on Physical Activity: results from 20 countries. *The international journal of behavioral nutrition and physical activity*, *6*, 21.

Beard, J. R., Blaney, S., Cerda, M., Frye, V., Lovasi, G. S., Ompad, D., … Vlahov, D. (2009). Neighborhood Characteristics and Disability in Older Adults. *The Journals of Gerontology Series B: Psychological Sciences and Social Science*s, 64B (2), 252–257.

Bloom, D.E., Cafiero, E.T., Jané-Llopis, E., Abrahams-Gessel, S., Bloom, L.R., Fathima, S., Feigl, A.B., Gaziano, T., Mowafi, M., Pandya, A., Prettner, K., Rosenberg, L., Seligman, B., Stein, A.Z., & Weinstein, C. (2011). The Global Economic Burden of Noncommunicable Diseases. Geneva: World Economic Forum.

Botticello, A. L., Rohrbach, T., & Cobbold, N. (2015). Differences in the Community Built Environment Influence Poor Perceived Health among Persons with Spinal Cord Injury. *Archives of Physical Medicine and Rehabilitation*, 96(9), 1583–1590.

Botticello, A. L., Rohrbach, T., & Cobbold, N. (2014). Disability and the Built Environment: An Investigation of Community and Neighborhood Land Uses and Participation for Physically Impaired Adults Annals of Epidemiology, 24(7), 545–550.

Brownson RC, Hoehner CM, Brennan LK, Cook RA, Elliott MB, McMullen KM. (2004). Reliability of two instruments for auditing the environment for physical activity. *Journal of Physical Activity and Health*, 1:189-207.

Cerin, E., Saelens, B.E., Sallis, J.F., and Frank, L.D. (2006). Neighborhood environment walkability scale: Validity and development of a short form. *Medicine and Science in Sports and Exercise*, 38, 1682-1691.

Clarke, P. J., Ailshire, J. A., Nieuwenhuijsen, E. R., & de Kleijn - de Vrankrijker, M. W. (2011). Participation among Adults with Disability: The Role of the Urban Environment. *Social Science & Medicine* (1982), 72(10), 1674–1684.

Clarke, P., & George, L. K. (2005). The Role of the Built Environment in the Disablement Process. *American Journal of Public Health*, 95(11), 1933–1939.

Conroy, D. E., Maher, J. P., Elavsky, S., Hyde, A. L., & Doerksen, S. E. (2013). Sedentary behavior as a daily process regulated by habits and

intentions. *Health psychology: official journal of the Division of Health Psychology*, American Psychological Association, 32(11), 1149–1157.

Cooper, A. R., Page, A. S., Wheeler, B. W., Hillsdon, M., Griew, P., & Jago, R. (2010). Patterns of GPS measured time outdoors after school and objective physical activity in English children: the PEACH project. *The international journal of behavioral nutrition and physical activity*, 7, 31.

Diaz, K. M., Goldsmith, J., Greenlee, H., Strizich, G., Qi, Q., Mossavar-Rahmani, Y. Vidot D., Buelna, C., Brintz, C.E., Elfassy, T., Gallo, L.C., Daviglus, M.L., Sotres-Alvarez, D., & Kaplan, R. C. (2017). Prolonged, Uninterrupted Sedentary Behavior and Glycemic Biomarkers Among US Hispanic/Latino Adults: The HCHS/SOL (Hispanic Community Health Study/Study of Latinos). Circulation, 136(15), 1362–1373.

Ellis, G., Hunter, R. F., Hino, A., Cleland, C. L., Ferguson, S., Murtagh, B., Anez, C., Melo, S., Tully, M., Kee, F., Sengupta, U., … Reis, R. (2018). Study protocol: healthy urban living and ageing in place (HULAP): an international, mixed methods study examining the associations between physical activity, built and social environments for older adults the UK and Brazil. *BMC public health*, 18(1), 1135.

Falck, R. S., Landry, G. J., Best, J. R., Davis, J. C., Chiu, B. K., & Liu-Ambrose, T. (2017). Cross-Sectional Relationships of Physical Activity and Sedentary Behavior with Cognitive Function in Older Adults with Probable Mild Cognitive Impairment. *Physical therapy*, 97(10), 975–984.

Fisher-Hoch, S. P., Rentfro, A. R., Salinas, J. J., Pérez, A., Brown, H. S., Reininger, B. M., … McCormick, J. B. (2010). Socioeconomic status and prevalence of obesity and diabetes in a Mexican American community, Cameron County, Texas, 2004-2007. *Preventing chronic disease*, 7(3), A53.

Fisher-Hoch, S. P., Vatcheva, K. P., Laing, S. T., Hossain, M. M., Rahbar, M. H., Hanis, C. L., … McCormick, J. B. (2012). Missed opportunities for diagnosis and treatment of diabetes, hypertension, and hypercholesterolemia in a Mexican American population, Cameron County Hispanic Cohort, 2003-2008. *Preventing chronic disease*, 9, 110298.

Flegal, K.M., Carroll, M.D., Ogden, C.L., Curtin, L.R. (2010) Prevalence and Trends in Obesity Among US Adults, 1999-2008. *JAMA*; 303(3), 235–241

Hafoka, S.F. (2017). Assessing the active living environment in three rural towns with a high proportion of Native Hawaiians and other Pacific Islanders. *Health promotion perspectives*.

Han, H., Pettee Gabriel, K., & Kohl, H. W., 3rd (2017). Application of the transtheoretical model to sedentary behaviors and its association with physical activity status. *PloS one*, 12(4), e0176330.

Heredia, N. I., Lee, M., & Reininger, B. M. (2017). Exposure to a community-wide campaign is associated with physical activity and sedentary behavior among Hispanic adults on the Texas-Mexico border. *BMC public health*, 17(1), 883.

Hidding, L. M., Altenburg, T. M., van Ekris, E., & Chinapaw, M. (2017). Why Do Children Engage in Sedentary Behavior? Child-and-Parent-Perceived

Determinants. *International journal of environmental research and public health*, 14(7), 671.

Kantomaa, M. T., Tikanmäki, M., Kankaanpää, A., Vääräsmäki, M., Sipola-Leppänen, M., Ekelund, U., … Tammelin, T.H. (2016). Accelerometer-Measured Physical Activity and Sedentary Time Differ According to Education Level in Young Adults. *PloS one*, 11(7), e0158902.

Koohsari, M.J., Nakaya, T., & Oka, K. (2018). Activity-Friendly Built Environments in a Super-Aged Society, Japan: Current Challenges and toward a Research Agenda. *International journal of environmental research and public health*, 15(9), 2054.

Koohsari, M. J., Owen, N., Cerin, E., Giles-Corti, B., & Sugiyama, T. (2016). Walkability and walking for transport: characterizing the built environment using space syntax. *The International Journal of Behavioral Nutrition and Physical Activity*, 13, 121.

Levasseur, M., Desrosiers, J., & St-Cyr Tribble, D. (2008). Do quality of life, participation and environment of older adults differ according to level of activity? *Health and Quality of Life Outcomes*, 6, 30.

Levasseur, M., Dubois, M.F., Généreux, M., Menec, V., Raina, P., Roy, M., … St-Pierre, C. (2017). Capturing how age-friendly communities foster positive health, social participation and health equity: a study protocol of key components and processes that promote population health in aging Canadians. *BMC Public Health*, 17, 502.

Levasseur, M., Gauvin, L., Richard, L., Kestens, Y., Daniel, M., & for the NuAge Study Group, H. (2011). Associations between perceived proximity to neighborhood resources, disability, and social participation among community-dwelling older adults: Results from the VoisiNuAge Study. *Archives of Physical Medicine and Rehabilitation*, 92(12), 1979–1986.

McDonald, J. A., Sroka, C., Olivares, E., Marin, M., Gurrola, M., & Sharkey, J. R. (2018). Patterns of Screen Time Among Rural Mexican-American Children on the New Mexico-Mexico Border. *Preventing chronic disease*, 15, E113.

Mielke, G.I., Brown, W.J., Nunes, B. P., Silva, I., & Hallal, P.C. (2016). Socioeconomic Correlates of Sedentary Behavior in Adolescents: Systematic Review and Meta-Analysis. *Sports medicine* (Auckland, N.Z.), 47(1), 61–75.

Murillo, R., Albrecht, S. S., Daviglus, M. L., & Kershaw, K. N. (2014). The Role of Physical Activity and Sedentary Behaviors in Explaining the Association Between Acculturation and Obesity Among Mexican-American Adults. *American journal of health promotion*: AJHP, 30(1), 50–57.

Ng, S. W., & Popkin, B. M. (2012). Time use and physical activity: a shift away from movement across the globe. *Obesity reviews: an official journal of the International Association for the Study of Obesity*, 13(8), 659–680.

Nooijen, C. F. J., Blom, V., Ekblom, Ö., Ekblom, M. M., & Kallings, L. V. (2019). Improving office workers' mental health and cognition: a 3-arm cluster randomized controlled trial targeting physical activity and sedentary behavior in multi-component interventions. *BMC Public Health*, 19(1), N.PAGE.

Omorou, A.Y., Coste, J., Escalon, H., & Vuillemin, A. (2016). Patterns of physical activity and sedentary behaviour in the general population in France: cluster analysis with personal and socioeconomic correlates, *Journal of Public Health*, 38(3), p. 483–492.

Pate, R.R., O'Neill, J.R., & Lobelo, F. (2008) The evolving definition of ''sedentary.'' *Exercise Sport Sci. Rev*., Vol. 36, No. 4,173-178.

Plouffe, L., & Kalache, A. (2010). Towards Global Age-Friendly Cities: Determining Urban Features that Promote Active Aging. *Journal of Urban Health: Bulletin of the New York Academy of Medicine*, 87(5), 733–739.

Radwan, H., Ballout, R. A., Hasan, H., Lessan, N., Karavetian, M., & Rizk, R. (2018). The Epidemiology and Economic Burden of Obesity and Related Cardiometabolic Disorders in the United Arab Emirates: A Systematic Review and Qualitative Synthesis. *Journal of obesity*, 2185942.

Rodríguez, D. A., Cho, G. H., Evenson, K. R., Conway, T. L., Cohen, D., Ghosh-Dastidar, B., Pickrel, J. L., Veblen-Mortenson, S., Lytle, L. A. (2011). Out and about: association of the built environment with physical activity behaviors of adolescent females. *Health & place*, 18(1), 55-62.

Rosenberg, D. E., Huang, D. L., Simonovich, S. D., & Belza, B. (2013). Outdoor Built Environment Barriers and Facilitators to Activity among Midlife and Older Adults with Mobility Disabilities. *The Gerontologist*, 53(2), 268–279.

Rosso, A. L., Auchincloss, A. H., & Michael, Y. L. (2011). The Urban Built Environment and Mobility in Older Adults: A Comprehensive Review. *Journal of Aging Research*, 816106.

Rosso, A. L., Grubesic, T. H., Auchincloss, A. H., Tabb, L. P., & Michael, Y. L. (2013). Neighborhood Amenities and Mobility in Older Adults. *American Journal of Epidemiology*, 178(5), 761–769.

Rosso, A. L., Taylor, J. A., Tabb, L. P., & Michael, Y. L. (2013). Mobility, Disability, and Social Engagement in Older Adults. *Journal of Aging and Health*, 25(4), 617–637.

Ruth, M., & Franklin, R. S. (2014). Livability for all? Conceptual limits and practical implications. *Applied Geography* (Sevenoaks, England), 49, 18–23.

Sallis J.F., Glanz K. (2006) The role of built environments in physical activity, eating, and obesity in childhood. *Future Child*; 16(1), 89-108.

Schüle, S. A., & Bolte, G. (2015). Interactive and independent associations between the socioeconomic and objective built environment on the neighbourhood level and individual health: a systematic review of multilevel studies. *PloS one*, 10(4), e0123456.

Shaw, R.J., Čukić, I., Deary, I.J. on behalf of the Seniors USP Team (2017). Relationships between socioeconomic position and objectively measured sedentary behaviour in older adults in three prospective cohorts. *BMJ Open*, **7:**e016436.

Shaw, R. J., Čukić, I., Deary, I. J., Gale, C. R., Chastin, S., Dall, P. M., … Der, G. (2017). The Influence of Neighbourhoods and the Social Environment on Sedentary Behaviour in Older Adults in Three Prospective Cohorts. *International journal of environmental research and public health*, 14(6), 557.

Siddique, J., de Chavez, P. J., Craft, L. L., Freedson, P., & Spring, B. (2015). The Effect of Changes in Physical Activity on Sedentary Behavior: Results from a Randomized Lifestyle Intervention Trial. *American journal of health promotion: AJHP*, 31(4), 287–295.

Smith, M., Hosking, J., Woodward, A., Witten, K., MacMillan, A., Field, A., Baas, P., Mackie, H. (2017). Systematic literature review of built environment effects on physical activity and active transport - an update and new findings on health equity. *The international journal of behavioral nutrition and physical activity*, 14(1), 158.

Stokols, D. (1992). Establishing and maintaining healthy environments: Toward a social ecology of health promotion. *American Psychologist, 47*(1), 6-22.

Tester, J.M. (2009) The built environment: Designing communities to promote physical activity in children. *Pediatrics*; 123: 1591–1598.

U.S. Department of Health and Human Services. (2018). Physical Activity Guidelines for Americans, 2nd edition. Washington, DC: U.S. Department of Health and Human Services.

Van Sluijs, E. M., Skidmore, P. M., Mwanza, K., Jones, A. P., Callaghan, A. M., Ekelund, U., Harrison, F., Harvey, I., Panter, J., Wareham, N. J., Cassidy, A., … Griffin, S. J. (2008). Physical activity and dietary behaviour in a population-based sample of British 10-year old children: the SPEEDY study (Sport, Physical activity and Eating behaviour: environmental Determinants in Young people). *BMC public health*, 8, 388.

Verbrugge, Lois M., Jette, Alan M. (1994)."The disablement process." *Social Science & Medicine* 38(1): 1-14.

Vuori, I., Blair, S., Bull, F. C., & Katzmarzyk, P. T. (2010). More collaboration-more power in combating ill health. *Journal of Physical Activity and Health, 7*(Suppl 3), S359–S360.

Wolch, J., Jerrett, M., Reynolds, K., McConnell, R., Chang, R., Dahmann, N., Brady, K., Gilliland, F., Su, J. G., … Berhane, K. (2010). Childhood obesity and proximity to urban parks and recreational resources: a longitudinal cohort study. *Health & place*, 17(1), 207-14.