LINKING PLACE OF EMPLOYMENT & HEALTHY LIVING: THE IMPACT OF THE BUILT ENVIRONMENT NEAR WORKPLACES ON PHYSICAL ACTIVITY, BODY MASS INDEX & SEDENTARY DRIVING TIME

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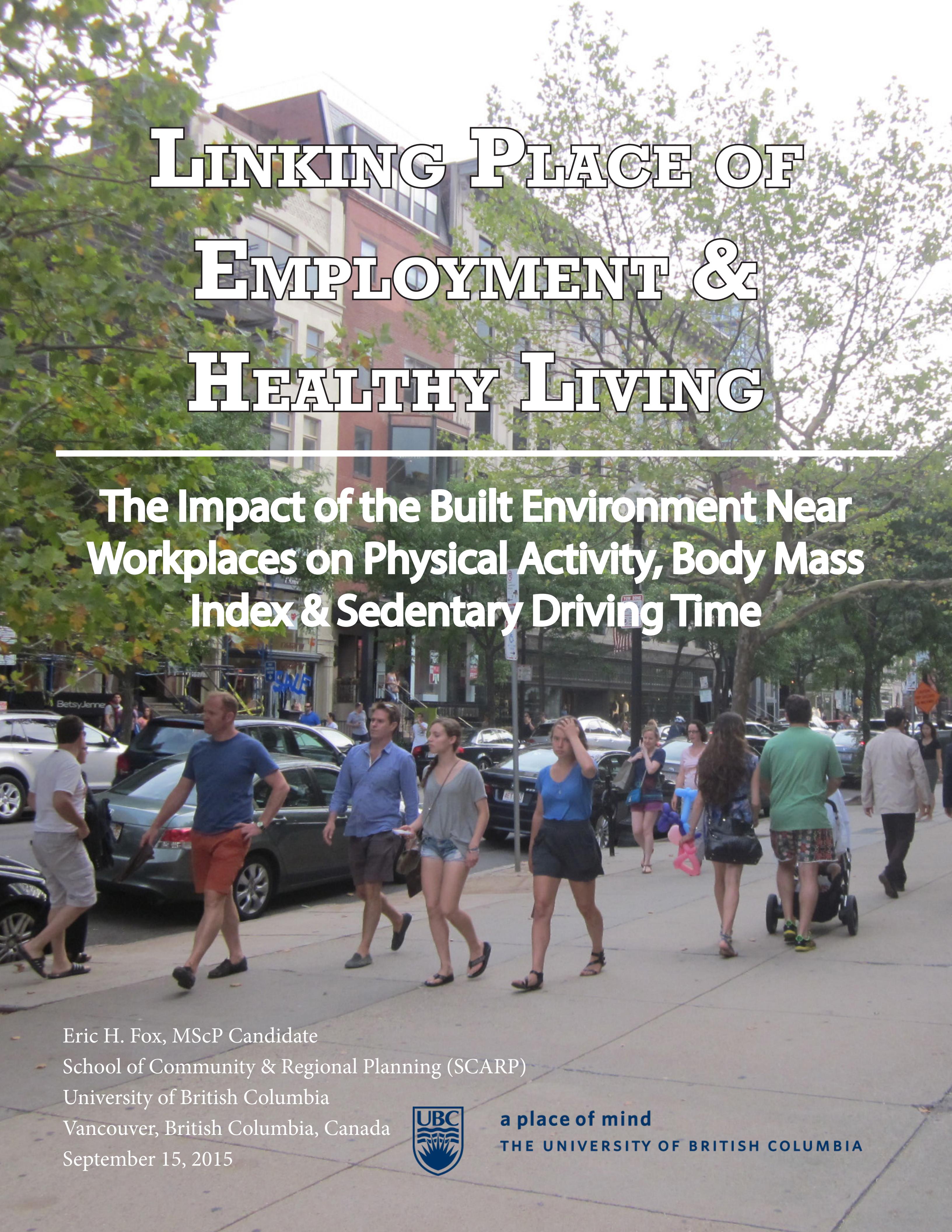

Linking Place of Employment & Healthy Living

The Impact of the Built Environment Near Workplaces on Physical Activity, Body Mass Index & Sedentary Driving Time

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Abstract

Background:
In the face of increasing rates of chronic diseases among working adults, urban planners and public health professionals have investigated the extent to which transportation systems, land use patterns and urban design have contributed to sedentary lifestyles. Although many studies have explored the relationships between health and the built environment for neighbourhoods around residences, few have analyzed urban form near workplaces. One of the limitations of health studies on workplaces is that the focus has primarily been on internal building environments such as the presence of fitness facilities, rather than the built environment around the worksite. The place of employment is an important setting for assessing walk environments because of the large amount of time spent at work, the mode of transportation used for regular commuting, and travel around the workplace during and outside of work hours. Despite this relevance, a limited understanding exists about the built environment at worksites and its impact on health and physical activity.

Objectives:
The study aimed to develop and analyze built environment measures around participants' worksite locations and examine them in relation to participants' moderate-vigorous physical activity (MVPA), body mass index (BMI) and sedentary time spent in automobiles. The study intended to report observed associations between where a person works and their health and demonstrate that work environments which better enable active transportation and transit use are more supportive of healthy living and thereby help to reduce sedentary behaviour.

Method:
The study employed a cross-sectional quasi-experimental research design that examined adult participants (n = 1,078) ages 18 to 66 in two large U.S. metropolitan regions from the Neighborhood Quality of Life Study (NQLS Prime). The recruitment process implemented a two stage clustered sample design to select participants with spatially clustered home locations stratified using a four quadrant matrix of annual median household income and type of home neighbourhood built environment based on the walkability index. Outcomes were objectively measured MVPA using accelerometers and self-reported BMI and sedentary time spent in cars. Utilizing a geographic information system (GIS), objectively measured built environment values were calculated for participant work locations. Independent urban form variables were constructed using three work environment buffer catchment areas: 500 m, 1 km and 15 minutes on transit or by foot. Multivariate linear regression and binary logistical regression models were developed to test the isolated explanatory power of worksite built environment to predict health outcomes while controlling for demographics and home built environment characteristics.

Results:
The walkability index within a 15 minute transit travel time around workplaces was found to be positively associated ($p < 0.05$; $OR = 1.148$) with MVPA whereby a 7 unit increase in walkability doubled the likelihood of achieving the recommended daily ≥30 minutes of MVPA while controlling for home walkability ($NR^2 = 0.263$).[1] Home-work trip distance ($p < 0.001$; OR 1.038) and transit travel time to regional activity centres from work ($p < 0.05$; OR 1.045) were statistically significant with the likelihood of ≥ 30 minutes of sedentary time in automobiles per day attributing to a 3.9% increase in predicted outcomes above home walkability ($NR^2 = 0.191$). Retail floor area ratio (FAR) around the workplace was a significant negative predictor ($p < 0.05$; $OR = 0.405$) of sedentary vehicle time. Explanatory power of workplace built environment variables for several models tested was diminished once home environment had been accounted for. BMI was not found to be

[1] Nagelkerke R-square (NR^2).

significantly related with worksite built environment being considered either continuously or as a dichotomous variable (BMI < 25 or BMI ≥ 25).

Conclusions:
Worksite built environment measures and travel patterns, including the walkability index, home-work distance and transit time to regional activity centres, are important predictors of MVPA and sedentary time spent in vehicles. Participant catchment areas based on 15 minutes on transit or by foot were found to be valid for measuring the impact of built environment exposure at places of employment on MVPA and sedentary time in vehicles. Successful health interventions may be implemented through strategies that increase workplace neighbourhood walkability and commercial FAR while decreasing home-work distance and transit travel time.

Implications for Practice & Policy:
An improved understanding of the link between workplace environment and health outcomes may guide interventions in the built environment made to foster increased walking benefiting public health. By expanding the knowledge base of pedestrian environments surrounding worksites and their impacts on health, effective planning policy can be implemented to better target infrastructure investments in cities.

Keywords: Workplace, Physical activity environments, BMI, Sedentary time in vehicles, GIS, Buffer, Pedestrian-enhanced walkable network, GTFS

Resumen

Historial:
Debido a los niveles crecientes de enfermedades crónicas de trabajadores adultos, urbanistas y profesionales de la salud pública han investigado el alcance acerca de cuál de los sistemas de transporte, patrones de ordenación urbana y diseño urbano han contribuido a estilos de vida sedentarios. Aunque muchos estudios han explorado las relaciones entre la salud y el ambiente construido para vecindarios cerca de las zonas residenciales, pocos han analizado la forma urbana cerca de los lugares de trabajo. Una de las limitaciones de los estudios acerca de la salud con respecto a lugares de trabajo es que primeramente se ha enfocado en el ambiente interno de edificios, tal como la presencia de gimnasios, más que el ambiente construido alrededor de sitios de trabajo. El lugar de empleo es un marco importante para evaluar ambientes peatonales debido a la gran cantidad de tiempo que se pasa en el trabajo, el modo de transporte usado para viajar diariamente a este sitio, y el movimiento dentro y fuera del mismo en horas laborales. A pesar de esta relevancia, existe un entendimiento limitado sobre el ambiente construido cerca de lugares de trabajo y su impacto a la salud y actividad física.

Objetivo:
El estudio pretendió desarrollar y analizar medidas del ambiente construido cerca de ubicaciones de trabajo de participantes y examinarlos en relación a sus niveles de actividad física moderada-vigorosa (AFMV), el índice de masa corporal (IMC), y el tiempo sedentario pasado en automóviles. El estudio pretendió informar sobre las asociaciones observadas entre donde una persona trabaja y su salud, y así demostrar que ambientes de trabajo posibilitan un transporte activo y el uso de transporte público que brinden un estilo de vida saludable, apoyando a reducir un comportamiento sedentario.

Método:
El estudio empleó un diseño de investigación de corte transversal cuasi-experimental que examinó participantes adultos (n = 1.078) de edades de 18 a 66 años en dos áreas metropolitanas grandes de los EE.UU. del Neighborhood Quality of Life Study (NQLS Prime). El proceso de reclutamiento implementó un diseño de muestra agrupado de dos etapas para seleccionar a los participantes con ubicaciones de hogar agrupadas espacialmente estratificados usando una matriz de cuatro cuadrantes de ingresos familiares anuales y tipo de ambiente construido cerca del vecindario del hogar basado en el índice de accesibilidad peatonal. Los resultados fueron calculados objetivamente AFMV usando acelerómetros, y el IMC y tiempo sedentario transcurrido en autos adquiridos en formato de autoinforme. Se calculó valores del ambiente construido de forma medida objetivamente para ubicaciones de trabajo de participantes usando un sistema de información geográfica (SIG). Se construyeron variables independientes de forma urbana usando tres búferes, representando áreas geográficas de alcance del ambiente de trabajo: 500 m, 1 km y 15 minutos en transporte público o a pie. Se desarrollaron modelos de regresión lineal multivariados y de regresión logística binaria para analizar el poder explicativo aislado del ambiente construido de lugares de trabajo y pronosticar resultados de salud mientras es controlado por agentes demográficos y características del ambiente construido del hogar.

Resultados:
Se encontró una asociación positiva (p < 0,05; RM^2 = 1,148) entre el índice de accesibilidad peatonal hasta 15 minutos viajando en transporte público y la AFMV a través del cual un aumento de 7 unidades en accesibilidad peatonal duplicó la probabilidad de lograr ≥30 minutos recomendados diariamente de la AFMV mientras controlando por accesibilidad peatonal cerca del hogar (NR^2 =

[2] Razón de momios (*RM*).

0,263).[3] La distancia de viaje de la casa al trabajo (p < 0,001; RM = 1,038) y el tiempo de viaje a centros de actividad regionales de trabajo (p < 0,05; RM = 1,045) presentaron estadísticas significativas con la probabilidad de llegar a ≥30 minutos de tiempo sedentario diario en automóviles atribuyendo a un aumento de 3,9% en resultados predichos sobre accesibilidad peatonal del hogar (NR^2 = 0,191). El coeficiente de utilización del suelo (CUS) del comercio alrededor de lugares de trabajo presentó un pronóstico significativamente negativo (p < 0,05; RM = 0,405) del tiempo sedentario en vehículos. Se disminuyó el poder explicativo de variables del ambiente construido de lugares de trabajo por algunos modelos examinados una vez que se había justificado el ambiente del hogar. Se descubrió que el IMC no tuvo relación significativa con el ambiente construido de sitos de trabajo, cuando se consideró como una variable continua ni como variable dicotómica (IMC < 25 u IMC ≥ 25).

Conclusiones:
Las medidas del ambiente construido del lugar de trabajo y los patrones de viaje, incluyendo el índice de accesibilidad peatonal, distancia hogar-trabajo y el tiempo viajando en transporte público a centros de actividades regionales, son pronosticadores importantes del AFMV y el tiempo sedentario que se pasa en vehículos. Se reconoció que áreas geográficas de alcance basado en 15 minutos en transporte público o caminando fueron válidas para calcular el impacto de la exposición del ambiente construido en lugares de empleo a la AFMV y el tiempo sedentario en autos. Intervenciones exitosas de la salud pueden ser implementadas por estrategias que aumentan la accesibilidad peatonal en vecindarios cerca de lugares de trabajo y el CUS de comercio mientras que reducen la distancia hogar-trabajo y el tiempo viajando en transporte público a centros de actividades regionales.

Implicaciones para práctica y política:
Una mejor comprensión de la relación entre el ambiente construido en el lugar de trabajo y los resultados de salud, puede generar intervenciones en espacios construidos hechos para fomentar el aumento del desplazamiento a pie beneficiando la salud pública. Por la expansión de la base de conocimiento de ambientes peatonales alrededor de los sitios de trabajo y sus impactos en la salud, se puede implementar una política efectiva de planeación la cual se enfoca en inversiones de infraestructura en ciudades.

Palabras clave: Lugar de trabajo, Ambientes de actividad física, IMC, Tiempo sedentario en vehículos, SIG, Búfer, Red de accesibilidad peatonal, GTFS

[3] R-cuadrado Nagelkerke (NR^2).

1. Background

The structure and organization of the built environment in cities influence human behaviour and have significant implications for public health. Over the last fifteen years, there has been an increasing focus on the importance of achieving daily standards for physical activity through utilitarian exercise rather than solely recreational exercise (Besser & Dannenberg, 2005; Frank, Andresen, & Schmid, 2004; Freeland, Banerjee, Dannenberg, & Wendel, 2013; Warburton, Nicol, & Bredin, 2006). The development of the built environment in ways that promote physical activity, healthy living and wellness through active transportation and public transit use has only recently been recognized as an objective for planning departments and public health authorities (Besser & Dannenberg, 2005; Brown & Werner, 2007; Freeland et al., 2013; Handy, Boarnet, Ewing, & Killingsworth, 2002; Lachapelle, Frank, Saelens, Sallis, & Conway, 2011). Recent literature has cited the rise of automobile dependent neighbourhoods and cities as a major barrier to achieving the thirty minutes of moderate physical activity required to meet public health standards in North America (Frank et al., 2004; Frank, Saelens, Powell, & Chapman, 2007; Frank & Kavage, 2009; Pate et al., 2011; Troiano et al., 2008).

The rising prevalence of obesity among all age cohorts from middle aged adults and seniors to young adults and even children in the United States and Canada has reached alarming levels in recent times and has become a focus area for public health officials (Booth, Pinkston, & Poston, 2005; Ewing & Schmidt, 2003; Frank et al., 2004). Obesity, the medical condition associated with significant excess body fat, can lead to a range of negative health outcomes such as decreased life expectancy due to the increased likelihood of coronary artery disease, hypertension, type 2 diabetes, osteoporosis and degenerative joint disease (Frank, Engelke, & Schmid, 2003; Frumkin, Frank, & Jackson, 2004; Ewing & Schmidt, 2003). There are many factors that contribute to people being overweight and obese including poor diet and nutrition, a lack of physical activity, hereditary genetics, personal behaviour and environment (Frank et. al., 2003, Freeland et al., 2013; Warburton et al., 2006). Obesity is a cause of death that is preventable and, therefore, much academic scholarship has focused attention on the modification of environment as a primary method for reducing exposure (Frank et al., 2004; Frank, Schmid, Sallis, Chapman, & Saelens, 2005; Frank, Sallis, et al., 2006; Saelens et al., 2012). Increasingly public health authorities have recognized the need to incorporate this research into practice and have taken the initiative to highlight the importance of the effect of the built environment on healthy living. Creating communities that are designed to encourage physical activity through walking and cycling is a way to address obesity and support more active lifestyles (Sallis, Frank, Saelens, & Kraft, 2004).

Despite recent emphasis on the benefits of vigorous physical activity through recreation, there has been a pushback away from concentrating on this form of exercise as the only way to keep physically fit (Ewing & Schmidt, 2003). According to a report by the U.S. Center for Disease Control and Prevention (CDC), only about 5% of the population receives enough physical activity from vigorous exercise to meet recommended average levels (Frank et al., 2003). In addition, Pate et al. (1995) demonstrates with a dose-response analysis that the levelling off of health benefits beyond moderate activity means that a strong emphasis on the importance of moderate physical activity will achieve the greatest results for healthy living among the public at large (Figure 1) (Ewing & Schmidt, 2003; Feng, Glass, Curriero, Stewart, & Schwartz, 2010). Even though minimum requirements for physical activity may be easily achieved through vigorous active recreation, since a relatively small portion of the population regularly engages in this type of physical activity, it may be more effective to build it into the daily lifestyles of ordinary citizens (Frank & Kavage, 2009; Lachapelle & Frank, 2009). Since the mandates of public health authorities are to promote broad-based, healthy living in an inclusive way for the entire population, moderate physical activity has been promoted as the best way to target the majority of the populous across the age spectrum (Frank et al., 2004; Frank, Sallis, et al., 2006; Handy et al., 2002; Lachapelle et al., 2011).

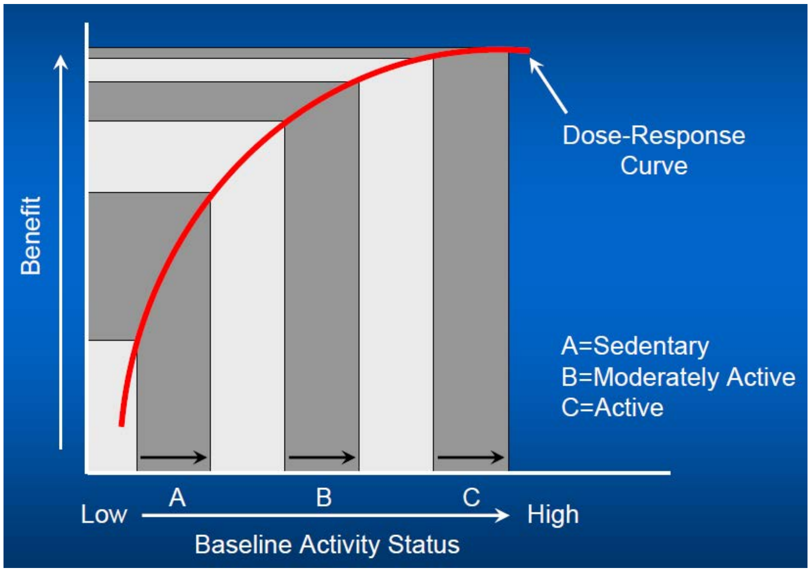

Figure 1: Dose-response curve demonstrating the health benefits associated with moderate and vigorous physical activity.
Source: Pate et al., 1995.

In the face of increasing rates of chronic diseases among working adults, urban planners and public health professionals have investigated the extent to which transportation systems, land use patterns and urban design have contributed to living sedentary lifestyles (Frank et al., 2003, Ewing & Schmidt, 2003; Frank et al., 2005; Handy et al., 2002). Together these components comprise the built environment and denote the arrangement, mixing and orientation of urban landscapes and physical design characteristics which influence travel behaviour and activity (Figure 2) (Frumkin et al., 2004, Frank et al., 2003, Cervero & Kockelman, 1997; Frank & Kavage, 2009; James F. Sallis et al., 2009). The place of employment is an important setting for assessing walk environments because of the large amount of time spent at work, the mode of transportation used for regular commuting, and travel around the worksite during and outside of work hours (Crespo, Sallis, Conway, Saelens, & Frank, 2011; Frank et al., 2007; Troped, Wilson, Matthews, Cromley, & Melly, 2010). Despite this significance, a limited understanding exists between the effects of the built environment at places of employment and its impact on employee health and physical activity (Hurvitz & Moudon, 2012; Schwartz, Aytur, Evenson, & Rodríguez, 2009).

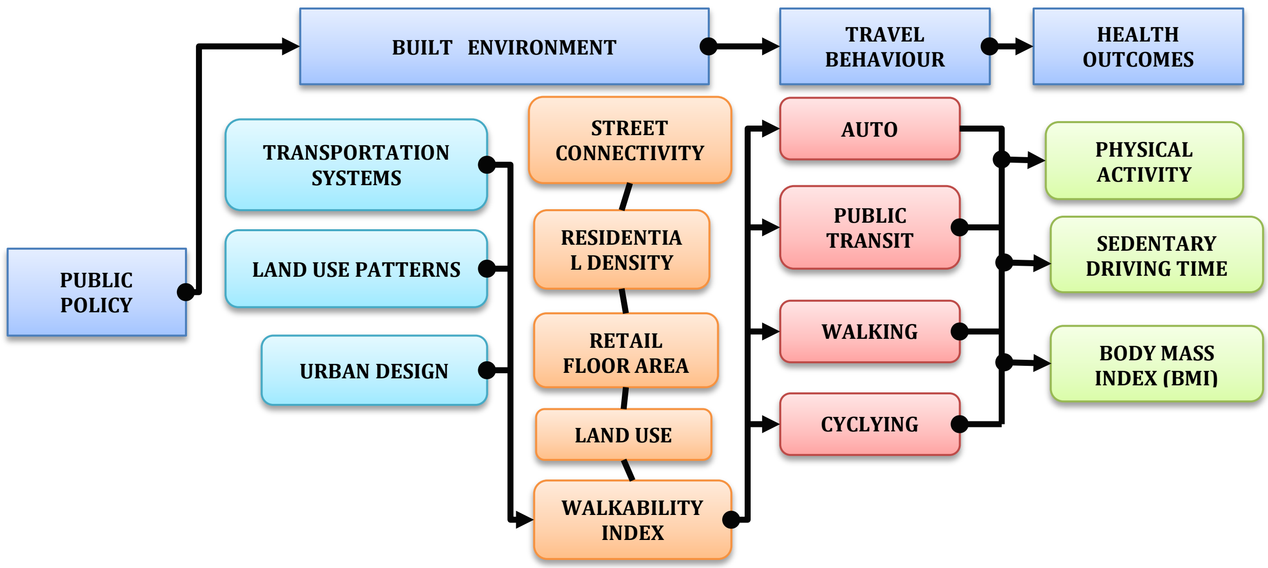

Figure 2: Flow chart showing the hypothesized process and relationships between the built environment, travel behaviour and health outcomes.
Source: Frank et al., 2003; Frumkin et al., 2004; Frank et al., 2005.

Although many studies have explored the relationships between health and the built environment for neighbourhoods around residences, relatively few have analyzed urban form near workplaces (Crespo et al., 2011; Matson-Koffman, Brownstein, Neiner, & Greaney, 2005). Other studies have examined objectively measured physical activity, but have mainly relied on participant perceived, self-reported characteristics of workplace environments (Schwartz et al., 2009). Many worksite studies have focused on analyzing the extent to which internal building environments containing physical activity-enabling infrastructure and physical activity promotion strategies by employers encourage increased physical activity and healthy living (Crespo et al., 2011; Proper et al., 2003). Instead, the focus of this research is on the macroscale neighbourhood built environment characteristics within the local area surrounding workplace locations. This study analyzes the impact of the built environment near workplaces on physical activity, body mass index (BMI) and sedentary time spent driving or riding in vehicles. It aims to quantitatively examine these environments using objective measurements of urban form as independent predictor variables to explain associations with health outcomes using statistical regression models. Furthermore, the piece highlights the health benefits of developing walkable environments near employment and demonstrates the positive effects on public health of continued investment in mixed-use development, and public transit and active transportation infrastructure near workplaces.

2. Literature Review

Over the past two decades, the rates of obesity and other related chronic diseases in North America, such as type-2 diabetes and heart disease, have reached alarming numbers (Brownson, Hoehner, Day, Forsyth, & Sallis, 2009; Pate et al., 2011). Recent reports have indicated that, despite an increase in healthier diet and nutrition practices, less than 50% of adults and 40% of youth meet the minimum U.S. physical activity guidelines (Adlakha et al., 2015; Brownson, Boehmer, & Luke, 2005). Academic scholarship related to the impact of the built environment on public health has presented a prominent body of research demonstrating the relationship between the health of the general public and the urban form of cities. Most studies have focused on the role of the built environment near people's homes and the extent to which these factors encourage or inhibit the ability to walk to nearby goods, services and recreation facilities. Although much research has presented persuasive evidence to suggest that the area around the home may be the most important environment for influencing levels of utilitarian and leisure physical activity (Troped et al., 2010), during the course of the day people traverse other areas and are exposed to various non-home built environments based on the destinations they visit from work, to school, commercial facilities and extracurricular activities (Hurvitz & Moudon, 2012). Carlson et al. (2012), also exploring work environments using the NQLS Prime study, concluded that the built environment near work played a larger role in determining active transportation behaviour than did the built environment near home. In order to obtain a more comprehensive picture of the continuum of spatial environments that impact health and opportunities for physical activity, it is necessary to build and include associations between public health outcomes in non-home environments (Barrington, Beresford, Koepsell, Duncan, & Moudon, 2015; Hurvitz & Moudon, 2012).

Recently, emerging research has attempted to repeat similar analyses of neighbourhood built environments performed near the home, around non-home locations such as places of employment and schools (Adlakha et al., 2015; Barrington et al., 2015; Carlson et al., 2014; Haug, Torsheim, Sallis, & Samdal, 2010; Hurvitz & Moudon, 2012; Sallis et al., 2001). Despite the potential for evaluating the impact of the urban form around the second most important location for the average working adult, there are significant gaps in the literature evaluating physical activity for worksite locations (Adlakha et al., 2015; Barrington et al., 2015; Hurvitz & Moudon, 2012). One such important lack of assessment around workplace locations are studies that employ both objectively measured health outcomes and built environment metrics (Adlakha et al., 2015; Schwartz et al., 2009). Several studies combine objectively measured variables for the independent or dependent variables with self-reported or participant perceived surveys for the other. Many of these studies lack the resources required to apply objective data for both variables in their analyses (Schwartz et al., 2009).

Adlakha et al. (2015) using perceived built environment features and self-reported physical activity scores from the International Physical Activity Questionnaire (IPAQ), found only limited significant associations between worksite neighbourhood built environment features and workplace physical activity although all adjusted odds of engagement were in the expected direction. An older meta-analysis study of 26 workplace physical activity interventions by Dishman, Oldenburg, O'Neal, & Shephard (1998), found no statistically significant increase in physical activity due to workplace interventions, although it acknowledged weak research design methods and a lack of exemplary samples. In contrast to urban form features that impact physical activity around home neighbourhoods which are more well-known, measurements of workplace neighbourhoods that draw direct associations to public health are less clear (Adlakha et al., 2015; Barrington et al., 2015). A study by Troped et al. (2010) focusing on worksite and home buffers discovered similar results noting that intersection density, land use mix and housing density nearby home neighbourhoods was positively associated with moderate-to-vigorous physical activity (MVPA), however, only population and housing density were significantly associated with physical activity in workplace neighbourhoods.

A study by Hurvitz & Moudon (2012) using objectively measured GPS data found that more than 90% of the built environment values at locations near participants' homes were significantly different from those away from individuals' homes, underscoring the need to assess built environment exposure across various activity spaces beyond the home. Findings from the Promoting Activity & Changes in Eating (PACE) longitudinal trial demonstrated that more walking among participants was associated with higher worksite neighbourhood socioeconomic status

(SES) and higher density of residential units (Barrington et al., 2015). Furthermore, the observational study concluded that workplace neighbourhood context may influence employees' obesogenic behaviours and that residential density around worksites could be a key indicator of infrastructure that promotes physical activity and health (Barrington et al., 2015). Schwartz et al. (2009) reported inconclusive results exhibiting no significant association between built environment measures and average weekday step count when evaluated continuously or categorically. Schwartz et al. (2009) concluded that despite most participants stating that perceived built environment characteristics around worksite locations were supportive of walking, a lack of association with objectively measured average weekday steps may indicate that these more walkable workplace neighbourhoods were not related to a greater amount of walking over the workday. Schwartz et al. (2009) site the potential shortcomings of utilizing self-reported built environment characteristics in the cross-sectional study and recommend a prospective design that diversifies the sample and draws on objectively measured built environment characteristics.

In addition to time spent at home and on transportation needs, the place of employment is a key location of interest not only because of the time spent in these spaces during the average work week, but also because workplaces are used as an origin point for trips elsewhere (Adlakha et al., 2015; Frank et al., 2007). Work locations are a primary origin or destination point for home-to-work commute trips including secondary layovers and work-to-work trips for business or pleasure. A study by Frank et al. (2007) in metropolitan Seattle concluded that the built environment played a more important role in determining active transportation behaviour around worksite locations than the built environment near the home. Frank et al. (2007) found that distance to transit from home and work locations was a significant predictor of transit use and that each additional 400 m (0.25 mile) to stops from home and work was associated with a 16% and 32% reduction in transit use respectively. Additionally, it was easier to get physical activity from walking to other destinations of interest from a work location when the built environment was supportive of trips to nearby facilities through walking (Frank et al., 2007). The presence of commercial shops and services within close walking distance or accessible on transit allows workers to run errands, pursue extracurricular interests and other activities before, during or after working hours (Cervero, 2002; Ewing & Cervero, 2010).

In addition to active transportation modes, riding public transportation has also been recognized as a useful way to achieve the recommended amount of daily physical activity defined by the U.S. Surgeon General (Besser & Dannenberg, 2005; Lachapelle & Frank, 2009; Troiano et al., 2008). Any evaluating of the impacts of the built environment in proximity to worksite locations on health must also consider employee access to transit services, especially rapid transit as infrastructure that supports walkable environments. The widespread availability of General Transit Feed Specification (GTFS), which provides transit schedule, stop and route information, is a useful asset to assist in the process of measuring access to public transportation. While still in the early stages of development, the use of GTFS data for research studies in the literature is limited. To date, no currently available scholarly articles published examine public health outcomes or use transit catchment area surfaces. Nevertheless, Charleux (2014), Farber et al. (2014) and Widener et al. (2014) have used GTFS data for GIS-based analyses to calculate pedestrian accessibility and transit travel time to food environments.

The choice of which transportation mode is used to commute from home-to-work trips is based on a series of factors including cost, mobility, the speed of the transport mode, and accessibility, the availability of destinations that are reachable within a certain distance or travel time. Elasticity thresholds vary by individual circumstances such as income, individual value of time assessment, and availability of transit service or auto, however, as travel time costs and comfort decrease for a particular mode, the utility of choosing that mode increases against other options. In a cross-sectional study of over 4,000 participants, Hoehner et al. (2012) found that commute distance was negatively associated with physical activity and positively associated with BMI, waist circumference and systolic and diastolic blood pressure. Although no distinction was made been type of travel mode, Hoehner et al. (2012) concluded that MVPA is adversely associated with longer commuting distance underscoring the importance of reducing time spent in automobiles for commuting. Urban form characteristics in the neighbourhood surrounding the workplace also play a role in choice of travel modes for commute trips. Active transportation and transit infrastructure, employment density, diversity of job types, a balance between jobs and housing in close proximity to the work location all contribute to the likelihood of using a non-auto form of transportation for regular commuting. Frank & Pivo (1994) found that higher employment densities near worksites were associated with less driving alone, more transit use and more utilitarian walking, while increased land use mix was also associated with higher levels of walking.

In addition to the home, the place of work is the focal point for commuting trends and extracurricular activities. Recent evidence has suggested that urban areas with high street connectivity and a mix of land use and density among other characteristics encourage increased physical activity by walking and taking transit (Brownson et al., 2009; Frank et al., 2009; Lachapelle et al., 2011). Crespo et al. (2011) highlight the importance of physical activity promotion programs at worksites as effective tools for increasing daily non-sedentary time in addition to other intervention options instituted by municipalities such as updated infrastructure. An improved understanding of the link between workplace environment and health outcomes may guide interventions in the built environment made to foster increased walking benefiting public health (Adlakha et al., 2015). Modifications to the built environment in communities present a promising way in which to improve health outcomes and reverse the obesity epidemic (Booth et al., 2005; Hurvitz & Moudon, 2012). Providing physical environments around workplaces which encourage walking, cycling and transit use presents an opportunity for widespread adoption of physical activity behaviours through active living and reducing sedentary time (Barrington et al., 2015; Schwartz et al., 2009). By expanding the knowledge base of pedestrian environments surrounding worksites and their impacts on health, effective planning policy can be implemented to better target infrastructure investments in cities.

3. Research Design

3.1 NQLS Prime Overview

The Neighborhood Quality of Life Study (NQLS Prime) was an observational epidemiological study aimed at evaluating the impact of the built environment on physical activity among adults. Objectively measured MVPA[4], primary data collections and survey assessments including the administration of the International Physical Activity Questionnaire (IPAQ) instrument for self-reported health indicators were conducted between 2001 and 2005 (Cerin, Saelens, Sallis, & Frank, 2006; Frank et al., 2009; Sallis et al., 2009). NQLS Prime was funded as part of a National Institutes of Health (NIH) grant and comprised a collaborative, multi-disciplinary team led by principal investigators Dr. Jim Sallis,[5] Dr. Lawrence Frank[6] and Dr. Brian Saelens.[7] The study has yielded

[4] Acquired using Acitgraph accelerometers (Actigraph, Inc.: Fort Walton Beach, FL, model: 7164 or 71256).
[5] University of California San Diego, San Diego State University.
[6] University of British Columbia.
[7] University of Cincinnati, University of Washington and Seattle Children's Research Institute.

numerous scholarly articles on findings from analyses performed on the participant home neighbourhood environments (Abercrombie et al., 2008; Cerin et al., 2006; Frank et al., 2009; Sallis et al., 2009).

NQLS Prime utilized a cross-sectional, quasi-experimental research design sampling a total of thirty-two participant home neighbourhoods across six counties in Maryland and Washington based on clusters of contiguous U.S. Census block group geography (Frank et al., 2009; Sallis et al., 2009). The recruitment process implemented a two stage clustered sample design to select participants with spatially clustered home locations stratified by annual median household income and type of urban environment based on a four quadrant walkability matrix (Cerin et al., 2006; Sallis et al., 2009). Participants were gathered from eight high and eight low walkable neighbourhoods with low and high income classifications for a total of sixteen distinct neighbourhoods in each region (Cerin et al., 2006). The applied research sample was made up of adult participants ranging in age from 18 years to 66 years of age originally recruited in the early 2000s (Frank et al., 2009).

Two study regions in large metropolitan areas were chosen, one on each coast in the United States: Baltimore, MD and Seattle, WA (Figure 3 and Table 1). On the East Coast, the study area encompassed the Washington D.C. – Baltimore metropolitan area of the Mid-Atlantic Eastern seaboard and included Baltimore City, Baltimore County, Howard County, Montgomery County and Prince George's County in Maryland (Figure 4).[8] In Washington, participants were recruited from King County, the largest of three counties in the metropolitan statistical area which included Seattle, some southern suburbs as well as most of the Eastside suburbs (Figure 5). In Maryland, 935 participants were successfully recruited for NQLS Prime and 1,287 adults in Washington for a total pooled study of 2,222 participants (Sallis et al., 2009).[9]

[8] No participants were recruited from Washington D.C. or Virginia for this study.
[9] Original recruited sample size. Not all participants were included for all study components and some reported missing values.

Figure 3: NQLS Prime study areas comprise metropolitan Baltimore, MD and Seattle, WA.
Source: ESRI, 2012.

Table 1: Overview of study area demographic, socio-economic status (SES) and mean pooled values.

Demographic Characteristic	*Baltimore*	*Seattle*	*Pooled*
Municipal Population	620,961	608,660	1,229,621
Urban Area Population	2,203,663	3,059,393	5,263,056
Combined Statistical Area (CSA)	9,443,180[10]	4,459,677[11]	13,902,857
Land Area (sq. km.)	210	217	427
Municipal Density	2,957/km^2	2,805/km^2	2,880/km^2
Median Age	34.5	36.1	35.3
Educational Attainment (% ≥ high school graduate)	80.2%	93.2%	86.7%
Median Household Income	$41,385	$65,277	$53,331
Individuals Below Poverty Line	23.8%	13.6%	18.7%

Source: U.S. Bureau of Census, 2010.

[10] Washington-Baltimore-Arlington CSA, DC-MD-VA-WV-PA.
[11] Seattle-Tacoma-Bellevue CSA, WA.

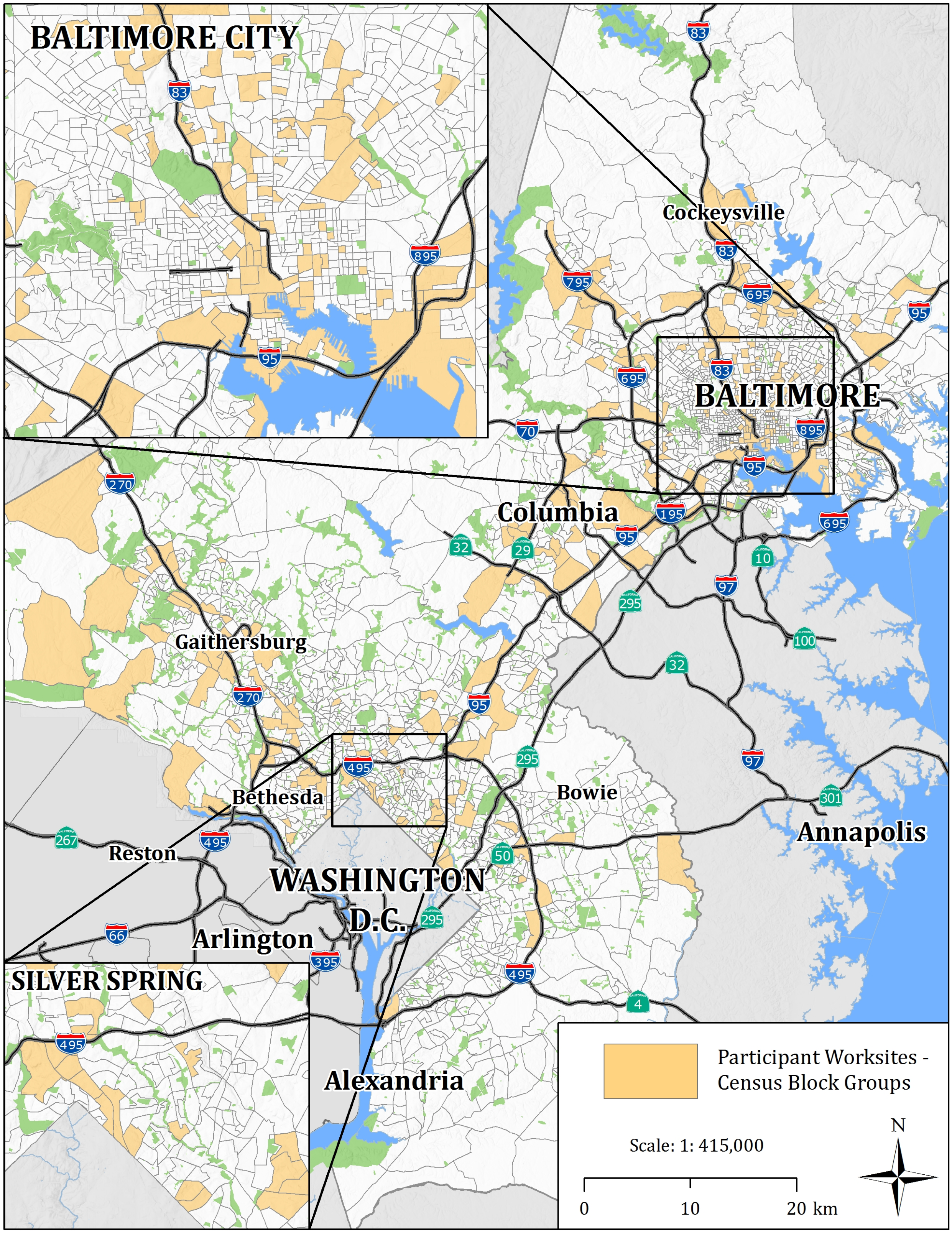

Figure 4: Participant worksite locations by Census block groups in metropolitan Baltimore.
Source: Government of Maryland, 2015; ESRI, 2012.

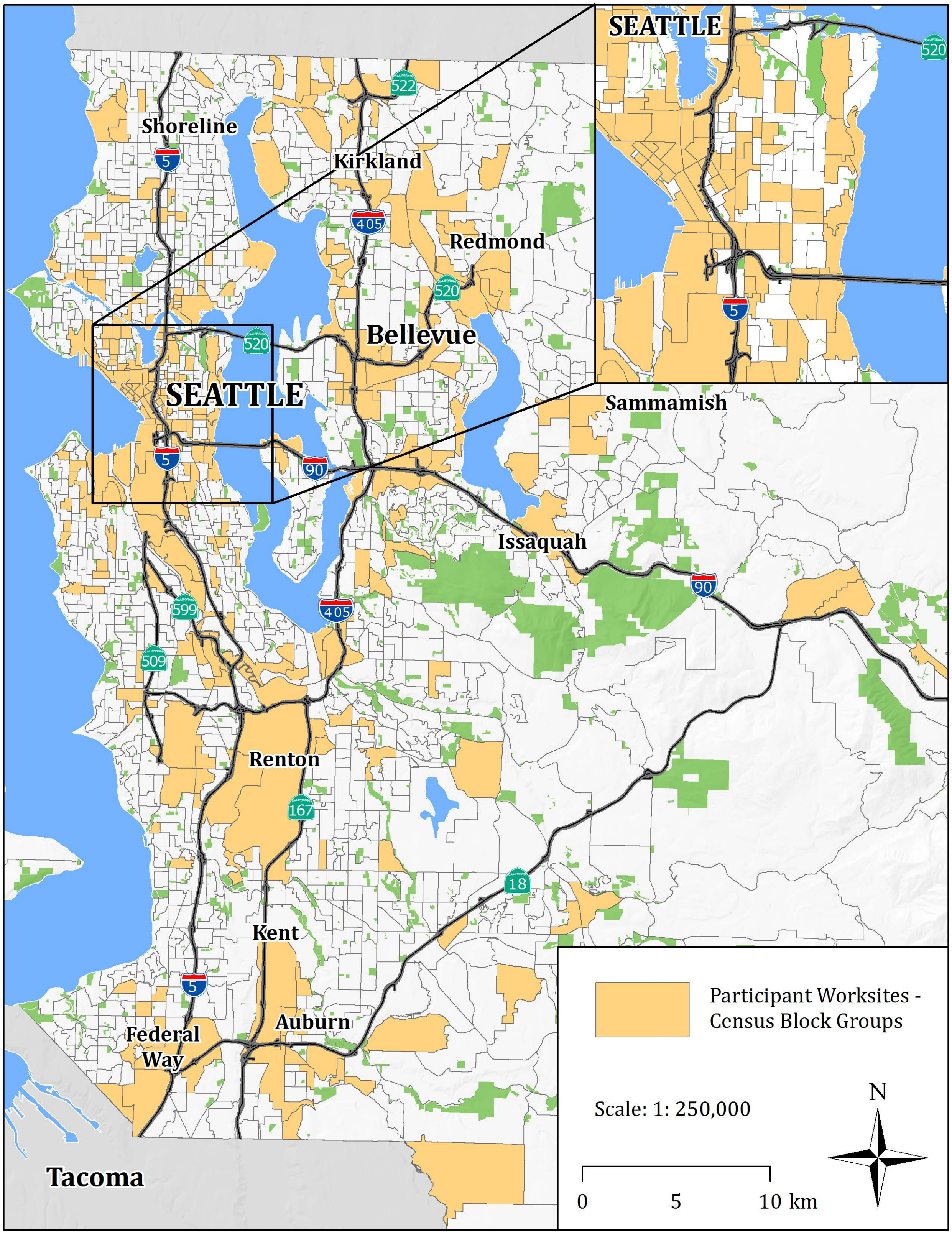

Figure 5: Participant worksite locations by Census block groups in King County, WA.
Source: King County, 2015; ESRI, 2012.

The primary focus of NQLS Prime was the study of the adult home neighbourhood environments (Frank et al., 2009), although the place of employment address was also recorded as the principal investigators were interested in researching health outcomes related to the workplace (Crespo et al., 2011). A modified Neighbourhood Environment Walkability Survey (NEWS) was developed to examine the perceived environment around participant worksites (Cerin et al., 2006). To date, analysis has been performed on the perceived built environment around worksite neighbourhoods, however, objectively measured urban form variables have not been developed (Crespo et al., 2011). Building from of the previous research and leveraging the tremendous resources invested into NQLS Prime, this paper intended to fill this gap by developing built environment measures around the workplace neighbourhoods for participants in both regions and testing statistical associations with health outcomes using predictive regression models.[12] For the first time on NQLS Prime, the same analysis performed for the neighbourhood environment using objectively measured urban form measures in combination with objectively measured physical activity and self-reported health outcomes was repeated for the workplace environment.

Although 2,222 participants were originally recruited for NQLS Prime in both regions, not all participants were employed or provided their place of employment. The databases utilized for this analysis comprised a total of 532 workplace locations in the Baltimore region and 723 in the Seattle region. Complete built environment data was only available for workplaces located within the NQLS Prime home study counties from which participants were sampled, denoting that urban form measures could not be developed for employment locations outside of these counties (Table 2).[13] The total number of participants included in this workplace study was 394 (74.1% of total) in the Baltimore region and 684 (94.6% of total) in the Seattle region. Lastly, participants who worked from home were excluded for all regression models that controlled for NQLS Prime home built environment, however, these participants made up only a small portion of the entire pool at 2.7% (n = 29). Once all factors were accounted for, the total pool for valid worksite locations within the study area was 1,078.

Table 2: Total counts of participant home and work locations by region and county.

State	*County/Independent City*	*Original*	*% of Total*	*Worksite Count*	*% of Total*	*Work from Home*	*% of Total*
Maryland	Baltimore City	286	30.8%	150	28.2%	0	0.0%
	Baltimore County	115	12.4%	76	14.3%	1	0.3%
	Montgomery	255	27.5%	105	19.7%	2	0.5%
	Prince George's	138	17.9%	37	7.0%	3	0.8%
	Howard	134	14.4%	26	4.9%	3	0.8%
	Anne Arundel	0	0.0%	16	3.0%	0	0.0%
	Harford	0	0.0%	5	0.9%	0	0.0%
	Total Included	928	99.2%	394	74.1%	9	2.3%
	Total	935	100%	532	100%	9	1.7%
District of Columbia	Washington D.C.	0	0.0%	97	18.2%	0	0.0%
Virginia	Arlington	0	0.0%	4	0.8%	0	0.0%

[12] All databases were used with permission and security precautions were employed to ensure that participant health data and address information was kept private and confidential at all times.

[13] An updated pedestrian-enhanced road network was developed for both regions to improve accuracy for network variables and buffers. Network buffers (without urban form measures) were developed for participant worksites in Washington D.C., Anne Arundel and Harford counties in Maryland, Arlington, Fairfax, Prince William and Loudoun counties in Virginia and Pierce, Snohomish and Kitsap counties in Washington.

Virginia	Alexandria	0	0.0%	2	0.4%	0	0.0%
	Fairfax	0	0.0%	9	1.7%	0	0.0%
	Prince William	0	0.0%	1	0.2%	0	0.0%
	Total	0	0.0%	16	3.0%	0	0.0%
Washington	King	1287	100%	684	94.6%	20	2.9%
	Pierce	0	0.0%	13	1.4%	0	0.0%
	Snohomish	0	0.0%	23	3.2%	0	0.0%
	Kitsap	0	0.0%	2	0.3%	0	0.0%
	Total Included	1287	100%	684	94.6%	20	2.9%
	Total	1287	100%	723	100%	20	2.8%
Pooled	Total	2,222	100%	1,255	100%	29	2.3%
	Adjusted Total	2,199	99.0%	1,078	85.9%	29	2.7%

3.2 Workplace Study

Although information on participant place of employment was acquired as part of NQLS Prime, limited research has been performed to study the interactions between workplace environment and health. An analysis of perceived workplace urban form is currently underway, however, only home to work distance has ever been objectively measured. As a result of the relatively limited published literature and understanding on the interactions between workplace neighbourhood environment and health outcomes, the NQLS Prime data provided a unique opportunity to test a series of hypotheses about the potential health impacts of worksite environments. The workplace study focused on three key dependent variables of interest pertaining to participant health status: 1) objectively measured daily minutes of MVPA collected using accelerometers, 2) BMI calculated through acquiring participant height and weight information and 3) self-reported IPAQ sedentary time spent driving or riding in vehicles in minutes per week. Multivariate statistical regression models were developed to determine the statistical significance of the relationship between health outcomes and the built environment at workplace locations (Figure 6).

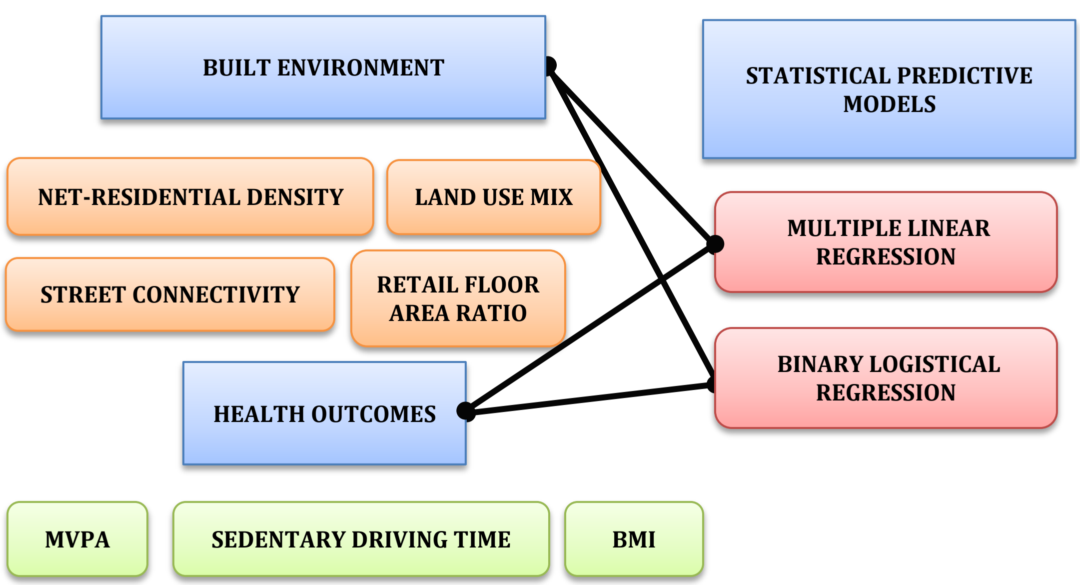

Figure 6: Flow chart showing the linking of objectively measured built environment variables with health outcomes through statistical analysis.
Source: Frank et al., 2010.

3.3 Research Questions

3.3.1 Primary Research Questions

1. To what extent is having a walkable environment[14] nearby workplaces associated with the likelihood of achieving moderate levels[15] of physical activity?
2. To what extent is not having a walkable environment nearby places of employment associated with the likelihood of having a BMI above 25 indicating overweight or obese status?
3. To what extent is not having a walkable environment nearby worksite locations associated with the likelihood of having more sedentary time spent driving or riding in vehicles?

3.3.2 Secondary Research Questions

1. Which of the core macroscale built environment components of the walkability index (land use mix, retail floor area ratio (FAR), net residential density or intersection density) at workplaces best predicts levels of physical activity minutes per day?
2. To what extent does travel time on transit or distance between home and work affect employee participant physical activity, BMI and sedentary time spent in vehicles?
3. To what extent does travel time on transit or average distance between work location and regional accessibility locations affect employee participant physical activity, BMI and sedentary time spent in vehicles?
4. To what extent does having access to high quality rapid transit near work have a positive impact on minutes of physical activity per day, BMI and sedentary time in vehicles?
5. Does having access to a park of any size or varying size near the worksite location have a positive impact on minutes of physical activity, BMI and sedentary time in vehicles?
6. Is having better access to facilities that promote increased physical activity and exercise such as private recreation locations near the place of employment positively associated increased minutes of physical activity?

3.4 Research Objectives

The study aimed to develop and analyze built environment measures at a variety of worksite locations across two study regions and compared them to participant levels of MVPA, BMI and sedentary time in vehicles. The association between dependent health outcomes and the explanatory power of selected urban form independent variables including the walkability index was tested for statistical significance. The key strategic objective of this research was the identification of independent variables (demographic covariates and built environment variables) with the strongest explanatory power in predicting the dependent variables (health outcomes) examined. An additional objective of the project was to analyze the use of a relatively unique catchment area buffer surface, based on accessible areas on transit or by foot within a certain timeframe, against standard distance-based buffer surfaces. The end goal of this study was to demonstrate that, in a single case in two regions in the United States, there was observed associations between where a person works and their health and that work environments which better enable active transportation and transit use are more supportive of healthy living and help to reduce sedentary behaviour.

[14] A walkable environment refers to a built environment that is supportive of walking and active-friendly activity including cycling and transit use as opposed to a more auto-dependent urban form.
[15] 30 minutes of physical activity per day as a recommended minimum by the U.S. Surgeon General.

3.5 Research Hypotheses

By examining the ample literature on the relationships between public health outcomes and the built environment, it was hypothesized that urban form near worksite locations correlates with employee health status. A large body of evidence exists to support this assertion for the environment near the home, but relatively limited studies have examined the workplace. It was hypothesized that the environment near places of employment has a reduced capacity, though still a significant impact, to explain health outcomes in comparison to the environment near the home. This study evaluated a series of hypothesized relationships between worksite environment and health as well as conducted an exploratory analysis to determine a set of packaged independent variables that most accurately explained health outcomes. The main alternative hypothesis (H_1) for the study was that walkable local workplace built environments which support active transportation or public transit use are associated, in a statistically significant manner, with healthy levels of MVPA, lower BMI and reduced amounts of time spent sedentary in vehicles. The null hypothesis (H_0) was that walkable local workplace built environments which support active transportation or public transit use are not associated, in a statistically significant manner, with healthy levels of MVPA, lower BMI or reduced amounts of time spent sedentary in vehicles.

3.5.1 Hypothesized MVPA Relationships

It was hypothesized that the likelihood of achieving healthy levels of daily MVPA was associated with several urban form metrics nearby and related to the workplace. Having a more supportive walk environment near work was hypothesized to be associated with a likelihood of achieving higher levels of physical activity than those worksites with poorer walking environments (Table 3) (Barrington et al., 2015; Schwartz et al., 2009). It was believed that those workplaces with a higher walkability index[16] at the 15 minute transit access buffer size had more of an ability to use active transportation or transit to travel to work and also had access to more amenities and services nearby worksites reducing the need for a vehicle (Besser & Dannenberg, 2005; Lachapelle & Frank, 2009). Having a longer trip on transit from home to work was believed to be associated with an increased likelihood of having a worksite that had poor transit access resulting in increased vehicle usage and commute times and decreasing overall MVPA (Freeland et al., 2013; Hoehner, Barlow, Allen, & Schootman, 2012). Having an increased number of cul-de-sacs near worksites was hypothesized to be associated with employment locations being in more suburban areas or linked to single-use industrial, business or office parks which are typically auto dependent resulting in less physical activity (Frank, Glanz, et al., 2006; Frank, Sallis, et al., 2006). Worksites that have an increased average distance to regionally significant activity centres may result in reduced MVPA due to longer trips by automobile and greater remoteness in the region. Lastly, sources of healthy food locations such as supermarkets and farmers' markets within a short proximity of 500 m was presumed to be associated with an increased ability to walk to these locations from work, therefore, increased daily MVPA achieved (Frank, Glanz, et al., 2006; Glanz, Sallis, Saelens, & Frank, 2005).

Table 3: Hypothesized relationships between independent variables and MVPA.

Variable	*Relationship*
Age[17]	(-) The older the participant the less physical activity gained.
Gender[18]	(-) Males obtain more daily physical activity than females.
Caucasian, non-Hispanic Ethnicity[19]	(+) Caucasians are more likelihood to achieve more physical activity than non-Caucasians.

[16] Two versions are tested using a land use mix four class and land use mix six class explained in 4. Methods.
[17] Continuous age variable for participants between 18 and 66 years of age.
[18] Binary gender variable where 0 = male and 1 = female.
[19] Binary Caucasian, non-Hispanic variable where 0 = non-Caucasian and 1 = Caucasian, non-Hispanic.

Children[20]	(-) Participants with children are likely to achieve less physical activity than those without children.
Household Vehicle[21]	(-) Participants with a vehicle in the household are likely to achieve less physical activity than those without a vehicle.
Annual Household Income[22]	(+) Participants that are wealthier are more likely to achieve more physical activity than those that are poorer.
Walkability Index – Mix 4 – 15 min.	(+) Having a more supportive walkable environment near work is associated with more physical activity.
Home-Work Trip - Transit Travel Time	(-) Having a longer trip on transit to work is associated with an increased likelihood of choosing a sedentary transportation type (vehicle).
Cul-de-sac Density – 1 km	(-) Having increased cul-de-sac density near worksites is associated with being located in more suburban areas linked to industrial, business or office parks that are often auto-dependent.
Regional Accessibility – Average Distance	(-) Being further from regionally significant locations is associated with decreased MVPA due to long trips by automobile.
Healthy Food Count – 500 m	(+) Being closer to sources of healthy food near worksites is associated with a higher likelihood of achieving more physical activity.

3.5.2 Hypothesized BMI Relationships

A main hypothesis made when evaluating healthy body weight was the potential for more supportive walk environments within 500 m from workplaces to be associated with lower BMI (Table 4) (Ewing & Schmidt, 2003; Frank et al., 2004). As with MVPA and sedentary time spent driving or riding in cars, it was presumed that increased travel time to regional accessibility locations was associated with higher BMI. Two measures of food environment were hypothesized to negatively contribute to BMI: counts of convenience stores and gasoline stations within a 1 km distance and distance to nearest fast food (limited service) restaurant (Glanz, 2009). Both of these food environment characteristics were considered to be potentially positively associated with a more auto-dependent urban form as well as having a limited amount of healthy food options, therefore, increasing the likelihood of being overweight or obese (Glanz et al., 2005; Glanz, 2009).

Table 4: Hypothesized relationships between independent variables and BMI.

Variable	*Relationship*
Walkability Index – Mix 4 – 500 m	(-) Having a more supportive walkable environment near work is associated with a lower BMI.
Regional Accessibility – Transit Travel Time	(+) Being further from regionally significant locations on transit is associated with increased BMI due to long trips by automobile.
Convenience Store/Gasoline Station Count – 1 km	(+) Having more convenience stores and gasoline stations is associated with more auto dependent environments increasing likelihood of being overweight or obese.
Nearest Distance – Fast Food	(+) Having fast food locations within closer proximity is associated with increased BMI.

3.5.3 Hypothesized Sedentary Time in Vehicle Relationships

It is hypothesized that having a more walkable built environment within 15 minutes on transit of workplaces had a negative correlation but a positive health impact on sedentary time in vehicles (Table 5) (Frank & Kavage, 2009; Freeland et al., 2013). Higher retail FAR and land use mix six values within 15 minutes on transit or walking of worksites was presumed to decrease

[20] Binary children variable where 0 = participant has no children and 1 = participant has children.
[21] Binary household vehicle variable where 0 = no household vehicle, 1 = ≥ 1 household vehicle.
[22] Eleven class categorical variable for annual household income separated by $9,000 increments (Figure 18).

sedentary time because of less auto-oriented retail and mixed land use offering a variety of proximate services reducing dependence on vehicle travel (Cervero, 1996; Frank et al., 2009, 2012). Decreased access to regionally important locations by transit were assumed to be associated with poorer health outcomes including more minutes spent in cars due to potential increased reliance on the automobile for commute trips (Cervero & Radisch, 1996). Similarly to regional accessibility, transit travel time from home to work was believed to be poorer in suburban areas as opposed to downtown worksites or urban locations, thus increasing the likelihood of having more minutes of driving time. Also considered for assessing time spent driving was counts of convenience stores and gasoline stations within 1 km which may have been associated with proximity to freeways, highways, main arterials as well as low density strip mall commercial areas resulting in more auto dependent worksites (Cervero, 1996; Frank, Glanz, et al., 2006; Glanz et al., 2005).

Table 5: Hypothesized relationships between independent variables and sedentary time spent in cars.

Variable	*Relationship*
Retail FAR – 15 min.	(-) Having a more supportive commercial environment for walking near work is associated less time spent in vehicles.
Land Use Mix 6 – 15 min.	(-) Having access to more of a mixing of land use categories nearby work is associated with a decreased likelihood of having a minutes spent in cars.
Regional Accessibility – Transit Travel Time	(+) Being further from regionally significant locations on transit is associated with increased BMI due to long trips by automobile.
Home-Work Trip – Transit Travel Time	(+) Being further from work by transit is associated with a higher likelihood of being overweight or obese.
Convenience Store/Gasoline Station Count – 1 km	(+) Having more convenience stores and gasoline stations is associated with more auto dependent environments increasing likelihood of driving time.

4. Methods

4.1 Data Acquisition & Variable Development

A geographic information system (GIS) was utilized to objectively measure a variety of macroscale neighbourhood characteristics of the built environment around participant workplace locations. Places of employment are non-temporary locations spread across the study area for a wide range of professions encompassing the sample. Workplace locations consisted of jobs in downtown office buildings, industrial and office parks, suburban employment centres, shopping malls and strip malls, schools and universities, civic and community centres as well as rural locations among others. Base secondary geospatial datasets including land use parcels, road networks, transit systems and background cartographic features such as water bodies were acquired from local government sources including counties, transit authorities and metropolitan planning organizations (MPOs) to develop built environment metrics.[23] Additionally, primary data audits and enumerations were completed as part of NQLS Prime and other related studies that includes field verified databases for parks, private recreation and food establishment inventories.[24] Participant worksite location addresses were geocoded using two online geocoding services,[25] differences between the spatial references were measured and reviewed and the most accurate location was determined. All spatial analyses were performed on each of the two study regions separately for consistency and to maintain geographic accuracy. In accordance with the systems used by the MPOs in both regions, the North American 1983 (NAD83) geographic coordinate

[23] An exhaustive list of data sources is provided in Section 10. Data Sources.
[24] All databases were acquired with written permission.
[25] 2010 ESRI Online Geocoding Service and 2013 U.S. Census TIGER Online Geocoding Service. See Section 11. Software & Application Services.

system (GSC) was used for both regions with the following State Plane projected coordinate systems (PCS) used: State Plane Maryland FIPS 1900 (metres) in Maryland and HARN State Plane Washington North FIPS 4601 (feet) in Washington.

4.1.1 Pedestrian-Enhanced Road Network

Developing a pedestrian network to effectively model the potential active transportation behaviour around worksite locations forms the backbone of the built environment variables. This comprehensive network was constructed at the initial stages of variable development and comprises all areas where pedestrians may travel including roadways, non-motorized and multi-use pathways. As part of creating a walkable network, all road types where pedestrians are not permitted including interstates, freeways, limited access highways, highway access ramps and interchanges were removed from the road network (Figure 7). The integration of pedestrian or cyclist-only pathways known as "pedestrian-enhanced" networks are crucial for estimating an accurate portrayal of active transportation networks. Such networks include bike paths, cul-de-sac, dead-end or traffic calming cut-throughs, park paths, trails and other connector segments. Alleys and laneways were included in the network for buffer development as pedestrians are permitted to traverse them, however, they were removed from the network used to calculate network distance variables and transit travel times. In addition, the walkable network, not the "pedestrian-enhanced" network, was used for calculating intersection counts and density based on road network junctions only. Road network and non-motorized pathway coverage was extended beyond the study areas in both regions to encompass the entire metropolitan area in order to allow for accurate transit travel time measures.

Figure 7: Pedestrian-enhanced road network at the eastern portal of the Mt. Baker Tunnel onto the I-90 Floating Bridge between Seattle and Mercer Island. Freeway road segments are removed while multi-use pathways and trails are included.
Source: King County, 2015; ESRI, 2012.

4.1.2 Buffer Development

In order to assess the impact of urban form, land use and transportation attributes on physical activity and public health, it is important to identify a consistent spatial unit that most accurately represents a participant's local environment (Forsyth, Van Riper, Larson, Wall, & Neumark-Sztainer, 2012; Frank et al., 2005; Lachapelle et al., 2011; Oliver, Schuurman, & Hall, 2007). Despite the widespread standardization and availability of predefined areal unit surfaces, such as U.S. Census block groups, U.S. Census tracts or Traffic Analysis Zones (TAZs), they provide a relatively coarse level of geographic detail for this type of study and are more susceptible to inconsistencies associated with the modifiable unit area problem (MAUP) (Cerin et al., 2006; Clark & Scott, 2013; Forsyth et al., 2012; Foster, 2011; Oliver et al., 2007). The MAUP is characterized by issues of spatial zone and scale when arbitrary boundaries are utilized to aggregate built environment features and report specific aspects of spatial phenomena under consideration (Clark & Scott, 2013; Frank, Fox, Ulmer, Chapman, Kershaw, Sallis, Conway, Cain & Adams, 2016). Even though MAUP effects are inevitable when conducting spatial analysis, their impacts can be greatly reduced and provide increased accuracy by using a consistent process of measurement based on a pedestrian-accessible network (Boruff, Nathan, & Nijënstein, 2012; Burton et al., 2009; Duncan, Aldstadt, Whalen, & Melly, 2013; Manaugh & El-Geneidy, 2011). The availability of the worksite address location for the NQLS Prime study allows for individual walk catchment areas to be developed in the immediate area around the place of employment, thereby better representing the possible walking options for pedestrians.

Findings from studies by Berke, Koepsell, Moudon, Hoskins, & Larson, (2007), Boruff et al. (2012), Burton et al. (2009) and Manaugh & El-Geneidy (2011) demonstrate that representing walk environments using distances along networks as opposed to crow-fly or straight-line distances greatly improve the on-the-ground representation of modeled walking environments (Figure 8). Polygon-based vector features known as "buffers" surrounding the pedestrian walkable networks are utilized to model a walking surface that selects all urban form features being points, polylines or polygons intersecting the buffers (Feng et al., 2010; Forsyth, Schmitz, Oakes, Zimmerman, & Koepp, 2006; Leal & Chaix, 2011). Additional studies by Forsyth et al. (2012), Oliver et al. (2007) and Frank et al. (2016) further test public health outcomes including physical activity using a variety of network buffer types at various scales and using multiple trim distances from the road network concluding that the "sausage" buffer offers the most consistent and easily replicable buffering method available to date. Sausage buffers are a type of buffer that delineates a polygon surface from the road network based on a specified trim distance and were incorporated in this study.

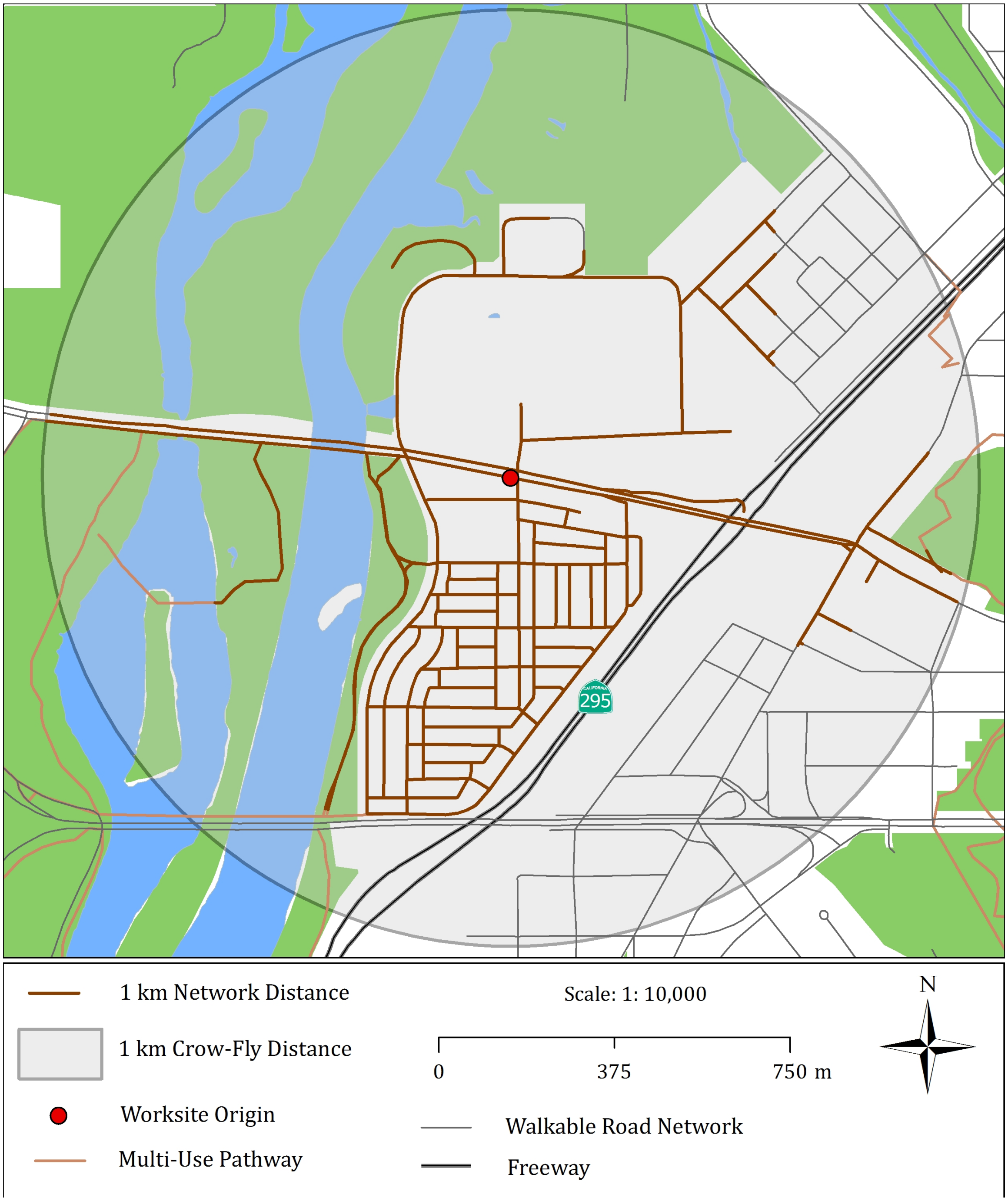

Figure 8: Comparison between 1 km network distance and 1 km crow-fly distance from a worksite location. The crow-fly buffer intersects with parcels to the east of the highway that are not accessible on the network within 1 km.

Source: District of Columbia, 2015; ESRI, 2012.

4.1.3 Walk Catchment Surface

Sausage buffers representing the environment nearby worksite locations for both short walk trips as well as local transit were developed for this study. Two standard buffer distances were chosen to construct the built environment surface used to analyze the walk environment: 500 m and 1 km representing an approximately 6 minute and 12 minute walk respectively for an average person at 5 km/hour (Figure 9). Although buffer distances for health assessment studies have varied depending on the purpose and type of study as well as the age cohort examined (Carlson et al., 2014; Frank et al., 2012; Moudon et al., 2005; Saelens et al., 2012), the said distances are used widely in the literature and are suitable for adult participants (Feng et al., 2010; Frank, Bradley, Kavage, Chapman, & Lawton, 2008; Frank et al., 2005; Lee & Moudon, 2006). Catchment areas extend from the worksite origin out in all directions along the network until the denoted threshold limits of the buffers were reached. A standard trim distance or crow-fly distance from the walkable network of 25 m was selected balancing the need to include intersecting polygon features set back from the roadway while not erroneously including features adjacent to nearby roads outside of the buffer distance threshold (Figure 10) (Lawrence D Frank, Kershaw, Chapman, Campbell, & Swinkels, 2015; Ulmer, Chapman, Kershaw, Campbell, & Frank, 2015; Frank et al., 2016). To ensure that all built environment features in point vector form within proximity of the road network, a 40 m snapping distance was utilized to systematically move points to the road network.[26]

[26] A manual review of snapped features was performed for all point features and the few found to exceed the distance were manually moved where appropriate.

Figure 9: Image A shows a sample worksite 500 m sausage walk buffer in a highly connected urban area. Image B illustrates the same sausage buffer in a suburban area with multi-use path connectivity between cul-de-sacs.

Source: City of Baltimore, 2015; Howard County, 2015; ESRI, 2012.

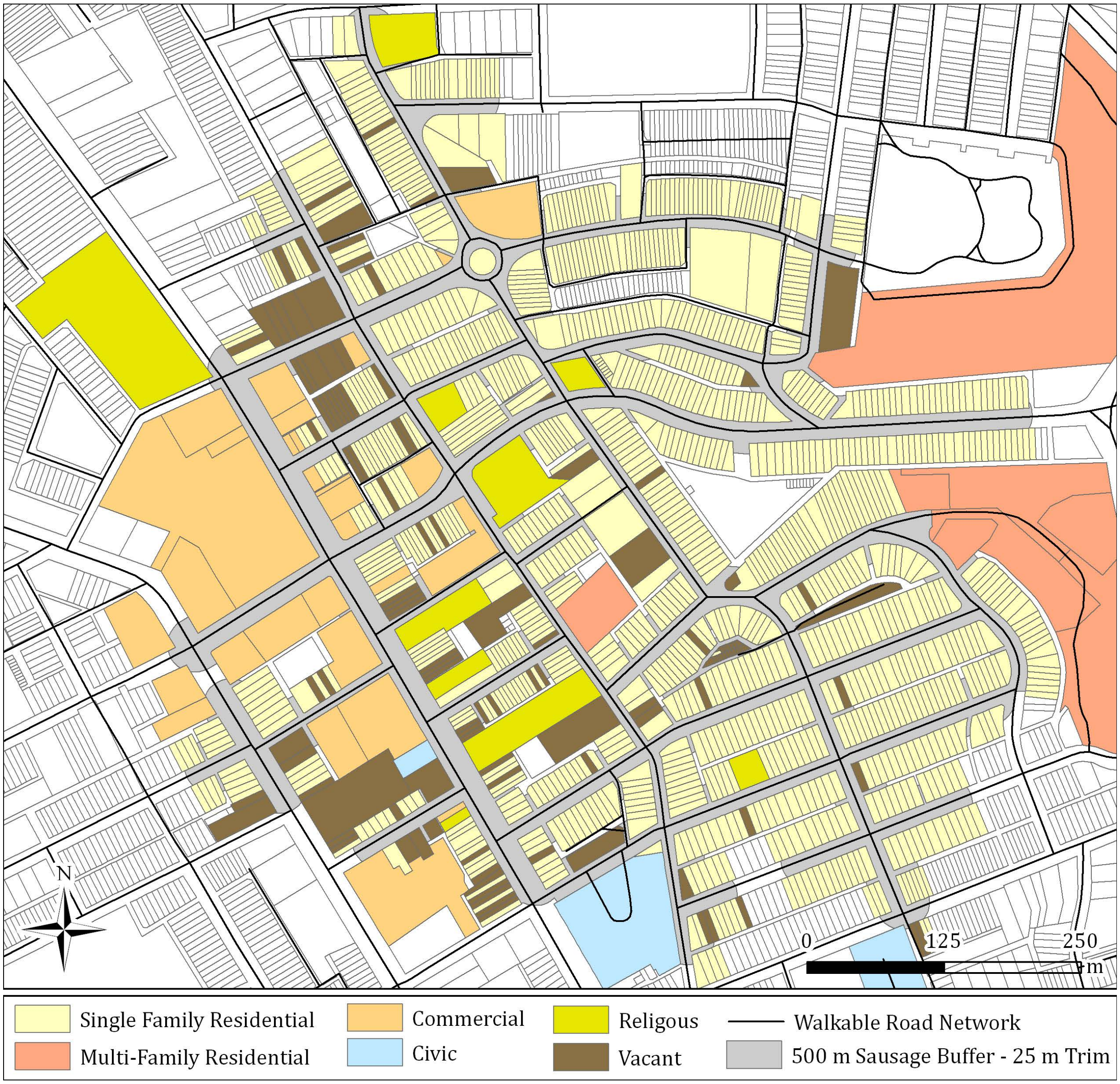

Figure 10: Parcels by land use class aggregated to 500 m sausage walk buffer with a 25 m trim distance from the road network.

Source: Maryland Department of Planning, 2012; ESRI, 2012.

Despite the fact that the sausage buffer provides the strongest representation of the walk areas readily accessible to pedestrians for determining which features intersect the surface, because of its "lattice" structure it underestimates the total area which the buffer covers. To achieve a more accurate measure of the total area the buffer encompasses, the interior polygons or isolated island features were extracted and then merged with the sausage buffers for use as the denominator for all gross density measures (Figure 11). Table 6 outlines the mean buffer area values comparing the "lattice" sausage buffer with the "solid surface" sausage buffer that includes interior polygons outlining a range of between an 11.1% and 24.7% increase in buffer size with the 500 m buffers exhibiting the smallest change and the 1 km and 15 minute transit shed buffers showing the largest change in buffer area.

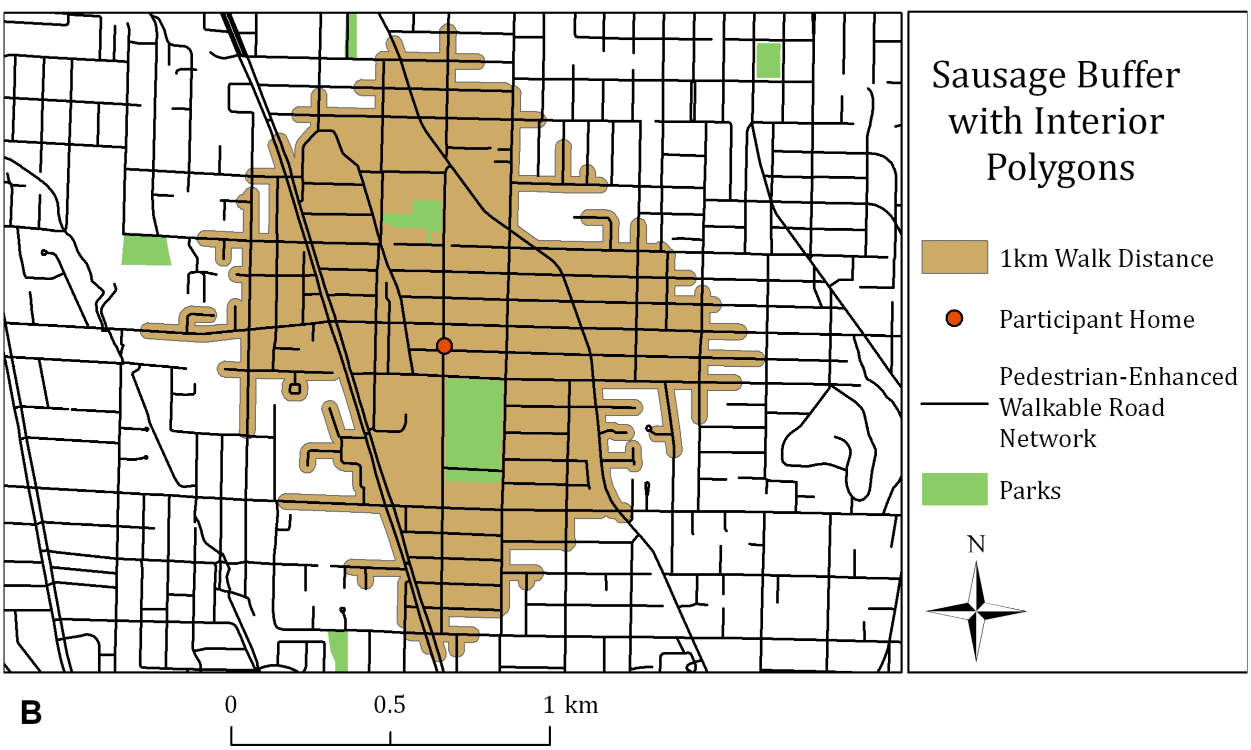

Figure 11: Sample buffer comparison showing the "lattice" structure of the 1 km sausage buffer and the same buffer combined with interior or island polygons. Image A is the buffer form used to select all intersecting built environment features. The area derived from the "solid surface" form (image B) was used as the denominator for all gross density measures.
Source: King County, 2014; ESRI, 2012.

Table 6: Comparison of mean buffer area for "lattice" sausage buffers and adjusted "solid surface" buffers that include interior polygons by region.

Buffer Size & Type	*Baltimore*	*% of Total*	*Seattle*	*% of Total*	*Pooled*	*% of Total*
Buffer Area: 500 m (sq. km.)	0.24	88.9%	0.24	82.8%	0.24	85.7%
Adjusted Buffer Area: 500 m (sq. km.)	0.27	100.0%	0.29	100.0%	0.28	100.0%
Buffer Area: 1 km (sq. km.)	0.92	80.7%	0.90	75.6%	0.91	77.8%
Adjusted Buffer Area: 1 km (sq. km.)	1.14	100.0%	1.19	100.0%	1.17	100.0%
Buffer Area: 15 min. (sq. km.)	2.15	79.6%	2.01	75.3%	2.06	76.9%
Adjusted Buffer Area: 15 min. (sq. km.)	2.70	100.0%	2.67	100.0%	2.68	100.0%

4.1.4 Transit Catchment Surface

Instead of limiting the analysis to only evaluating specific walk distances based on average walking time, an exploration of the total catchment area that could be reached by walking or by transit within a total of 15 minutes was also performed (Figure 12).[27] GTFS data is a common format for geospatial public transit data and schedule information compiled and released widely by American and Canadian transit authorities and some international operators (Farber et al., 2014; Widener et al., 2014). GTFS transit data was retrieved for the fifteen transit authorities offering transit service in both metropolitan regions including those outside of the NQLS Prime study areas (Table 7).[28] GTFS-based transit catchment area sausage buffers were produced using schedule information to determine the furthest reachable point from all worksite locations during weekday PM peak hour service (Friday, 5PM).[29] A walking speed of 5km/hour and zero boarding delay time were additional parameters utilized to determine the total network-based transit shed traversable on transit or by walking within fifteen minutes. For workplace locations in areas with no transit service, these sausage buffers extent 1.5 km in length for 15 minute trips at 5km/hour. Regardless of transit routes taken, stops and stations are the entry and exit point of transit trips and are the principal focal point for this analysis (Farber et al., 2014). Transit shed sausage buffers often contain non-contiguous segments especially at the edges of the buffers and for transit that has increased distances between stops such as rail lines greatly increasing the resources required for geoprocessing (Figure 13).

[27] A 30 minute transit catchment area buffer was also created for the study, but was discarded because of extreme data processing and time requirements.
[28] The fastest transit routes from origin to destination are not always direct routes, but may require going into adjacent jurisdictions, such as around the Washington D.C. area.
[29] The Transit Service Analysis ESRI ArcGIS extension was utilized to create all GTFS-based variables and is highlighted in Section 11. Software & Application Services.

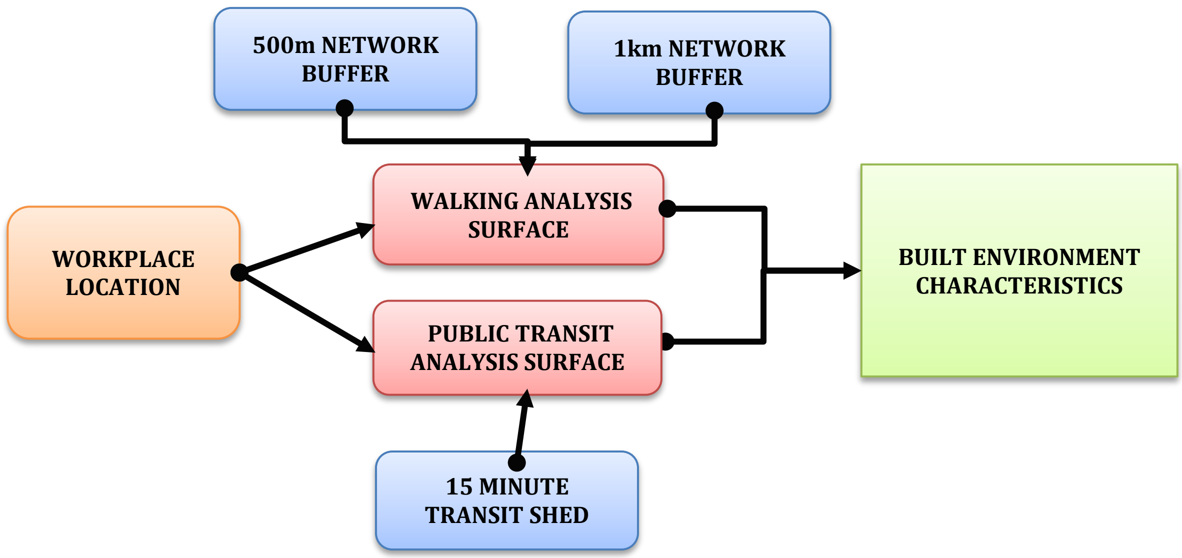

Figure 12: Spatial analysis work flow process for calculating built environment variables near workplaces.

Source: Forsyth et al., 2012; Frank et al., 2010.

Table 7: All transit operators serving the metropolitan areas of both study region with GTFS data available.

Region	*State*	*Operator*	*Transit Type*[30]
Baltimore	MD, DC	Maryland Transportation Authority (MTA)	Metro, Commuter Rail, Light Rail, Express Bus, Bus
	MD, DC, VA	Washington Metropolitan Area Transit Authority (WMATA)	Metro, Express Bus, Bus
	MD	Montgomery Ride-On	Bus
	MD	Charm City Circulator	Bus
	MD	Regional Transportation Agency of Central Maryland (RTA)	Bus
	MD	Annapolis Transit	Bus
	VA	Arlington Transit	Bus
	VA	Fairfax Connector	Bus
	DC	DC Circulator	Bus
	VA, DC	Virginia Railway Express (VRE)	Commuter Rail
Seattle	WA	King County Metro	Express Bus, Streetcar, Bus
	WA	Sound Transit	Commuter Rail, Light Rail, Express Bus
	WA	Pierce Transit	Bus
	WA	Community Transit	Express Bus, Bus
	WA	King County Marine Division	Ferry

Source: GTFS Data Exchange Inventory, 2015.

[30] Paratransit service on non-fixed routes not noted or included.

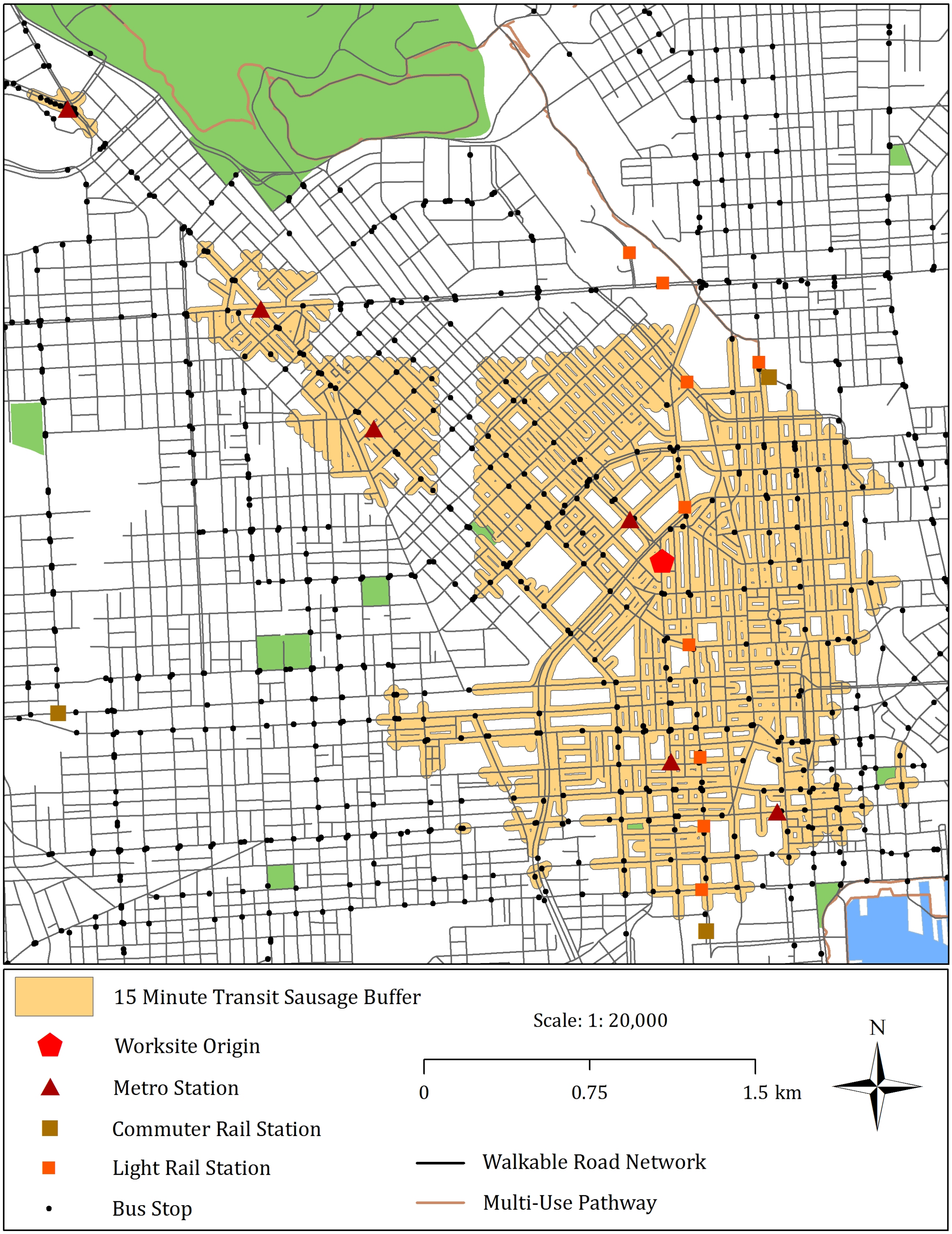

Figure 13: Sample 15 minute transit sausage buffer generated using multimodal GTFS transit data.
Source: GTFS Data Exchange Inventory, 2015; MTA, 2015; ESRI, 2012.

4.1.5 Distance & Travel Time Variables

In addition to the built environment variables that were developed directly by aggregating data to the walk and transit buffer surfaces, nearest distance and transit travel time variables were also created from worksite locations origins to a series of nearest destinations, specific destinations such as home-to-work travel or average distances to a series of destinations used as a measure of regional accessibility. Alleys and laneways were removed from the network utilized to calculate shortest route variables to deter routing to locations where destinations may be snapped (location on network) to lanes rather than street addresses, thus creating a potential inaccuracy in nearest distance without knowing whether there was an entrance in the lane behind the destination and assuming it would not be the most common entry point. Nearest distance measures were developed from worksite locations to a series of destinations including private recreation, food establishments and vendors, parks by size and both bus and rail transit stops. Both shortest path distance and travel time on transit were examined in the modelling process to discern which variable had stronger explanatory power at predicting the health outcome dependent measures examined.

The ability to access regionally significant destinations is an important measure of geographic central tendency across a metropolitan area. Locations of regional significance include the downtown core, employment centres, airports, major transit hubs, universities, hospitals, shopping malls and tourist centres (Table 42[31]). Regional accessibility location information was gathered from regional activity and growth centre reports issued by the main MPOs in both regions (Figure 14) (Baltimore Metropolitan Council, 2004; Washington Metropolitan Council of Governments, 2007; Puget Sound Regional Council, 2013). The regional accessibility measure calculated the mean network distance from the place of employment to all regional accessibility locations along the vehicular road network. As with the home-to-work measure, the GTFS transit data was utilized to calculate the average travel time on transit to all regional accessibility locations during weekday PM peak hour commute. By leveraging the GTFS data based on schedule information, this measure of regional accessibility is more representative of regional accessibility in comparison to TAZ-based modelled travel times because it generates direct origin to destination measures rather than travel times aggregated to TAZ areal units (Widener et al., 2014).

[31] Located in Section 14. Appendices (*14.1 Methods*).

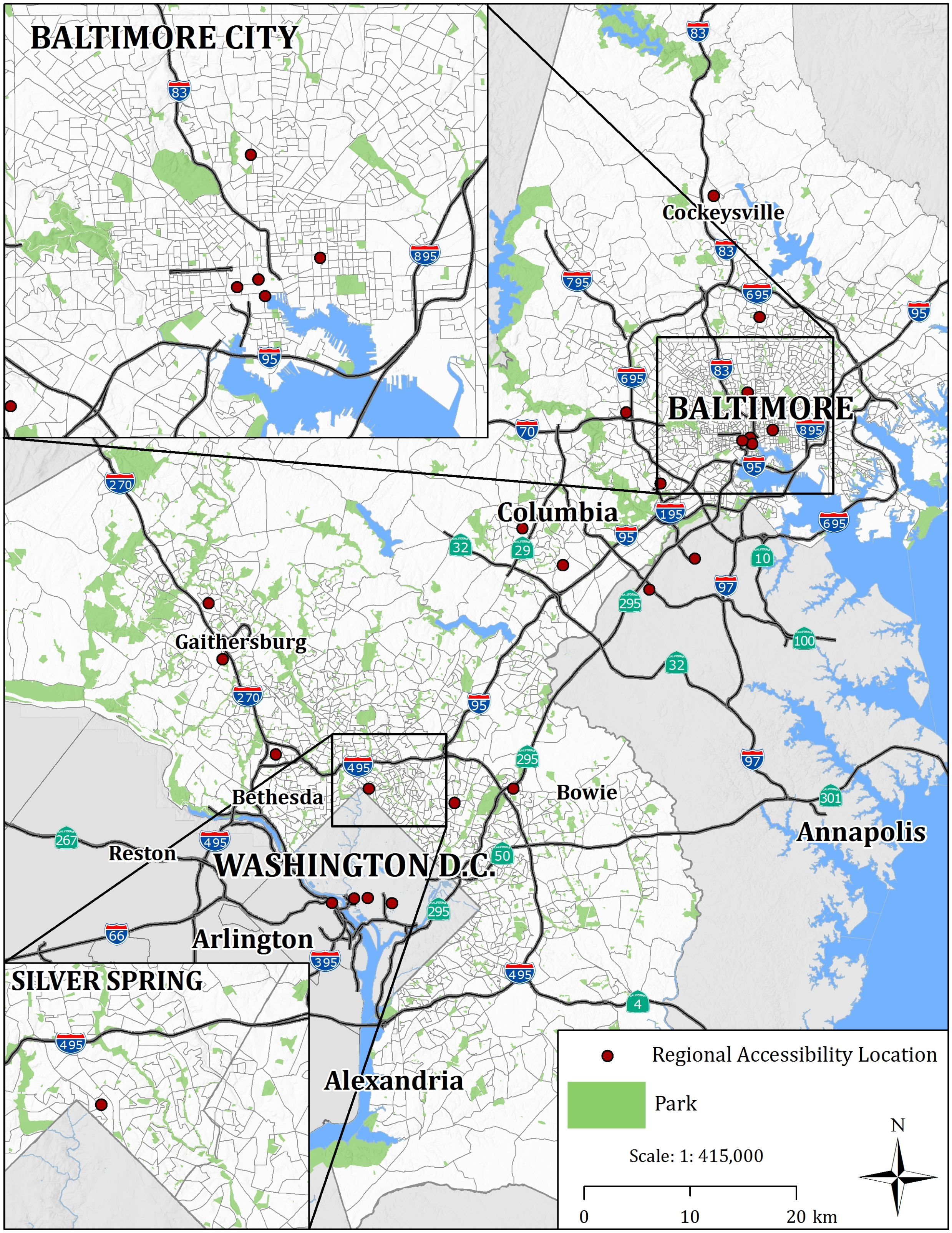

Figure 14: Regional accessibility locations within block groups in metropolitan Baltimore.
Source: BMC, 2004; WMGOG, 2007; ESRI, 2012.

4.2 Worksite Built Environment Measures

In addition to the SES and demographic variables that were utilized as independent variables to statistical test associations with dependent variable health outcomes, the focus of this study was to assess the impact of independent variables that represent various facets of the built environment. At the core of the urban form metrics were four land use measures that quantify the density, diversity, connectivity and design of communities (Cerin et al., 2006; Cervero & Duncan, 2006; Cervero & Radisch, 1996; Cervero, 1996; Frank et al., 2005; Lee & Moudon, 2006). The driving dataset for the main land use variables was the parcel dataset retrieved in polygon format for the Seattle region and centroid form in the Baltimore region that contained land use classifications, parcel land area and building floor area among other attributes required to construct the variables.

Residential density characterizes the compactness of urban areas based the amount of people living in an area and the type of housing available. Concentrations of residential areas are an important factor in determining the amount of shops, services, transit and jobs nearby that can be supported. A common representative measure of density is net residential density which was calculated by dividing the total single family and multi-family dwelling units by the gross residential land area (Frank & Kavage, 2009; Frank et al., 2009). It was assumed that net residential density would not have as much of an association with the health outcomes analyzed for worksite environments as it does for home environments because of single use worksite locations. Nevertheless, mixing of employment, services and residential land uses has been shown to have significant positive impacts on physical activity (Ewing & Cervero, 2010).

Land use mix is an entropy measure that describes diversity among land uses evaluating the extent to which mixing exists between residential, commercial, retail and office types, civic and entertainment parcel uses (Cervero & Kockelman, 1997; Cervero, 1996; Frank et al., 2005). The measure of land use mix examines the evenness of the distribution of building floor area for various land use types and ranges from zero (homogeneity, all single use types) and one (heterogeneity, completely even distribution of types) (Cervero & Kockelman, 1997; Ewing & Cervero, 2010). A mixing of land uses allows for the characterization of proximity of a wide variety of possible destinations visited as part of daily life reducing the need to travel longer distances for goods and services. A high mixing of uses allows more opportunity for walking and cycling and less need for automobile use (Cervero & Kockelman, 1997; Frank et al., 2009, 2005). For this study, two sets of land use mix variables were developed using four land use categories and six land use categories using the following formula (Cervero & Kockelman, 1997; Cervero, 2002; Ewing & Cervero, 2010):

$$Land\ use\ mix = \frac{\sum_i^n \left(\frac{b_i}{\sum_i^n b_i} \times \ln \frac{b_i}{\sum_i^n b_i}\right)}{-\ln(n)}$$

where b = building floor area (sq. ft.) for each of i land use categories:

- 1 = Residential (land use mix 4); Single family residential (land use mix 6 only)
- 2 = Retail & services
- 3 = Office
- 4 = Entertainment and food establishment
- 5 = Multi-family residential (land use mix 6 only)
- 6 = Civic & education (land use mix 6 only)

A standard measure of non-residential density is commercial, retail and office FAR which considers building area as it relates to parcel lot area (Brownson et al., 2009; Frank et al., 2009). As an assessment of the built environment, commercial or retail FAR is a valuable metric in determining whether commercial areas are orientated toward pedestrian or vehicular transportation (Brownson et al., 2009). Auto-oriented retail design is often associated with large scale surface parking lots and usually low rise development while neighbourhood retail consists of multi-storey, often mixed-use buildings with little or no parking or underground parking (Brownson et al., 2009). Commercial locations with low FARs are orientated towards customers traveling by vehicle such as mall complexes and big box stores and have a poorer utilization of ground floor space requiring large amounts of space for parking, consequently making walking and cycling uncomfortable and impractical (Frank et al., 2009). Retail targeted towards smaller scale, neighbourhood level shopping is advantageous for physical activity because it encourages travel by active transportation and transit (Sallis et al., 2009). FAR as a land use metric is frequently used in development zoning codes and for commercial locations ranges from low FARs around 0.3 or lower to well above 1.0 for high density retail locations.

The final component utilized to calculate the walkability index was intersection density which quantitatively describes connectivity of street networks. Intersection density is a useful tool for depicting urban form because it describes the layout of the street pattern between more gridded, walkable areas and disconnected poorer walk environments typical of suburban forms. Interconnected street networks make it easier for pedestrians to walk in all directions providing more route choice and direct routes to destinations (Frank & Kavage, 2009). Increased block size associated with cul-de-sac-based and single, detached residential uses tend to reduce connectivity making it more difficult to walk or cycle and affecting travel behaviour (Dill, 2004; Handy et al., 2002). Intersection counts were identified by using junction point features that are generated at every vertex along the walkable road network[32] and selecting only those with greater than or equal to three legs representing intersections. A gross intersection density measure was then derived by dividing intersection counts as the numerator by the sausage "solid surface" buffer area in square kilometres at each worksite location.

The walkability index is a composite built environment measure that brings the four base macro urban form measures together to identify areas that are supportive for pedestrians (Cerin et al., 2006; Frank et al., 2009, 2008, 2015, 2005). The walkability index has been used widely in public health literature to analyze various interactions between urban form and various health outcomes including objectively measured physical activity, BMI and sedentary driving time (Cerin et al., 2006; Frank et al., 2009, 2012, 2004, 2005; Saelens et al., 2012). The literature makes use of the walkability index to show that the most walkable areas are not only primarily urban cores and centre cities, but also older town centres that have connected street networks, neighbourhood retail and density more conducive to walking and cycling for leisure and utilitarian transportation (Saelens et al., 2012). Furthermore, walkability can transcend areas of high and low income demographics reporting some of the highest levels of obesity and chronic diseases in wealthy suburbs (Saelens et al., 2012). Each of the core urban form metrics are combined deriving an overall rating using z-score normalization with a normal range from between approximately -15 in rural, semi-rural or single-use suburban areas to around +15 in the metropolitan core depending on the study region.

In addition to counts of bus, rail and transit stops combining both bus stops and rail stations within each buffer size, a gross density value was also generated for all transit counts. Rather than

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[32] The pedestrian-enhanced network is not used because this measure is only concerned with street connectivity.

relying on these two types of transit measurements alone, a weighted index was utilized to quantify access to high quality transit prioritizing rail systems over bus service (Table 8). Ranking weights were established to order transit stops based on travel speed, dedicated right-of-way (ROW) and access to services and major activity centres. Metro systems were ranked highest based on faster transit travel times along dense corridors with access to employment centres and goods and services followed by commuter rail providing suburban and intra-regional transport. Streetcar systems were ranked lower because of a lack of dedicated ROW operating in mixed traffic. Regular fixed-route bus stops were ranked the lowest because of their widespread presence across the region. In many cases bus stops in suburban participant worksite locations have limited connections, indirect routes and long headways which make efficient travel by public transit difficult.

Table 8: Transit modes and weighting used in the development of the transit index.

Transit Mode	*System*	*Stop Type*	*Index Weight*	*Region*
Metro	Baltimore Subway, DC Metro	Rail	10	Baltimore
Commuter Rail	MARC, Sounder	Rail	8	Baltimore, Seattle
Light Rail	Baltimore Light Rail, Central Link	Rail	6	Baltimore, Seattle
Streetcar	South Lake Union Streetcar	Rail	4	Seattle
Express Bus	WMATA/MTA Express Bus, Sound Transit Express Bus	Bus	4	Baltimore, Seattle
Ferry	Baltimore Water Taxi, King County Marine Division, Washington State Ferries	Ferry	4	Baltimore, Seattle
Bus	MTA, WMATA, Ride-On, RTA, Charm City Circulator, King County Metro	Bus	1	Baltimore, Seattle

Source: GTFS Data Exchange Inventory, 2015.

Access to parks and trail facilities nearby worksite locations was also examined using three park size categories: 1) < 1 acre, 2) 1 acre to 50 acres and 3) > 50 acres. Parks are important public services which provide opportunity for physical activity through recreation, sports, entertainment and leisure activity (Abercrombie et al., 2008; Perry, Saelens, & Thompson, 2011). In the case of parks near worksite locations, parks also offer a convenient location to go on a break, eat lunch or for small meetings, not necessarily activities associated with bouts of moderate or vigorous physical activity, but contributing to overall physical activity nonetheless (Abercrombie et al., 2008). Park size may impact usage depending on age cohorts examined with small parklets or pocket parks catering more to small children or seniors and adults preferring medium sized urban parks or larger parks with trail networks with abundant natural and open space features (Abercrombie et al., 2008; Perry et al., 2011). For this study, park polygons classified by size were intersected with workplace walk and transit buffers to derive counts and total park area measured in acres. Nearest distance to parks by size were calculated using access points at the boundaries of park polygons by generating equal interval points every 60 m and selecting only those points within 60 m from the road network to ensure valid entry points (Figure 15).

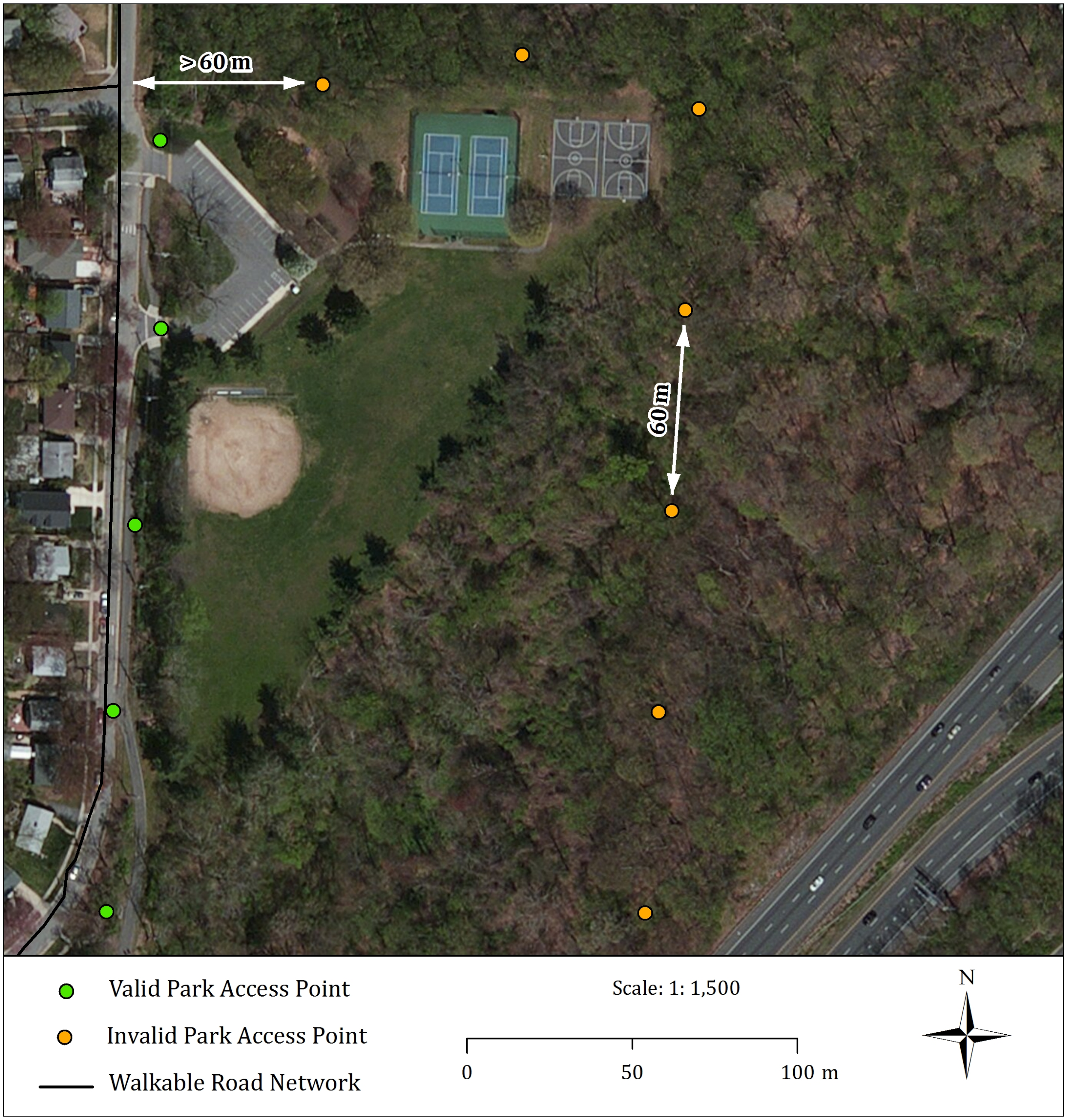

Figure 15: Park boundary points at a 60 m equal interval identifying valid points of entry within 60 m of the walkable network.
Source: ESRI, 2012.

An inventory of private recreation establishments was undertaken as part of the NQLS Prime study to assess opportunities for physical activity such as golf courses, fitness training, gyms, swimming, club recreation, dancing, yoga and martial arts. These types of private recreation locations provide prospects for employees to achieve physical activity and may be important as part of complex tour travel behaviour before or after work hours (Frank et al., 2008). Private recreation variables at the buffer level included total counts and gross density. Food environments and access to quality food have been found to not necessarily vary across neighbourhoods based on walkability, but rather based on income (Frank, Glanz, et al., 2006; Glanz et al., 2005). Though perhaps not as important for the worksite environment as the home environment, data from the NQLS Prime food establishment inventory was compiled to assess access to a variety of food shops and restaurants (Table 9). Food for daily meal preparation and consumption is often purchased in close proximity to the home when not using a vehicle because of the need to carry only small amounts comfortably and because of the perishable nature of some food items. Nevertheless, small amounts of food may be purchased as part of the workday commute on transit or by people that live in close proximity to their work and walk or cycle (Frank, Glanz, et al., 2006). Although many farmers' markets both in the Seattle and Baltimore regions operate on the weekend when most employees are not working, many also occur on weekdays usually between 10AM and 4PM meaning that farmers' markets in close proximity may offer employee shopping opportunities during breaks in work otherwise not possible for standard working hours (Maryland Department of Agriculture, 2015). Understanding the types of food outlets and their proximity to employment is also important for recognizing the lunchtime meal options available to employees and whether these can be accessed by walking or require driving. A combination of counts of markets or produce stores, supermarkets and farmer's markets was created to highlight outlets that are likely to have healthier food choice options. Table 41[33] outlines all buffer-based built environment variables developed for this study.

Table 9: NQLS Prime food establishment inventory counts by region.

Type of Food Establishment	*Count – Baltimore*	*Count - Seattle*	*Count - Pooled*
Convenience stores (including gas stations)	2,049	572	2,621
Market or produce store	1,095	649	1,744
Supermarket	463	242	705
Limited service - Fast food (including deli)	3,317	1,736	5,053
Full service – Sit-down restaurant	3,331	4,248	7,579
Specialty foods (including bakery, specialty markets, coffee shops, bagel, dessert, juice)	2,141	2,542	4,683
Pharmacy	514	299	813
Dollar stores	286	73	359
Farmers' markets	71	49	120
Total	13,267	10,410	23,677

4.3 Covariate Demographics & SES

As part of analyzing human behaviour in observational studies it is crucial that both demographics and SES is explored and included in predictive models. A core component of attempting to explain behaviour is to look at demographic trends of the population in the region examined as well as among the sample of participants. As a result of the recruitment process that including acquiring participants from clustered home locations and stratifying by walkability and median household income, the samples from both regions showed similar characteristics (Table 10, Table 11 and Table 12). Participants had a mean age of 45 years with an average height of 5'7" (1.73 m) and weigh approximately 176 pounds (80 kg). Vehicle ownership was high at 96.7% of participants owning at least one vehicle in both regions and an average of two vehicles per household and one vehicle per adult (Table 13). Approximately 61.8% of participants in both regions did not have any children under the age of eighteen years while 33.1% had two children to a maximum of five children.

[33] Located in Section 14. Appendices (*14.1 Methods*).

Table 13 provides additional demographic statistics showing a higher number of female participants at 50.8% in Baltimore in comparison to only 40.6% in Seattle and 22.7% owned their property in Seattle in comparison to only 15.7% in Baltimore. Ethnicity differed slightly between the regions with 66.7% of Baltimore participants identifying as Caucasian, 24.3% as African American and only 3.6% as Asian Americans in contrast to 81.9%, 10.8% and 8.0% respectively in Seattle (Figure 16). A majority of participants from the pooled database were married at 58.4% with 6.6% indicating they lived with a partner while 18.8% were singled and never married and 16.1% were divorced, separated or widowed (Figure 17). Annual household income was separated into eleven category classes ranging from < $10,000 per year to ≥ $100,000 per year on $9,000 increments (Figure 18). Nearly 28% of participant households earned more than $100,000 per year while only 10.4% had annual household incomes of less than $30,000 while the median household income was between $70,000 and $79,000.

Table 10: Descriptive statistics of demographic variables for participants in the Baltimore region.

Demographic Variable	*N*	*Minimum*	*Maximum*	*Mean*	*SD*
Age	394	21	65	46	10.53
Height (inches)	394	53	77	67.57	4.02
Weight (pounds)	393	105	350	176.30	39.17
Number of people in household	394	1	7	2.64	1.35
Number adults in household	394	1	6	1.98	0.84
Number of children under 18 years	394	0	4	0.66	0.95
Number of driveable vehicles in household	394	0	9	1.99	1.04
Number of motor vehicles per adults in household	394	0.0	3.0	1.06	0.49

Table 11: Descriptive statistics of demographic variables for participants in the Seattle region.

Demographic Variable	*N*	*Minimum*	*Maximum*	*Mean*	*SD*
Age	683	20	66	44	10.16
Height (inches)	684	58	92	68.30	4.19
Weight (pounds)	684	93	320	175.80	38.01
Number of people in household	682	1	10	2.63	1.37
Number adults in household	682	1	6	1.96	0.81
Number of children under 18 years	683	0	5	0.67	1.00
Number of driveable vehicles in household	684	0	9	2.05	1.19
Number of motor vehicles per adults in household	682	0.0	3.0	1.06	0.48

Table 12: Descriptive statistics of demographic variables for participants in both regions.

Demographic Variable	*N*	*Minimum*	*Maximum*	*Mean*	*SD*
Age	1077	20	66	45	10.30
Height (inches)	1078	53	92	68.03	4.14
Weight (pounds)	1077	93	350	175.98	38.42
Number of people in household	1076	1	10	2.63	1.36
Number adults in household	1076	1	6	1.96	0.82
Number of children under 18 years	1077	0	5	0.67	0.98
Number of driveable vehicles in household	1078	0	9	2.03	1.14
Number of motor vehicles per adults in household	1076	0.0	3.0	1.06	0.48

Table 13: Descriptive statistics of demographics and household characteristics of participants.

Demographic Variable	Baltimore		Seattle		Pooled	
	N	Mean	N	Mean	N	Mean
Gender (% Female)	394	50.8%	684	40.6%	1078	44.3%
% Hispanic (non-Caucasian)	388	2.3%	684	3.7%	1072	3.2%
% Caucasian (non-Hispanic)	391	66.8%	684	81.9%	1075	76.4%
% Household with children	394	38.8%	683	37.8%	1077	38.2%
% Own household	394	15.7%	684	22.7%	1078	20.1%
% Valid driver's license	394	95.9%	684	96.8%	1078	96.5%
% Vehicles in household	394	96.7%	684	96.6%	1078	96.7%
% Married or living with partner	394	62.7%	684	66.4%	1078	65.0%

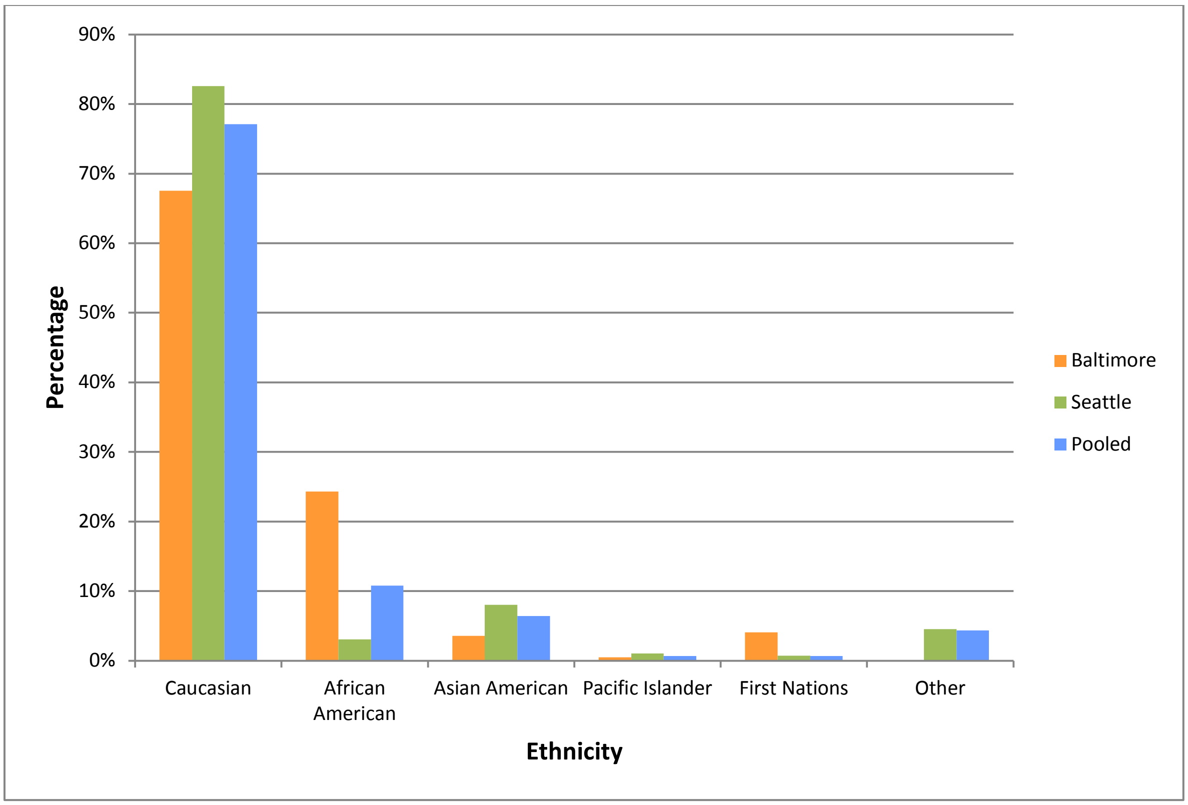

Figure 16: Bar chart showing participant ethnicity by region.

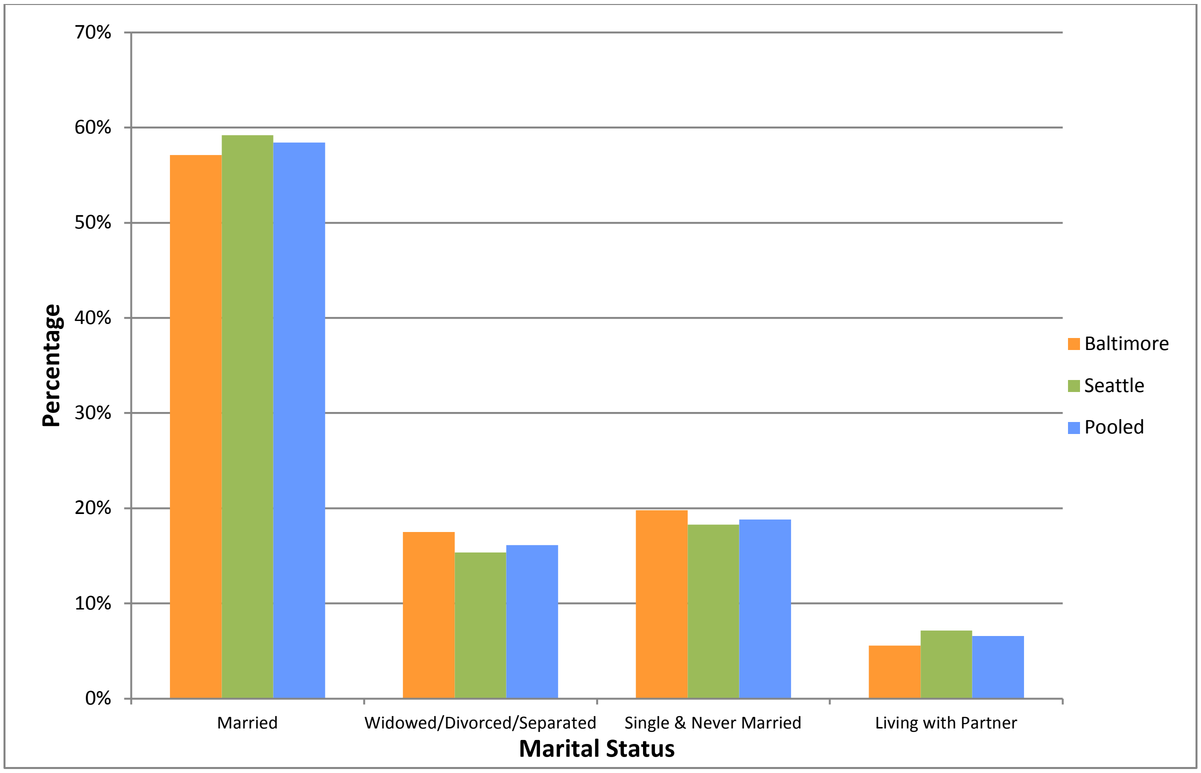

Figure 17: Bar chart illustrating participant marital status by region.

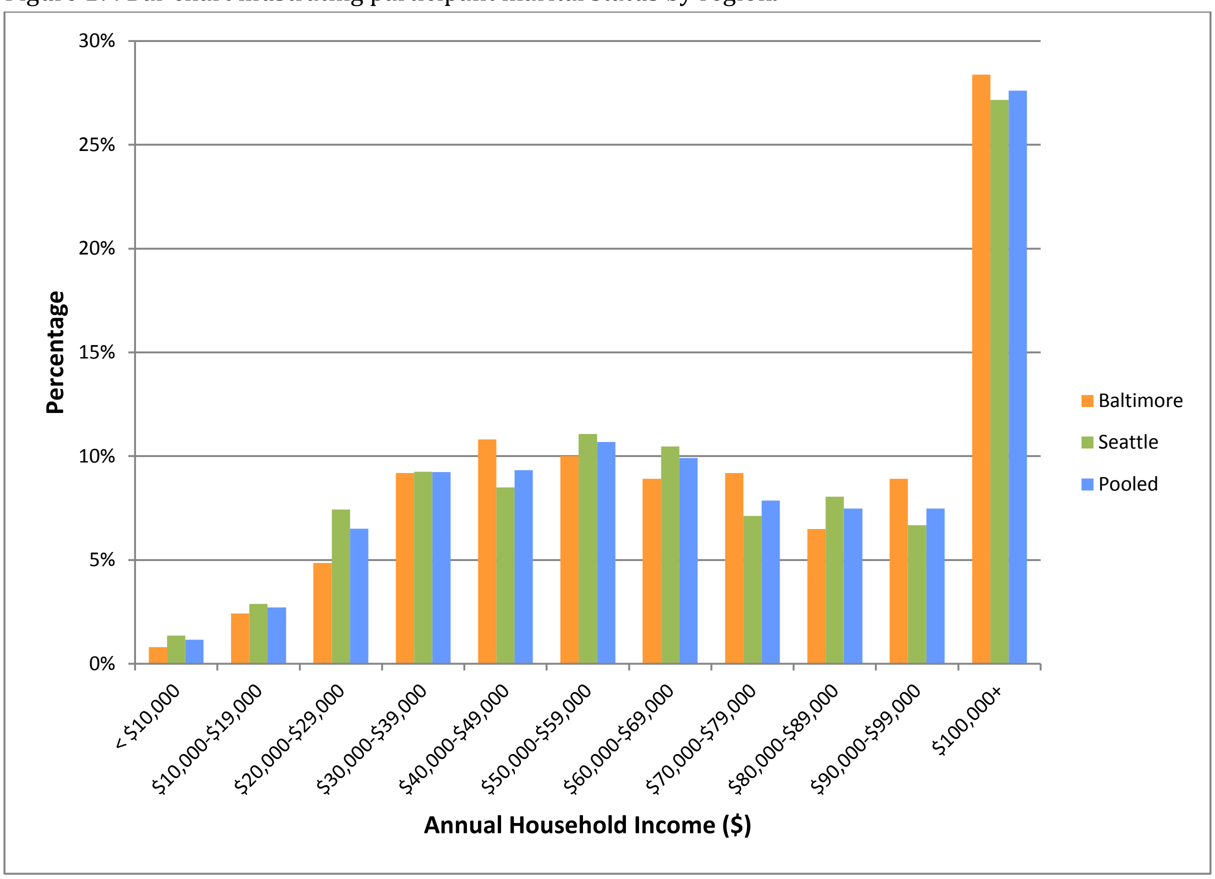

Figure 18: Bar chart illustrating participant annual household income by region.

4.4 Home Built Environment Measures

In order to assess how the built environment near worksite locations is associated with physical activity, time spent driving or riding in vehicles for BMI, it is important to ensure that potential urban form impacts health outcomes are not already accounted for by the environment near the home. As part of the NQLS Prime study, objectively measured built environment variables were developed around participant homes for both regions. To statistically control for the potential explanatory power of the home environment in this worksite analysis, the walkability index using land use entropy 4 was utilized as an independent variable when developing the regression models. Only this home environment variable was utilized in the models because it is a composite urban form index that was expected be associated with the health outcomes examined. This control block in the statistical models was also constrained due to the fact that new variables were developed for the worksite environment that were not previously available including variables constructed from the 15 minute transit shed catchment area. To ensure limited collinearity to improve and highlight unique explanatory power between independent variables, it was determined that further compounding potential issues of multicollinearity by adding more home environment variables to the models would exacerbate problems and was deemed not useful. When controlling for the home environment, the nine participants in Baltimore and twenty in Seattle that work from home were not included to prevent duplication of built environment variables.

5. Statistical Analysis

Once built environment variables had been produced, they were merged with demographics and health outcome data from NQLS Prime participants. Data cleaning processes were required to align these three datasets with a final matching of 394 valid participant worksite locations in Baltimore and 684 locations in Seattle for a pooled total of 1,078.[34] Built environment variables were developed for every participant, however, missing values were reported for demographic covariates and health outcomes for a few participants. A default standard of excluding cases listwise for missing values was employed for all models developed. Given the relatively small amount of missing values in the dataset, excluding these was not believed to be introducing a discernable bias to the analysis. Three main steps were undertaken to statistically analyze the data to quantify relationships and construct predictive models between dependent health outcomes, covariate demographics and urban form measures: 1) descriptive statistics and exploratory analysis, 2) multicollinearity identification and variable transformation and 3) regression modelling. The primary focus of the study was to answer the research questions and evaluate the hypothesized relationships between worksite built environment and health. As part of the analysis, an iterative assessment review of demographics and independent workplace environmental measures was performed to determine the most accurate and strongest predictive models explaining the health outcomes under consideration.

5.1 Exploratory Analysis & Descriptives

5.1.1 Dependent Variable Descriptives

Participants in Seattle reported more minutes of physical activity per day at 35 minutes with only 30.60 minutes in Baltimore and a pooled average of 33.38 minutes (Table 14, Table 15 and Table 16). Figure 24 shows a histogram of the frequency distribution of physical activity for

[34] Participant counts vary slightly as some demographics and health outcome data contain missing values.

Seattle showing the single outlier on the maximum range with the next closest participant in Seattle at only 134 minutes and, when removed, both regions show a similar positively skewed distribution (Figure 23). The range in mean physical activity over two days of accelerometer measurements was between less than one minute and a maximum of 241 minutes (about four hours) in Seattle and 107.5 minutes in Baltimore with 75% of participants receiving less than 45 minutes of physical activity per day (Figure 19). Approximately 35.5% of participants in Baltimore logged less than twenty minutes of physical activity in comparison to 22.2% of participants in Seattle.

Table 14: Descriptive statistics of health outcome dependent variables for the Baltimore region.

Health Outcome	*N*	*Minimum*	*Maximum*	*Mean*	*SD*
Total daily minutes of physical activity	394	0.64	107.50	30.60	20.55
Body mass index (BMI)	393	17.63	54.92	27.14	5.80
Sedentary minutes driving or riding in vehicle per week	393	0.00	4,200.00	424.88	438.04

Table 15: Descriptive statistics of health outcome dependent variables for the Seattle region.

Health Outcome	*N*	*Minimum*	*Maximum*	*Mean*	*SD*
Total daily minutes of physical activity	682	1.87	241.13	34.99	21.57
Body mass index (BMI)	684	16.25	51.65	26.41	4.89
Sedentary minutes driving or riding in vehicle per week	684	0.00	3,360.00	302.68	301.93

Table 16: Descriptive statistics of health outcome dependent variables for both regions.

Health Outcome	*N*	*Minimum*	*Maximum*	*Mean*	*SD*
Total daily minutes of physical activity[35]	1076	0.64	241.13	33.38	21.30
Body mass index (BMI)	1077	16.25	54.92	26.68	5.25
Sedentary minutes driving or riding in vehicle per week	1077	0.00	4,200.00	347.27	362.26

[35] Mean 2 day accelerometer measured total minutes of physical activity.

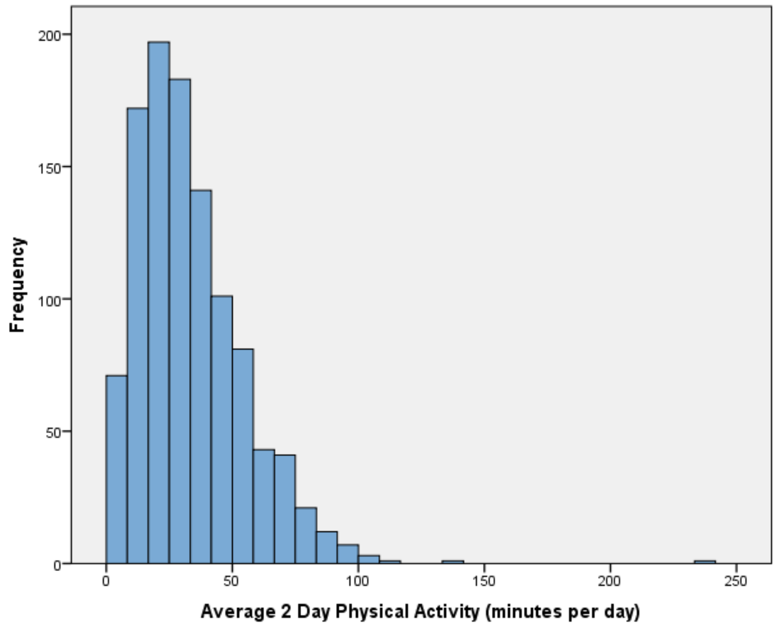

Figure 19: Histogram of average physical activity in minutes per day over two days in both regions.

BMI was very similar between the regions with slightly lower minimum, maximum and mean for the Seattle region in comparison with Baltimore with a pooled mean of just less than 27 (Figure 20). Both regions displayed a relatively normal distribution for BMI with 60.3% of Baltimore participants being overweight (> 25 BMI) and 21.9% being obese in comparison to only 55.1% and 18.9% in Seattle respectively (Figure 25 and Figure 26). Mean BMI between regions was similar at 27.1 in Baltimore and 26.4 in Seattle with 3.8% (n = 15) and 4.4% (n = 30) reporting underweight status (< 20 BMI) in each region respectively.

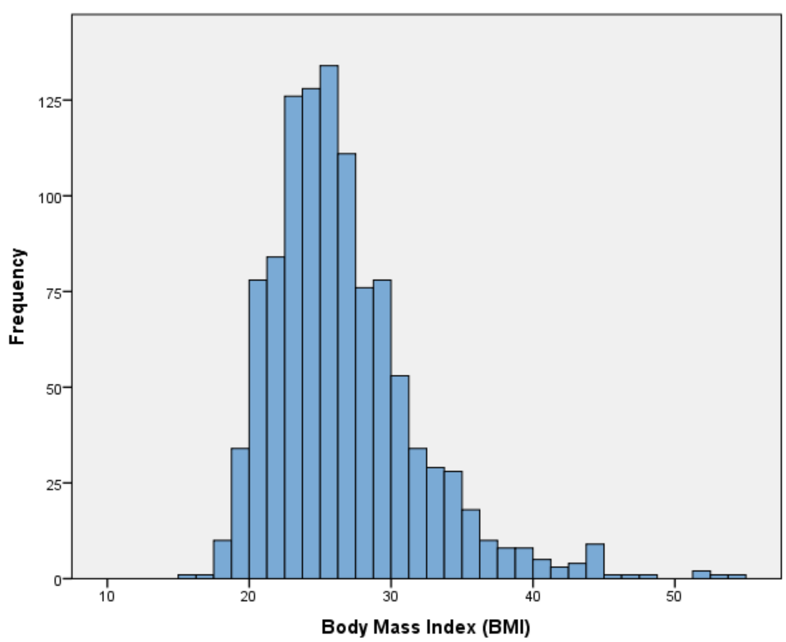

Figure 20: Histogram of participant BMI in both regions.

Self-reported sedentary time spent driving or riding in vehicles measured in minutes per week between the two regions with Baltimore participants reporting a total seven day mean sedentary time in vehicles at nearly 425 minutes (over seven hours total, over one hour per day) while Seattle participants identified a mean time of only 303 minutes (five hours total, 43 minutes per day) yielding a pooled mean of 347 minutes (5.8 hours total, 50 minutes per day) (Figure 21, Table 14, Table 15 and Table 16). Baltimore participants reported a maximum sedentary time spent in vehicles at 4,200 minutes per week (70 hours per week, 10 hours a day) while Seattle reported a maximum of 3,360 minutes per week (56 hours per week, eight hours per day) which corresponds well to the high percentage of households with vehicles and participants with a valid driver's license (Table 13). In Baltimore, 19 participants (4.8%) acknowledged no driving or riding time per week and of those participants who were in a vehicle, 19.1% drove 20 minutes or less per day in comparison to 42 participants (6.1%) and 29.1% for the same factors in Seattle (Figure 27 and Figure 28).

In terms of positive public health indicators, the Seattle region performed better in each of the three dependent variable categories analyzed for this study. It should be acknowledged that, because of a larger portion of places of employment being located outside of the study area, the sample size was smaller for the Baltimore region. Nevertheless, the Baltimore region exhibited less minutes of physical activity, a lower percentage of participants meeting 20 and 30 minute per day thresholds, reported a higher BMI with a higher portion of the sample overweight and obese as well as an average of nearly 20 minutes more sedentary time spent driving and riding in vehicles per day.

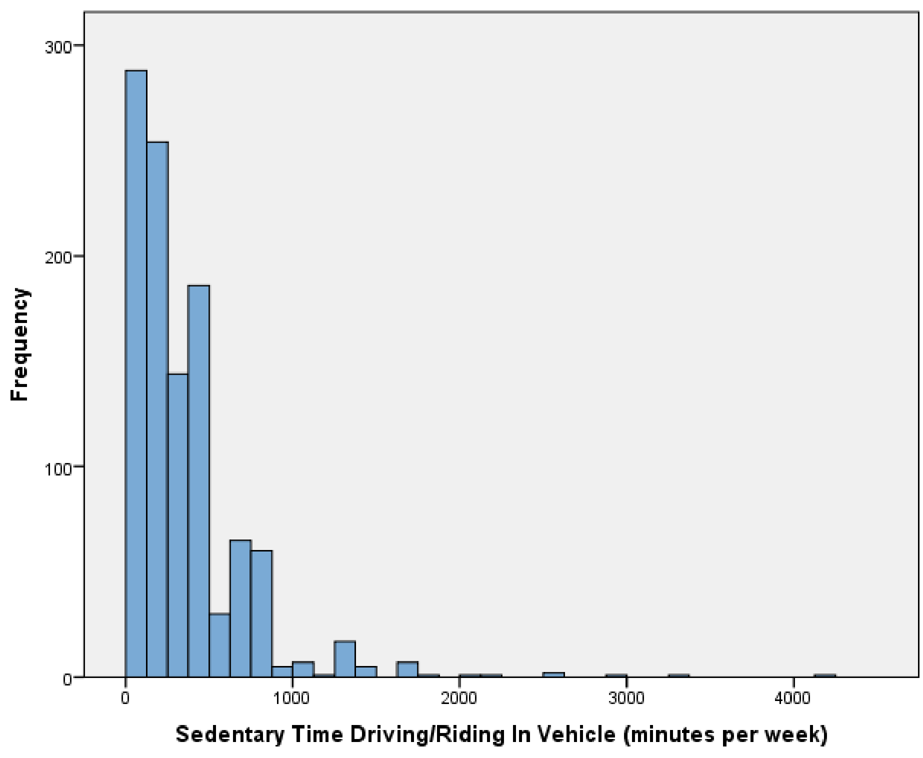

Figure 21: Histogram of sedentary time (weekly minutes) spent driving or riding in vehicles in both regions.

5.1.2 Independent Built Environment Variable Descriptives

The walkability index and each of the four component metrics used to derive the composite show some distinctive patterns when examining the distributions across the three sets of buffers tested. A high level overview of the mean values for the base walkability measures indicated that the variables aggregated to the 1 km walk buffers and the 15 minute transit shed were similar with the 500 m walk buffers demonstrating relatively dissimilar values (Table 17, Table 18 and Table 19). At the 500 m walk buffer level net-residential density varied dramatically between Baltimore and Seattle with an average of 76 units per acre with some large outlier values and resulting standard deviation in Baltimore. Both Seattle and Baltimore maintained an average Retail FAR of 0.30 in close proximity to worksites indicating an overall commercial environment orientated towards more automobile than neighbourhood retail and services. Land use mix tended to be slightly higher in Seattle than Baltimore for both the four class mix and the six class mix at between 0.39 and 0.44 indicating a moderate inclination towards single use classifications rather than mixing of uses. Mean overall connectivity was very similar between regions illustrating approximately 94 intersections per square kilometre with a range from between zero intersections per square kilometre to 171 in Seattle and 224 in Baltimore.

The walkability index is based on normalized z-scores, resulting in the mean value clustering near zero. The 500 m walk buffers often tended to have higher values for net-residential density and gross intersection density, the latter being reduced from 94 intersections per square kilometre at the 500m level to 45 and 35 intersections per square kilometre at the 1 km and 15 minute buffer level respectively (Table 18 and Table 19). Retail FAR at all three buffer levels remained relatively constant near 0.30 while land use mix increased towards more mixing of land uses at the 1 km level and even further at the 15 minute buffer level to 0.52 (land use mix 4) and 0.62 (land use mix 6) respectively.

Table 17: Mean core built environment variables for the 500 m walk buffers in both regions.

Variable	*Baltimore*			*Seattle*			*Pooled*		
Walk Buffer – 500 m	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*
Net-Residential Density (dwelling/acre)	394	145.30	1040.53	684	36.19	56.69	1,078	76.07	632.36
Retail FAR	394	0.30	0.49	684	0.29	0.29	1,078	0.29	0.37
Land Use Mix 4	394	0.34	0.28	684	0.41	0.26	1,078	0.39	0.27
Land Use Mix 6	394	0.39	0.24	684	0.47	0.23	1,078	0.44	0.24
Intersection Density (count/sq. km.)	394	93.87	47.35	684	93.59	30.07	1,078	93.69	37.31
Walkability Index – Mix 4	394	0.00	2.62	684	0.31	2.71	1,078	0.19	2.68
Walkability Index – Mix 6	394	0.00	2.60	684	0.38	2.61	1,078	0.24	2.61

Table 18: Mean core built environment variables for the 1 km walk buffers in both regions.

Variable	*Baltimore*			*Seattle*			*Pooled*		
Walk Buffer – 1 km	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*
Net-Residential Density (dwelling/acre)	394	83.16	39.41	684	80.83	23.68	1,078	81.68	30.39
Retail FAR	394	0.32	0.36	684	0.30	0.25	1,078	0.30	0.29
Land Use Mix 4	394	0.43	0.27	684	0.48	0.24	1,078	0.46	0.25
Land Use Mix 6	394	0.52	0.20	684	0.57	0.19	1,078	0.55	0.20
Intersection Density (count/sq. km.)	394	63.84	212.49	684	33.30	49.54	1,078	44.46	135.08
Walkability Index – Mix 4	394	0.00	2.78	684	0.07	3.05	1,078	0.04	2.95
Walkability Index – Mix 6	394	0.00	2.73	684	0.09	2.95	1,078	0.06	2.87

Table 19: Mean core built environment variables for the 15 minute transit buffers in both regions.

Variable	*Baltimore*			*Seattle*			*Pooled*		
Walk Buffer – 15 min.	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*
Net-Residential Density (dwelling/acre)	394	83.77	39.92	684	80.48	21.44	1,078	81.68	29.59
Retail FAR	394	0.31	0.27	684	0.30	0.21	1,078	0.30	0.24
Land Use Mix 4	394	0.49	0.25	684	0.53	0.22	1,078	0.52	0.23
Land Use Mix 6	394	0.59	0.19	684	0.64	0.16	1,078	0.62	0.17
Intersection Density (count/sq. km.)	394	45.81	201.91	684	28.53	38.54	1,078	34.85	126.05
Walkability Index – Mix 4	394	0.00	2.76	684	0.02	3.09	1,078	0.01	2.97
Walkability Index – Mix 6	394	0.00	2.70	684	0.03	2.97	1,078	0.02	2.87

Three main forms of transit variables were tested in addition to the 15 minute transit catchment buffer. On average both worksite locations indicated similar access to transit across the study area level for both bus stops, rail stops and the transit index at all buffer levels (Table 20). At the 1 km buffer level, 68.8% of worksite buffers in Baltimore had no access to rail stops while 77.6% of Seattle worksites had no access to rail stops within 1 km. At the 15 minute transit catchment area, 38.3% of worksites had access to a rail stop in Baltimore while only 29.1% of Seattle worksites had access. In Seattle only 9.2% of worksite locations had no bus stop within 500 m in comparison to 13.2% in Baltimore. Despite Baltimore having a more extensive metro and commuter rail system than Seattle, the transit index measure indicated relatively equal access to transit between both regions for each of the buffers examined which may be related to the differences in sample sizes and that a higher percentage of Baltimore worksites were located in areas with limited transit access.

Table 20: Central tendency descriptives for transit variables in both regions.

Transit Variable	*Baltimore*			*Seattle*			*Pooled*		
	N	*Mean*	*SD*	*N*	*Mean*	*SD*	*N*	*Mean*	*SD*
Bus Stop Count – 500 m	394	7.08	6.97	684	7.49	8.40	1,078	7.34	7.91
Rail Stop Count – 500 m	394	0.29	0.68	684	0.31	0.84	1,078	0.31	0.78
Transit Index – 500 m	394	0.08	0.08	684	0.08	0.10	1,078	0.08	0.10
Bus Stop Count – 1 km	394	21.97	20.52	684	23.01	24.18	1,078	22.63	22.91
Rail Stop Count – 1 km	394	0.94	1.89	684	0.89	1.91	1,078	0.91	1.90
Transit Index – 1 km	394	0.26	0.25	684	0.25	0.28	1,078	0.25	0.27
Bus Stop Count – 15 min.	394	56.19	61.79	684	51.91	51.00	1,078	53.47	55.20
Rail Stop Count – 15 min.	394	2.19	4.28	684	2.01	3.86	1,078	2.07	4.02
Transit Index – 15 min.	394	0.19	0.22	684	0.23	0.25	1,078	0.21	0.24

Table 21 outlines the mean shortest path in metres and the shortest travel time on transit in minutes for both regions. Given that both the study area and the greater metropolitan area in the Baltimore region is larger than that in Seattle, this may result in both average distances or travel times being slightly longer in addition to the smaller sample size. On the whole, Seattle performed better with regards to park variables yielding a shorter overall mean distance to all parks at 522 m, parks < 1 acre in size at 1.7 km and parks between 1 acre and < 50 acres at 687 m in comparison to 775 m, 7.8 km and 974 m respectively in Baltimore. It should be noted that Baltimore had more parks of larger size (> 50 acres) and a shorter distance to those parks and far less small pocket parks in the inventory in comparison to Seattle. Limited discernable patterns could be recognized from the food environment variables between the two regions with food establishment types being roughly the same distances away in both regions as with private recreation facilities.

Table 21: Mean nearest distance (m) and travel time on transit (minutes) for both regions.

Nearest Distance (m) /Transit Travel Time (minutes) Variable	*Baltimore*		*Seattle*		*Pooled*	
	N	*Mean*	*N*	*Mean*	*N*	*Mean*
Nearest Distance – Park (any size)	394	774.69	684	521.80	1,078	614.23
Nearest Distance – Park (< 1 acre)	394	7,766.63	684	1,704.27	1,078	3,920.01
Nearest Distance – Park (1- < 50 acres)	394	974.37	684	687.32	1,078	792.24
Nearest Distance – Park (> 50 acres)	394	1,879.42	684	2,250.29	1,078	2,114.74
Nearest Distance – Private Recreation	394	514.62	684	498.92	1,078	504.66
Nearest Distance – Convenience Store	394	628.05	684	986.59	1,078	855.55
Nearest Distance – Market/Produce	394	1,039.47	684	888.77	1,078	943.85
Nearest Distance – Supermarket	394	1,108.77	684	1,232.97	1,078	1,187.57
Nearest Distance – Limited Service	394	551.35	684	562.53	1,078	558.44
Nearest Distance – Full Service	394	536.36	684	360.15	1,078	424.55
Nearest Distance – Specialty Foods	394	674.42	684	410.20	1,078	506.77
Nearest Distance – Pharmacy	394	949.98	684	1,032.95	1,078	1,002.62
Nearest Distance – Dollar Store	394	1,978.77	684	2,656.85	1,078	2,409.02
Nearest Distance – Farmers' Market	394	2,366.30	684	2,463.73	1,078	2,428.12
Nearest Distance – Healthy Food	394	697.19	684	720.42	1,078	711.93
Nearest Distance – Bus Stop[36]	394	257.86	684	206.15	1,078	225.05
Nearest Distance – Rail Station[37]	394	3,401.78	684	8,010.67	1,078	6,326.16
Nearest Distance – Transit Stop[38]	394	229.15	684	205.78	1,078	214.32
Average Distance – All Regional Accessibility Locations	394	38,490.23	684	22,942.47	1,078	28,625.05
Nearest Distance – Home to Work	393	13,442.58	684	12,678.14	1,077	12,957.09
Average Transit Travel Time – All Regional Accessibility Locations	394	147	684	80	1,078	104
Transit Travel Time – Home to Work	393	81	684	56	1,077	65

Participant worksites in the Seattle region tended to have shorter distances to travel to get to bus stops at 206 m compared to 258 m, however, a much further distance to rail stops at over 8 km in contrast to 3.4 km due to a larger network of rail-based transit in metropolitan Baltimore. Even though distance from home to work was only approximately 765 m longer in Baltimore than Seattle, the average travel time on transit from home to workplace was 25 minutes longer in the Baltimore region at over 81 minutes compared to 56 minutes in Seattle. This reflected the same tendency in sedentary time spent driving or riding in vehicles with Baltimore reporting more time spent, however, this health outcome was reflecting more than just commute times but rather all time spent in cars. The difference between these two metrics underscores the importance of comparing travel time rather than just distance especially for home-work trips and regional accessibility. The average distance to regional accessibility locations in Baltimore was over 15 km further and 67 minutes longer on transit than in Seattle. This supported the assertion that the larger study site and metropolitan area in Baltimore may have been impacting these variables in addition to Baltimore having more regional accessibility locations. Nevertheless, this does not necessarily signify that worksites or homes in the Baltimore region were located in more suburban or auto-dependent areas. The nearest distance to rail indicated that, even though transit travel times for both regional accessibility and home-work trips were longer, Baltimore had a more

[36] All bus and express bus stops.
[37] All rail stations including metro, commuter rail, light rail and streetcar.
[38] All bus stops and rail stops.

supportive high quality rapid transit system than Seattle even if many Baltimore participant worksite locations did not have access to these services.

5.2 Correlates & Associations

The core macroscale built environment variables including net-residential density, retail FAR, land use mix, intersection density and the composite walkability index were presumed to have the strongest explanatory power when testing for significance with health outcomes (Frank et al., 2009, 2005; Sallis et al., 2004). Worksite walkability as a normalized, combined metric was tested extensively when developing the predictive models including assessing its interaction with the walkability index at the home environment. Bivariate correlations were performed using a two-tailed Pearson correlation coefficient to test relationships between independent built environment variables and dependent variables, covariate demographics and SES variables as well as to detect multicollinearity between independent variables. Correlation coefficients also offer a first test of hypotheses by indicating the direction of the relationship between the variables as an indicator of the expected impact in the models.

5.2.1 Dependent Bivariate Correlates

Bivariate correlation between dependent health outcomes and covariate demographics were explored to see what types of relationships existed within the sample. As with the sets of statistical models built as part of this study, correlates were run for each region and then using the pooled combination of both to be able to detect differences between the regions. Demographics and SES traits play an important role in the explanatory power of predictive models that analyze travel behaviour, commute mode and the effect of urban form on activity near workplaces. For the pooled worksite database at the 0.001 confidence level, physical activity was found to be significantly negatively correlated with age, being a female and positively correlated with being Caucasian while being positively correlated with annual household income negatively correlated with number of vehicles in the household at the 0.05 confidence level (Table 76[39]). BMI was found to be significantly positively correlated with age, negatively correlated with annual household income and being Caucasian at the 0.001 level as well as negatively correlated with having a driver's license and being single at the 0.05 confidence level (Table 77). Lastly, at the 0.001 confidence interval level sedentary time driving or riding in vehicles was found to be significantly negatively correlated with being Caucasian, owning the household and positively correlated with having a valid driver's license and number of vehicles per household and vehicles per adults in addition to being positively correlated with having children at the 0.05 level (Table 78).

The two tailed Pearson correlation coefficient was also utilized to identify correlations between dependent variables and independent built environment measures across all buffers. Table 22 highlights statistically significant bivariate correlations between physical activity and built environment measures for both regions demonstrating strong negative correlations between home-work trip transit travel time, distance and transit travel time to regional accessibility locations and distance to small parks and positive correlations with small park counts, private recreation facilities, sit-down full service restaurants and multi-use pathway length. The walkability index at all three buffer levels as well as retail FAR and land use mix 4 were positively correlated at the 0.05 confidence level in addition to bus stop counts and the transit index. All statistically significant coefficients were found to be correlating in the expected direction with physical activity, although this was not the case for BMI or sedentary time in vehicles and worksite independent

[39] Located in Section 14. Appendices (*14.2 Statistical Analysis*).

variables were not always found in the expected direction when added to multivariate regression models.

Table 22: Sample significant correlations between MVPA and the built environment for the both regions.

Variable	*Relationship*	*Coefficient*	*P-Value*
Walk Index – Mix 4 – 500 m	+	0.069*	0.024
Walk Index – Mix 4 – 1 km	+	0.078*	0.011
Walk Index – Mix 4 – 15 min.	+	0.073*	0.017
Retail FAR – 1 km	+	0.068*	0.026
Retail FAR – 15 min.	+	0.069*	0.024
Land Use Mix 4 – 15 min.	+	0.087**	0.004
Nearest Distance (m) – Home-Work Trip	-	-0.072*	0.018
Transit Travel Time (min.) – Home-Work Trip	-	-0.079**	0.009
Average Distance (m) – Regional Accessibility Locations	-	-0.115**	0.000
Transit Travel Time (min.) – Regional Accessibility Locations	-	-0.079**	0.009
Private Recreation Count – 500 m	+	0.075*	0.014
Private Recreation Count – 1 km	+	0.096**	0.002
Private Recreation Count – 15 min.	+	0.095**	0.002
Park Count – Any Size – 15 min.	+	0.078*	0.010
Park Count – Size 1 (< 1 acre) – 500 m	+	0.076*	0.012
Park Count – Size 1 (< 1 acre) – 1 km	+	0.078*	0.010
Park Count – Size 1 (< 1 acre) – 15 min.	+	0.097**	0.001
Park Area (acres) – Size 1 (< 1 acre) – 500 m	+	0.060*	0.047
Park Area (acres) – Size 1 (< 1 acre) – 1 km	+	0.068*	0.025
Bus Stop Count – 500 m	+	0.072*	0.018
Bus Stop Count – 1 km	+	0.068*	0.025
Market/Produce Shop – 1 km	+	0.066*	0.031
Sit-Down Restaurant (full service) Count – 500 m	+	0.090**	0.003
Sit-Down Restaurant (full service) Count – 1 km	+	0.099**	0.001
Sit-Down Restaurant (full service) Count – 15 min.	+	0.098**	0.004
Specialty Food Count – 500 m	+	0.078*	0.011
Specialty Food Count – 1 km	+	0.091*	0.003
Pharmacy Count – 1 km	+	0.070*	0.021
Transit Index – 0-1 Range Normalization – 500 m	+	0.062*	0.042
Transit Index – 0-1 Range Normalization – 1 km	+	0.062*	0.042
Transit Index – 0-1 Range Normalization – 15 min.	+	0.065*	0.033
Multi-Use Trail Length (m) – 15 min.	+	0.079**	0.010
Nearest Distance – Park Size 1 (< 1 acre)	-	0.122**	0.000

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.001 level (2-tailed).

5.2.2 Multicollinearity

Bivariate correlations assist in recommending independent variables that may be significant predictors of dependent variable health outcomes. These correlations also help indicate which independent variables are highly correlated with each other and present potential issues of multicollinearity. Independent variables that are collinear should not be included in regression models since they may comprise the same explanatory power and must either be put into a composite index or one or both variables may be discarded. Collinear variables should be avoided as they present difficulty when interpreting relationships of individual explanatory variables and the health outcome under consideration. The walkability index already contains the four main built environment measures, therefore, individual components of the walk index must only be used in models that also exclude the walkability index. During the regression modelling process, collinear statistics including collinearity tolerance and variance inflation factor (VIF) were also examined to determine potential multicollinearity between independent variables in the model. The VIF quantifies the extent of inflation within a specific variable's standard error (O'Brien, 2007). A variable with a VIF value of one indicates no multicollinearity and, while there is no standard VIF threshold to determine multicollinearity, a value of four is often utilized as an indicator of collinear variables (O'Brien, 2007). Conversely, the collinear tolerance value can also be utilized where values approaching 1.0 indicate no multicollinearity and values < 0.20 usually mark the threshold for assigning collinear variables (O'Brien, 2007). Collinear tolerance and VIF values must be utilized in combination with bivariate correlations when conclusively identifying collinear independent variables. In addition to collinearity tolerance and the VIF, two tailed Pearson coefficients were also generated to identify correlated independent variables and all three indicators were assessed to ensure two collinear variables were not included in the same model.

5.2.3 Variable Transformation

During the exploratory analysis stage of the study, there was also a need to transform specific built environment variables so that they better approached an approximate normal distribution. Several built environment measures are not normally distributed and are often positively skewed where values are heavily concentrated on the left side or to lower values along the spectrum. Measures of skewness and kurtosis were explored through descriptive statistics as well as visually through the use of histograms plotting the frequency distribution. A natural logarithm was performed on variables that were positively skewed to transform original values so that the data approximately resemble a bell-shaped curve of a normal distribution. A linear transformation adding a small non-zero value to the variable and then running the natural logarithm transformation was completed to resolve issues of zero values. Net residential density and transit stop counts were examples of variables that were transformed using a natural logarithm when assessing worksite locations (Figure 22). Although net residential density and transit count variables were found to have a few significant bivariate correlations with the examined health outcomes, they were not hypothesized nor discovered to have important relationships when applied to the regression models. Distance variables calculated in metres for home-work distance and average distance to regional accessibility locations tended to yield high numbers and were transformed to distance in kilometres for binary logistical regression models in order to more easily interpret odds ratio decimal places and results.[40]

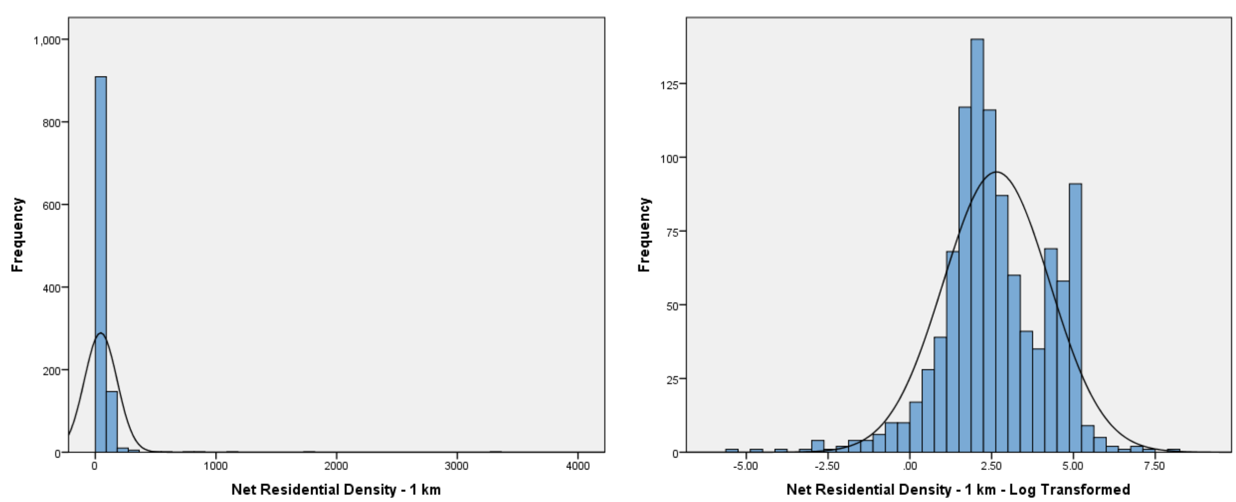

Figure 22: Positively skewed net residential density for 1 km buffers and after log transformation.

[40] Some model tables show the untransformed distance variables in metres.

5.3 Regression Modelling

Multivariate regression models were utilized to predict values of three dependent variable health outcomes based on the value of predictor independent variables comprising covariate demographics and built environment measures. Two types of regression models were utilized in this study: 1) multiple linear regression (MLR) models test associations between a single dependent variable and multiple continuous independent variables to generate a predictor value on a linear spectrum and 2) binary logistical regression (BLR) tests dichotomous variables on a two level categorical scale for the dependent variable. Multiple linear regression is typically used to predict continuous outcomes with a relatively normal distribution. Data issues of zero-inflated and heavily skewed variables associated with some built environment measures, may present potential statistical analysis problems. In contrast to multinomial logistical regression for dependent variables with more than two categories, binary regression as a probabilistic classification model aims to calculate the likelihood of two binary values (zero or one) based on a predefined threshold. The three dependent continuous variables were transformed into binary variables based on specific thresholds of interest: 1) 30 minutes of physical activity per day (Frank et al., 2005), 2) healthy or underweight (BMI < 25) versus overweight or obese (BMI ≥ 25), and 3) 30 minutes[41] of daily (210 weekly minutes) sedentary time driving or riding in a vehicle (Table 23).

Models were constructed for each dependent health outcome using both model types and implemented on each region separately and then using the pooled database. The same demographics covariates and independent variables selected as explanatory variables for each health outcome were repeated using both model types (Table 24). Hypothesized buffer-based worksite environmental variables were examined at a combination of buffer sizes when assessing the relationships with health outcomes. Independent variables selected for each model were forced to be included in the model rather than using a stepwise or other approach to define a specific procedure for including or excluding variables from the regression process. It was noted that because the adjusted R-square takes into account the sample size of the model, differences between the R-square and adjusted R-square were always highest in Baltimore and lowest in the pooled models.

Table 23: Threshold cut points for health outcomes utilized for binary logistical regression.

Dependent Variable	*Threshold Value*	*Zero Value*	*One Value*	*Outcome*
Minutes of daily physical activity	30 minutes	< 30 minutes/day	≥ 30 minutes/day	Positive
Body Mass Index (BMI)	25 (overweight or obese)	< 25 BMI	≥ 25 BMI	Negative
Minutes of sedentary time driving/riding in vehicle per week	30 minutes per day (210 minutes per week)	< 30 minutes/day	≥ 30 minutes/day	Negative

Table 24: All regression models developed for the worksite study varying model type and controls.

Model	*Dependent Variable*	*Model Type*	*Controls*
1	MVPA	MLR	Demographics covariates only
2	BMI	MLR	Demographics covariates only
3	Sedentary Time in Vehicle	MLR	Demographics covariates only
4	MVPA	BLR	Demographics covariates only
5	BMI	BLR	Demographics covariates only
6	Sedentary Time in Vehicle	BLR	Demographics covariates only
7	MVPA	MLR	Demographics covariates, home walkability

[41] While 30 minutes of sedentary time in vehicles per day is below the mean in both regions, this threshold was used to identify those participants that drive more than two short trips commuting to and from work each day assuming ≤ 15 minutes per trip. It is recognized that not driving trips are commute trips.

8	BMI	MLR	Demographics covariates, home walkability
9	Sedentary Time in Vehicle	MLR	Demographics covariates, home walkability
10	MVPA	BLR	Demographics covariates, home walkability
11	BMI	BLR	Demographics covariates, home walkability
12	Sedentary Time in Vehicle	BLR	Demographics covariates, home walkability

5.3.1 MLR - MVPA

Hypothesized variables, and those found to be significantly associated with the likelihood of achieving increased MVPA during the exploratory analysis stage of the study, were tested using a MLR model. The results of the model for the Baltimore region yielded no significant independent built environment measures and an R-square value of 0.190 (Table 25). Model coefficients were found to be in the expected direction for all model variables except for cul-de-sac density and healthy food count where increased MVPA was associated with increased cul-de-sac density and decreased healthy food locations within 500 m. In Seattle, home-to-work transit travel time and cul-de-sac density were found to be significant at the 0.05 level and the model had an R-squared value of 0.105 (Table 26). Unlike in Baltimore, cul-de-sac density and healthy food counts were found to be in the expected direction, although surprisingly increased walkability was found to be associated, not significantly, with decreased MVPA. Table 27 outlines the model results for the pooled dataset indicating an R-square of 0.117 and demonstrating covariate demographics variables such as age, gender, Caucasian and vehicle in household significant at the 0.001 confidence level, but home-work trips travel time on transit as the only significant built environment measure at the 0.05 level.

Table 25: MLR MVPA model summary statistics for Baltimore.

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Collinearity Tolerance*
Constant (y-intercept)	60.721		.000**	
Age[42]	-.412	✓	.000**	.922
Gender[43]	-10.326	✓	.000**	.941
Caucasian, non-Hispanic Ethnicity[44]	11.085	✓	.000**	.835
Children[45]	-1.075	✓	.625	.849
Household Vehicle[46]	-5.653	✓	.337	.894
Annual Household Income[47]	.516	✓	.188	.770
Walkability Index – Mix 4 – 15 min.	.131	✓	.765	.663
Home-Work Trip - Transit Travel Time	-.021	✓	.208	.847
Cul-de-sac Density – 1 km	.151	✗	.209	.967
Regional Accessibility – Average Distance	.000	✓	.178	.857
Healthy Food Count – 500 m	-.005	✗	.975	.730
R-Square	*Adjusted R-Square*		*ANOVA: F-Statistic*	*ANOVA: P-Value*
.190	.165		7.571	.000
Dependent Variable	*Mean*		*Standard Deviation*	*N*
MVPA	31.17		20.73	367

**. Correlation is significant at the 0.001 level (2-tailed).

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42 Continuous age variable for participants between 18 and 66 years of age.
43 Binary gender variable where 0 = male and 1 = female.
44 Binary Caucasian, non-Hispanic variable where 0 = non-Caucasian and 1 = Caucasian, non-Hispanic.
45 Binary children variable where 0 = participant has no children and 1 = participant has children.
46 Binary household vehicle variable where 0 = no household vehicle, 1 = ≥ 1 household vehicle.
47 Ten class categorical variable for annual household income separated by $10,000 increments.

*. Correlation is significant at the 0.05 level (2-tailed).

Table 26: MLR MVPA model summary statistics for Seattle.

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Collinearity Tolerance*
Constant (y-intercept)	77.078		.000**	
Age	-.374	✓	.000**	.944
Gender	-6.687	✓	.000**	.900
Caucasian, non-Hispanic Ethnicity	3.184	✓	.142	.949
Children	-1.847	✓	.288	.928
Household Vehicle	-21.563	✓	.000**	.913
Annual Household Income	.392	✓	.196	.810
Walkability Index – Mix 4 – 15 min.	-.534	✗	.243	.324
Home-Work Trip - Transit Travel Time	-.060	✓	.017*	.902
Cul-de-sac Density – 1 km	-.171	✓	.039*	.823
Regional Accessibility – Average Distance	0.000	✓	.586	.568
Healthy Food Count – 500 m	.324	✓	.133	.459
R-Square	*Adjusted R-Square*		*ANOVA: F-Statistic*	*ANOVA: P-Value*
.105	.090		6.918	.000
Dependent Variable	*Mean*		*SD*	*N*
MVPA	35.06		21.77	658

Table 27: MLR MVPA model summary statistics for both regions (pooled).

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Collinearity Tolerance*
Constant (y-intercept)	66.644		.000**	
Age	-.387	✓	.000**	.944
Gender	-7.879	✓	.000**	.920
Caucasian, non-Hispanic Ethnicity	6.907	✓	.000**	.937
Children	-1.880	✓	.170	.909
Household Vehicle	-15.472	✓	.000**	.912
Annual Household Income	.468	✓	.050*	.819
Walkability Index – Mix 4 – 15 min.	-.037	✗	.899	.525
Home-Work Trip - Transit Travel Time	-.027	✓	.050*	.864
Cul-de-sac Density – 1 km	-.081	✓	.224	.894
Regional Accessibility – Average Distance	.000	✓	.162	.830
Healthy Food Count – 500 m	.118	✓	.363	.602
R-Square	*Adjusted R-Square*		*ANOVA: F-Statistic*	*ANOVA: P-Value*
.117	.108		12.217	.000
Dependent Variable	*Mean*		*SD*	*N*
MVPA	33.67		21.48	1025

5.3.2 MLR – BMI

The MLR BMI model for Baltimore showed weak associations with the built environment variables examined and indicated that only age and being Caucasian, non-Hispanic were statistically significant (Table 43[48]). In Seattle, only average distance to all regional accessibility

[48] Note that the individual model result tables cited in the 5.3.x sections are stored in the Section 14. Appendices (*14.2 Statistical Analysis*).

locations were found to be statistically significant ($p < 0.05$) with BMI indicating a positive relationship with body weight and increased distance to regional activity centres (Table 44). As with Baltimore, when both regions were combined no built environment variables were found to be significant predictors of BMI and all three models indicated that the walkability index was performing in the opposite direction than anticipated (Table 45).

5.3.3 MLR – Sedentary Time in Vehicles

Model results from the MLR for sedentary time spent driving or riding in vehicles yields an R-squared value of 0.173 with only regional accessibility travel time on transit being significant at the 0.001 level, but with a moderate positive coefficient in the expected direction (Table 46). Land use mix six for Baltimore worksites is not in the expected direction as minutes of sedentary time increase with increased mixing of uses, however, this variable is not significant. Table 47 show the model results for sedentary time in Seattle showing regional accessibility transit travel time as being significant at the 0.001 confidence level in the anticipated direction with an R-square value of 0.094. When both regions are combined the model produced as R-square of 0.120 with retail FAR at the 15 minute transit shed being significant at the 0.05 level in the expected direction as there is a decrease in retail FAR there is an increase in minutes of sedentary time (Table 48). Land use mix six is not found in the expected direction although it is not significant as was found with the individual models for Baltimore and Seattle.

Table 28 provides a model performance evaluation summary of each of the MLR models applied for each health outcome by region without controlling for the home. The table rates each model based on R-square value, number of independent built environment variables that were significant and whether each variable had a coefficient in the expected direction. The MLR – MVPA model performed best for the Seattle region meeting all three criteria, despite having a lower R-square value at 0.105 in comparison to Baltimore at 0.190. MLR –BMI models faired relatively poorly in comparison to the models from the other region with lower R-square values and limited significant built environment variables. Models developed using MLR – Sedentary time in vehicle performed relatively well overall in all regions especially Baltimore and the pooled database with R-square values at 0.173 and 0.120 respectively along with significant variables in the anticipated direction.

Table 28: Summary table evaluating each MLR model by region and model characteristic.

Model	*Characteristic*	*MLR – MVPA*	*Component Performance*	*MLR – BMI*	*Component Performance*	*MLR – Sedentary time in vehicles*	*Component Performance*
Baltimore	R-squared	.190	✓	.123	✓	.173	✓
	Significant Variables	0/5	×	0/4	×	1/5	
	Expected Direction	3/5	✓	3/4	✓	3/5	✓
	Model Performance	2/3		2/3		3/3	✓
Seattle	R-squared	.105	✓	.060		.094	
	Significant Variables	2/5		1/4		2/5	
	Expected Direction	4/5	✓	2/4		4/5	✓
	Model Performance	3/3	✓	2/3		2/3	
Pooled	R-squared	.117	✓	.062		.120	✓
	Significant Variables	1/5		0/4	×	3/5	✓

	Expected Direction	4/5	✓	3/4	✓	4/5	✓
	Model Performance	2/3		1/3		3/3	✓

5.3.4 BLR - MVPA

Table 49 outlines the model summary of the BLR model for MVPA in Baltimore yielding a Nagelkerke R-square of 0.239 showing the walk index mix four in the expected direction with a 0.05 significance level. All other built environment measures were in the expected direction except cul-de-sac density and healthy food counts, however, no others were significant. In Seattle, the walkability index was significant, however, in the opposite direction of expected showing walkability decrease and minutes of MVPA increase (Table 50). All other variables are in the expected direction including home to work transit travel time which is significant at the 0.001 level. The Nagelkerke R-square was 0.133 with a percentage modelled change of 10%. In both regions, all independent built environment measures were found to be in the expected direction in contrast to the individual models for each region, and the model yielded a Nagelkerke R-square value of 0.149 with the largest percent change at 14.0% (Table 51).

5.3.5 BLR - BMI

Table 52 highlights the BLR model summary results for predicting BMI in the Baltimore region which, as was the case for BMI model using the MLR model type, performs relatively poorly in comparison to the models for MVPA and sedentary time in vehicles. In all three models it was noted that the walkability index mix four at the 500 m distance was operating in the operated direction from anticipated as increased walkability was resulting in increased BMI (Table 53 and Table 54). Overall the models had lower Nagelkerke R-square scores all below 0.100 with limited percentage change in variable explanation using independent ranging from the poorest at 3.8% in Baltimore to the highest at 6.7% in Seattle. Only transit time to regional accessibility locations in Seattle was significant at the 0.05 level and this variable appeared to have limited explanatory power judging by the coefficient.

5.3.6 BLR – Sedentary Time in Vehicles

Table 55 illustrates the BLR model results for sedentary time in automobiles for Baltimore indicating a 0.159 value for the Nagelkerke R-square. In contrast to the model results for sedentary time in the MLR models, the BLR models had limited significant values for the demographics or built environment variables for both regions and pooled (Table 56 and Table 57). Land use mix six was in the opposite direction that expected for all of the models, though not significant. The Nagelkerke R-squared value was determined to be 0.161 in Seattle and 0.139 for both regions combined. Retail FAR appeared to be the strongest buffer-based built environment predictor of sedentary time in vehicles and was significant for the pooled database.

Table 29 shows the results of the BLR models for dependent variables across all regions using six criteria for evaluation. The BLR sedentary time model performed the strongest across all regions with BLR for MVPA performing relatively well and the BLR model for BMI performing poorly. BLR models are useful for making policy statements based on the *Exp(B)* odds ratios when variables are significant and usually over 1.100. No variables examined met this criteria except for land use mix six except it was not in the expected direction. The Hosmer & Lemeshow Test was satisfied above 0.2 in all models except for sedentary time in Baltimore. Percentage change obtained by including demographic covariates and independent built environment were low for the BMI models and highest at 14.0% change for the BLR MVPA model at the pooled level.

Table 29: Summary table evaluating each BLR model by region and model characteristic.

Model	*Characteristic*	*BLR – MVPA*	*Component Performance*	*BLR – BMI*	*Component Performance*	*BLR – Sedentary time in vehicles*	*Component Performance*
Baltimore	Nagelkerke R-squared	.239	✓	.071		.159	✓
	Significant Variables	1/5		0/4	×	1/5	
	Expected Direction	3/5	✓	3/4	✓	3/5	✓
	Exp(B) ≥ 1.5	0/5	×	0/4	×	0/5	×
	Hosmer & Lemeshow Test	.248		.472	✓	.190	×
	% Change	11.7%	✓	3.8%	×	8.2%	
	Model Performance	3/6		2/6		3/6	✓
Seattle	Nagelkerke R-squared	.133	✓	.070		.161	✓
	Significant Variables	3/5	✓	1/4		2/5	✓
	Expected Direction	4/5	✓	2/4		3/5	✓
	Exp(B) ≥ 1.5	0/5	×	0/4	×	1/5	✓
	Hosmer & Lemeshow Test	.514	✓	.522	✓	.311	
	% Change	10.0%	✓	6.7%		13.2%	✓
	Model Performance	4/5	✓	1/6	×	5/6	✓
Pooled	Nagelkerke R-squared	.149	✓	.054	×	.139	✓
	Significant Variables	0/5	×	0/4	×	2/5	✓
	Expected Direction	5/5	✓	2/4		3/5	✓
	Exp(B) ≥ 1.5	0/5	×	0/4	×	0/5	×
	Hosmer & Lemeshow Test	.722	✓	.244		.453	✓
	% Change	14.0%	✓	4.7%		11.3%	✓
	Model Performance	4/6	✓	0/6	×	5/6	✓

5.3.7 MLR – MVPA – Controlling for Home Environment

In order to isolate the explanatory power of built environment measures at the workplace, it is necessary to also test regression models by controlling for the home built environment. An ordered regression procedure was utilized whereby independent variables were loaded into the model in blocks beginning with the demographics and SES covariates (block 1) and then adding the home built environment (block 2) before finally including the workplace built environment measures (block 3). For this study only the home walkability index with land use mix four at the 1 km buffer level was included. As with the other models a stepwise or other automated method of adding or excluding variables was not utilized in order to test the strength of each hypothesized measure. In Baltimore, a total R-square value of .204 was achieved for the model, however, only a 0.011 R-square change was observed after the worksite variables were included which was not statistically significant (Table 58). All built environment variables were in the anticipated direction except for cul-de-sac density which was increasing with increased minutes of physical activity and no worksite built environment variables were statistically significant. In Seattle and the both regions combined worksite walkability was not found to be in the anticipated direction as it was decreasing with increased minutes of physical activity, although no variables were significant (Table 59 and Table 60). In both regions as well as Seattle on its own, cul-de-sac density was in the excepted direction as well as counts of healthy food within 500 m.

5.3.8 MLR – BMI – Controlling for Home Environment

Given that the MLR and BLR models for predicting BMI were relatively weak without controlling for the home environment, it was expected that the model would yield even less explanatory power when including the home walkability index mix four. The home walkability index mix four was not significant in either region or the pooled region although it was in the expected direction. The worksite walkability index mix four at the 500 m was also not significant for each of the modelled regions and it was noted that was in the wrong direction as BMI increases and walkability increases. Although the demographic variables were strong in predicting BMI values and several are significant, the built environment did not add any useful additional explanatory power to the models. Table 61 reports the model results for the MLR BMI model when controlling for the home environment in Baltimore and produced the highest R-squared value at 0.126. The Seattle region also had convenience store and gasoline station counts within 1 km negatively contributing to BMI meaning BMI was being reduced by having more convenience stores nearby (Table 62). The pooled model showed an R-square change of only 0.07 when home walkability was added and only 0.004 when worksite walkability was included (Table 63).

5.3.9 MLR – Sedentary Time in Vehicles – Controlling for Home Environment

The MLR models to predict sedentary time in vehicles while controlling for the home environment presented the most statistically significant and most compelling models of the three dependent health outcomes examined. In both regions as well as the pooled database, the worksite variables provided more isolated explanatory power than the home environment and in the case of Seattle had more explanatory power at predicting sedentary time spent in vehicles than the demographics covariates. In all three models retail FAR was found to not be operating in the expected direction while the land use mix six variable was contributing in the anticipated direction. It should be noted that the direction of these two variables have been transposed in comparison to the MLR sedentary time model without the home environment control. Table 64 highlights an overall R-square value of 0.171 with a statistically significant F statistic change value of 3.285 in Baltimore. Even though only a 0.99 R-square value was yielded, an R-square change of 0.48 was reported in Seattle with home to work distance being statistically significant (Table 65). The pooled model followed suit with an R-square value of 0.134 and 0.054 of R-square change attributed to worksite built environment variables (Table 66).

Table 30 shows the summary results of the MLR models controlling for the home environment for each health outcome by region with the MLR sedentary time in vehicle model clearly outperforming the other two variables. The MLR sedentary time in vehicles model showed statistically significant explanatory power from the worksite built environment measures that exceeded that of the home environmental variables. Although the Baltimore region had the highest R-squared value at 0.171, the Seattle and pooled models also recorded reasonable values at 0.099

and 0.134 respectively for sedentary time in vehicles. The worksite environmental variables added more R-square change to the model than the demographics variables in the Seattle region and nearly the same in the pooled model. The MLR MVPA model produced relatively high R-square values at both regions, however, had limited significant variables and did not statistically contribute to the R-square change. The MLR BMI model, which performed poorly without the addition of the home environment, fared the worst having no statistically significant independent built environment variables for either the work or the home environments.

Table 30: Summary of each MLR model by region and model characteristic while controlling for home environment.

Model	*Characteristic*	*MLR – MVPA*	*Component Performance*	*MLR – BMI*	*Component Performance*	*MLR – Sedentary time in vehicles*	*Component Performance*
Baltimore	R-squared	.204	✓	.126	✓	.171	✓
	Work Environment R-squared change	.011		.005	✗	.039	✓
	Work Environment – F Statistic Change Sig.	.418	✗	.710	✗	.007**	✓
	Significant Variables	0/5	✗	0/4	✗	1/5	✓
	Expected Direction	4/5	✓	2/4		3/5	✓
	Model Performance	2/5		1/5		4/5	✓
Seattle	R-squared	.102	✓	.064		.099	✓
	Work Environment R-squared change	.012		.008	✗	.048	✓
	Work Environment – F Statistic Change Sig.	.127		.231	✗	.000**	✓
	Significant Variables	0/5	✗	0/4	✗	1/5	✓
	Expected Direction	4/5	✓	2/4		3/5	✓
	Model Performance	3/5	✓	1/5		4/5	
Pooled	R-squared	.125	✓	.067		.134	✓
	Work Environment R-squared change	.006	✗	.004	✗	.054	✓
	Work Environment – F Statistic Change Sig.	.284	✗	.319	✗	.000**	✓
	Significant Variables	0/5	✗	0/4	✗	2/5	✓
	Expected Direction	4/5	✓	3/4	✓	4/5	✓
	Model Performance	2/5		1/5		5/5	✓

5.3.10 BLR – MVPA – Controlling for Home Environment

Utilizing the same worksite independent variables as the original BLR MPVA, the model was applied to isolate the worksite variables and controlling for the home walkability index mix four at the 1 km distance. In Baltimore, both home walkability and worksite walkability were found to be significant contributors to explaining physical activity, whereby having supportive walk environments at the participant home and workplace contribute to more daily minutes of physical activity (Table 67). The Nagelkerke R-square value increased from 0.205 with demographics to 0.230 with home built environment to 0.263 when employment built environment were contributed, however, this change only accounted for a 0.9% change with demographics variables driving the predictive power of the model. The worksite walkability index was found to be negatively associated with minutes of physical activity in both Seattle and when both regions were combined deviating from the anticipated coefficient direction (Table 68 and Table 69). Nagelkerke R-square values of 0.151 and 0.167 were derived in Seattle and in the pooled model respectively accounting for only 3.4% and 2.6% change in explanatory power from demographics covariates.

5.3.11 BLR – BMI – Controlling for Home Environment

Table 70 outlines the BLR BMI model outputs when controlling for the home environment in Baltimore where the home environment walkability index was negatively associated with BMI as expected, however, worksite environment was positively associated with the likelihood of being overweight or obese. Overall the Nagelkerke R-square value was low at 0.093 and demonstrating a very low percentage of explanatory change between demographics and worksite environment at only 0.9%. The Seattle region and both regions combined performed even more poorly with Nagelkerke R-square values between 0.067 and 0.062 even showing a decrease of -0.1% and -0.2% respectively in explanatory power (Table 71). For the Seattle and the pooled models, demographic and SES variables by themselves more accurately predicted the likelihood of being overweight than when home or work environmental variables were added (Table 72). This is further underscored by the fact that the Hosmer & Lemeshow Test in the pooled model which yielded a Chi-square value of 16.972 and a 0.030 significance value indicating a weak model.

5.3.12 BLR – Sedentary Time in Vehicles – Controlling for Home Environment

Self-reported sedentary time spend driving or riding in vehicles was also tested by including the home walkability index mix four at the 1 km distance and work environment explanatory power. Table 73 reports the model output for the Baltimore region indicating a Nagelkerke R-square of 0.156 and a change of 0.058 when worksite environmental variables were applied to the model. The Hosmer & Lemeshow Test at the block 1 stage for demographics also indicated a high Chi-square value and a low significance level potentially resulting in a weak goodness of fit. Though not significant, the coefficient for worksite retail FAR trended towards the projected direction. For the Seattle model, home to work distance and transit travel time to regional accessibility locations were found to be significant contributors to the model yielding a 0.191 Nagelkerke R-square and a 9.9% increase in predicted outcomes through worksite variables (Table 74). The pooled model rendered similar results with a 8.8% increase in predicted outcomes achieved by adding worksite environmental variables and a Nagelkerke R-square of 0.156 (Table 75).

Table 31 is a model performance summary table of the BLR models controlling for home environment and isolating worksite explanatory power for each health outcome for Baltimore, Seattle and both regions pooled. As with the MLR models controlling for home walkability, the BLR model for predicting sedentary time in vehicles performed the strongest demonstrating the most significant Nagelkerke R-square change when demographics and home environment was already accounted for. In Baltimore, Seattle and the both regions, the Nagelkerke R-square values were above 0.10 and the Seattle and pooled models showed a significant percentage change in predicting power when worksite variables were added at 9.9% and 8.8% respectively. Retail FAR was found to be stronger at predicting sedentary time than land use mix six, but was not statistically significant for any of the models. The BLR physical activity model displayed the strongest worksite variable explanatory power in Seattle contributing to a 0.057 Nagelkerke R-square change and a 3.4% increase in predicting power. As with the MLR BMI model, the BLR BMI model had limited explanatory power yielding Nagelkerke R-square values of between 0.062 at the pooled level and 0.093 in Baltimore. In Seattle and when both regions were combined, the worksite variables and the home walkability index for the BLR BMI model actually decreased the explanatory power to a lower level than was predicted by using demographics alone.

Table 31: Summary of each BLR model by region and model characteristic while controlling for home environment.

Model	*Characteristic*	*BLR – MVPA*	*Component Performance*	*BLR – BMI*	*Component Performance*	*BLR – Sedentary time in vehicles*	*Component Performance*
Baltimore	Nagelkerke R-squared	.263	✓	.093	✓	.156	✓
	Work Environment R-squared change	.033	×	.032	×	.065	✓
	Work Environment – % Change	0.9%		0.9%		3.6%	✓
	Significant Variables	1/5		0/4	×	1/5	✓
	Expected Direction	4/5	✓	3/4	✓	4/5	✓
	Model Performance	3/5		1/5		4/5	✓
Seattle	Nagelkerke R-squared	.151	✓	.067		.191	✓
	Work Environment R-squared change	.057		.011	×	.127	✓
	Work Environment – % Change	3.4%		-.1%	×	9.9%	✓
	Significant Variables	1/5		0/4	×	2/5	✓
	Expected Direction	4/5	✓	3/4	✓	3/5	✓
	Model Performance	3/5	✓	2/5		5/5	
Pooled	Nagelkerke R-squared	.167	✓	.062		.134	✓
	Work Environment R-squared change	.037	×	.004	×	.100	✓
	Work Environment – % Change	2.6%		-.2%	×	8.8%	✓
	Significant Variables	0/5	×	0/4	×	2/5	✓
	Expected Direction	4/5	✓	3/4	✓	4/5	✓
	Model Performance	2/5		1/5		5/5	✓

6. Results

The use of both multivariate linear regression and binary logistical regression models in the analysis of worksite locations was an effective way of determining variability in built environment measures, demographic covariates and the dependent health outcomes under investigation. Explanatory power of workplace built environment variables for several models tested was diminished once home environment had been accounted for especially with BMI, however, predicted values were improved in others such as MVPA in Baltimore by adding walkability near the home. Table 32, Table 33 and Table 34 outline performance indicators for each of the four model types evaluating MVPA, BMI and sedentary time driving or riding in vehicles in Baltimore, Seattle and both regions combined and explanations for the models with the strongest worksite associations provided below by health outcome. Worksite built environment measure values often differed with buffer type and among study regions with more agreement observed between variables developed at the 15 minute transit buffers and 1 km buffers in comparison to the 500 m buffer level. Baltimore and Seattle tended to vary with some worksite measures being associated with health outcomes in one region, but not the other. Intuitively, the pooled dataset tended to follow the Seattle results because of the larger sample in that region, however, cases were presented where variables were not significant in Seattle, but became significant once the Baltimore sample was added. Transit-based variables were tested for significance for each of the health outcomes evaluated and were found not to be significant or presented collinearity problems with other worksite variables especially when utilizing the 15 minute transit buffers. In addition, access to parks and private recreation were tested for all three health outcomes, but were eventually discarded from the final models due to a lack of significance and predictive power.

Table 32: Model performance evaluation for the Baltimore Region.

Health Outcome	*Model Type*	*R-square/ Nagelkerke R-square*[49]	*R-square/ Nagelkerke R-square Change*	% Change[50] / % Worksite Change[51]	*Significant Variables*	*Expected Direction*	*Highest Performance/ Lowest Performance*[52]
MVPA	MLR	.190			0/5	3/5	×
	BLR	.239		11.7%	1/5	3/5	
	MLR – Controlled	.204	.011		0/5	1/5	
	BLR – Controlled	.263	0.033	0.9%	1/5	4/5	✓
BMI	MLR	.123			0/4	3/4	
	BLR	.071		3.8%	0/4	3/4	
	MLR – Controlled	.126	0.005		0/4	2/4	×
	BLR – Controlled	.093	.032	0.9%	0/4	2/4	✓
Sedentary time in vehicles	MLR	.173			1/5	3/5	
	BLR	.159		8.2%	1/5	3/5	✓
	MLR – Controlled	.171	0.039		1/5	3/5	×
	BLR – Controlled	.156	.065	3.6%	1/5	4/5	

Table 33: Model performance evaluation for the Seattle Region.

Health Outcome	*Model Type*	*R-square/ Nagelkerke R-square*	*R-square/ Nagelkerke R-square Change*	% Change/ % Worksite Change	*Significant Variables*	*Expected Direction*	*Highest Performance/ Lowest Performance*
MVPA	MLR	.105			2/5	4/5	✓
	BLR	.133		10.0%	3/5	4/5	
	MLR – Controlled	.102	.012		0/5	4/5	×
	BLR – Controlled	.151	.057	3.4%	1/5	4/5	
BMI	MLR	.060			1/4	2/4	
	BLR	.070		6.7%	1/4	2/4	✓
	MLR – Controlled	.064	.008		0/4	2/4	×
	BLR – Controlled	.067	.011	-0.1%	0/4	2/4	
Sedentary time in vehicles	MLR	.094			2/5	4/5	

[49] Note that the R-square and the Nagelkerke R-square used for BLR models are not the same. In all cases the Nagelkerke R-square is higher than the R-square.
[50] Additional explanatory percentage added by including demographic covariates and worksite variables.
[51] Additional explanatory percentage added by worksite variables beyond home environment for controlled models.
[52] Overall performance based on equal weights for each evaluation category except for increase value placed on significant worksite variables.

Sedentary time in vehicles	BLR	.161		13.2%	2/5	3/5	
	MLR – Controlled	.099	.048		1/5	3/5	×
	BLR – Controlled	.191	.127	9.9%	2/5	3/5	✓

Table 34: Model performance evaluation for both regions.

Health Outcome	*Model Type*	*R-square/ Nagelkerke R-square*	*R-square/ Nagelkerke R-square Change*	% Change/ % Worksite Change	*Significant Variables*	*Expected Direction*	*Highest Performance/ Lowest Performance*
MVPA	MLR	.117			0/5	4/5	
	BLR	.149		14.0%	0/5	5/5	✓
	MLR – Controlled	.125	.006		0/5	4/5	×
	BLR – Controlled	.167	.037	2.6%	0/5	4/5	
BMI	MLR	.062			0/4	3/4	✓
	BLR	.054		4.7%	0/4	2/4	
	MLR – Controlled	.067	.004		0/4	3/4	
	BLR – Controlled	.062	.004	-0.2%	0/4	3/4	×
Sedentary time in vehicles	MLR	.120			3/5	4/5	
	BLR	.139		11.3%	3/5	3/5	✓
	MLR – Controlled	.134	.054		2/5	4/5	×
	BLR – Controlled	.134	.100	8.8%	2/5	4/5	

Table 35 summarizes the key independent worksite variables found to be statistically significant with the health outcomes analyzed highlighting occurrence of significance and expected direction for the two model types, controlling and excluding home environment. The walkability index, home-work trips and cul-de-sacs were found to be a significant predictor of MVPA, and retail FAR, regional accessibility and home-work trips were significantly associated with sedentary time spent in cars. The following sections provide detail on types of associations, strength and test statistics for each outcome.

Table 35: Summary of variable significance and expected direction for each model by region and outcome.[53]

Variable	*Baltimore*			*Seattle*			*Pooled*		
	MVPA	BMI	Sedentary Time	MVPA	BMI	Sedentary Time	MVPA	BMI	Sedentary Time
Work - Walkability Index	✓[54]			✗[55]					
P-Value (≤ 0.05)	2/4[56]	0/4		2/4	0/4		0/4	0/4	
Expected Direction	4/4	1/4		0/4	1/4		1/4	0/4	
Home-Work – Distance/ Transit Travel Time			✓	✓		✓			✓
P-Value (≤ 0.05)	0/4		4/4	2/4		4/4	1/4		4/4
Expected Direction	4/4		4/4	4/4		4/4	4/4		4/4
Regional Accessibility – Distance/Transit Travel Time					✓	✓			✓
P-Value (≤ 0.05)	0/4	0/4	0/4	0/4	2/4	2/4	0/4	0/4	4/4
Expected Direction	4/4	4/4	1/4	4/4	4/4	3/4	4/4	4/4	4/4
Retail FAR			✓			✓			✓
P-Value (≤ 0.05)			1/4			1/4			2/4
Expected Direction			3/4			3/4			4/4
Cul-de-sac Density				✓					
P-Value (≤ 0.05)	0/4			2/4			0/4		
Expected Direction	0/4			4/4			4/4		

6.1 MVPA

In Baltimore, the workplace walkability index at the 15 minute transit shed was found to be a positive predictor of MVPA whereby a 3.5 unit rise in walkability increased the likelihood by 50% of achieving the Surgeon General's recommended minimum of 30 minutes of MVPA both controlling for, and excluding home environment using the BLR model (p < 0.05; OR[57] = 1.148; CI[58] = 1.022-1.289) (Table 36) (Pate et al., 1995; Besser & Dannenberg, 2005; Troiano et al., 2008). Age, gender and Caucasian, non-Hispanic ethnicity were also found to be significant predictors of MVPA in the expected direction with Caucasians being 2.5 times more likely to attain at least 30 minutes of MVPA per day (p <0.001; OR = 2.560; CI = 1.446-4.531). In the Seattle, both home to work travel time on transit (p < 0.05; CI = -0.109 – -0.011) and cul-de-sac density within 1 km (p < 0.05; CI = -0.333 – 0.009) were negatively associated with minutes of MVPA per day yielding an R-square value of 0.103 and a small, but significant 1.8% increase in explained variation workplace built environment variables when excluding home environment (Table 37). Age, gender and presence of

[53] Only statistically significant final worksite environmental variables included.
[54] Denotes at least one model that has a statistically significant (≤ 0.05) variable in the expected direction.
[55] Model that has at least one statistically significant (≤ 0.05) variable in the direction opposite of expected.
[56] Two model types (MLR and BLR) were examined both including and excluding home environment (n = 4).
[57] Odds ratio/*Exp(B)* (OR).
[58] Confidence interval of 95% lower and upper bounds for *Exp(B)* (CI).

vehicles in household were all found to be statistically significant and in the expected direction with vehicles in household demonstrating the highest semi-partial correlation (-0.166) with MVPA. No significant worksite built environment associations were found for the pooled model.

Table 36: BLR model summary for MVPA controlling for home environment in Baltimore.

Variable	*β*[59]	*SE*[60]	*Wald*	*P value*	*Exp(B)*	*95% CI*	
						Lower	*Upper*
Age	-.044	.012	12.807	.000	.957	.934	.980
Sex	-1.076	.247	18.914	.000	.341	.210	.554
Caucasian, non-Hispanic ethnicity	.940	.291	10.408	.001	2.560	1.446	4.531
Children	-.016	.266	.004	.951	.984	.584	1.659
Vehicles in household	.925	.856	1.168	.280	2.523	.471	13.514
Annual Household Income	.081	.048	2.858	.091	1.084	.987	1.191
Home – Walkability Index Mix 4 – 1 km	.107	.045	5.648	.017	1.113	1.019	1.216
Work – Walkability Index – Mix 4 – 15 min.	.138	.059	5.454	.020	1.148	1.022	1.289
Home-Work – Transit Travel Time	.000	.002	.045	.833	1.000	.996	1.005
Cul-de-sac Density – 1km	.026	.015	3.174	.075	1.027	.997	1.056
Regional Accessibility - Distance	-.021	.025	.698	.403	.979	.932	1.029
Healthy Food Count – 500 m	-.014	.020	.501	.479	.986	.949	1.025
Constant (y-intercept)	.636	1.429	.198	.657	1.888		

Table 37: MLR model summary for MVPA excluding home environment in Seattle.

Variable	*β*	*SE*	*P value*	*Zero-order*[61]	*Semi-Partial*[62]	*95% CI*		*Collinearity Tolerance*
						Lower	*Upper*	
Age	-.374	.082	.000	-.152	-.170	-.536	-.213	.944
Sex	-6.687	1.741	.000	-.149	-.143	-10.106	-3.269	.900
Caucasian, non-Hispanic ethnicity	3.184	2.167	.142	.042	.055	-1.071	7.438	.949
Children	-1.847	1.739	.288	-.037	-.040	-5.261	1.567	.928
Vehicles in household	-21.563	4.820	.000	-.173	-.166	-31.028	-12.098	.913
Annual Household Income	.392	.303	.196	.021	.048	-.203	.987	.810
Work – Walkability Index – Mix 4 – 15 min.	-.534	.458	.243	.078	-.043	-1.433	.364	.324
Home-Work – Transit Travel Time	-.060	.025	.017	-.102	-.089	-.109	-.011	.902
Cul-de-sac Density – 1km	-.171	.083	.039	-.113	-.077	-.333	-.009	.823
Regional Accessibility - Distance	-.090	.165	.586	-.076	-.020	-.415	.234	.568
Healthy Food Count – 500 m	.324	.215	.133	.072	.056	-.099	.746	.459
Constant (y-intercept)	77.078	7.054	.000					

6.2 BMI

BMI was the health outcome least associated with worksite built environment overall across the regions. Both as a continuous variable, as well as a dichotomous variable, urban form measures near worksites had relatively weak correlations with BMI with the strongest associations with age

[59] Unstandardized coefficient (beta weights) (β).
[60] Standard error (SE).
[61] Two tailed Pearson correlation coefficient (zero-order).
[62] Semi-partial correlation coefficient

(p < 0.05) in the anticipated direction as age increases so did BMI. In Baltimore, the home environment walkability index within 500 m was found to be statistically significant where each unit increase in walkability was associated with a 9.2% reduction in the odds of being obese (p < 0.05; OR =0.908; CI = 0.841-.981) (Table 38). Worksite variables were not found to have any statistically significant associations with BMI in the Baltimore region. In King County, the average travel time on transit to regional accessibility locations from worksites was found to be significantly associated with an increase in BMI when testing workplace measures on their own (p < 0.05; OR = 1.009; CI = 1.001-1.018), but was not a significant predictor of BMI when accounting for the home environment. The walkability index for participant home environment was not significantly associated with BMI for either region. As was the case for MVPA models, worksite variables were not found to have significant associations with BMI across any of the models when both regions were combined.

Table 38: BLR model summary for BMI controlling for home environment in Baltimore.

Variable	*β*	*SE*	*Wald*	*P value*	*Exp(B)*	*95% CI*	
						Lower	*Upper*
Age	.033	.011	8.811	.003	1.034	1.011	1.056
Caucasian, non-Hispanic ethnicity	-.316	.266	1.406	.236	.729	.433	1.229
Children	.072	.256	.078	.780	1.074	.651	1.774
Vehicles in household	-.240	1.123	.046	.831	.786	.087	7.101
Annual Household Income	-.007	.048	.024	.878	.993	.904	1.091
Valid driver's license	-.543	.987	.303	.582	.581	.084	4.019
Married/Living with partner	-.177	.274	.419	.518	.838	.490	1.433
Own household	.238	.329	.524	.469	1.269	.666	2.419
Home – Walkability Index Mix 4 – 1 km	-.096	.039	6.023	.014	.908	.841	.981
Work – Walkability Index – Mix 4 – 500 m	.053	.066	.637	.425	1.054	.926	1.200
Regional Accessibility – Transit Travel Time	.000	.003	.001	.977	1.000	.994	1.006
Convenience Store Count – 1km	.014	.019	.557	.455	1.014	.977	1.053
Fast Food – Nearest Distance	.000	.000	.438	.508	1.000	1.000	1.000
Constant (y-intercept)	-.252	.981	.066	.797	.777		

6.3 Sedentary Time in Vehicles

Sedentary time spent driving or riding in vehicles presented the strongest modeled associations with worksite urban form measures of the group. In Baltimore, only the home to work distance was found to be positively significant indicating that increased home to work distance was associated with increased sedentary minutes per week when controlling for walkability at the home (p < 0.001; CI = 0.004-0.011; Nagelkerke R-square = 0.156). In Seattle, distance from home to work (p < 0.001; OR = 1.000; CI = 1.000-1.000) as well as average distance to regional accessibility locations (p < 0.05; OR = 1.000; CI = 1.000-1.000) were found to be significantly positively associated with increased sedentary time in vehicles as was home walkability (p < 0.001; OR = 0.886; CI = 0.828-0.948). Home walkability contributed substantially to the explanatory power of the model increasing the Nagelkerke R-square from 0.064 (demographic covariates only) to 0.125 while worksite built environment measures increased performance a further 6.6% to 0.191 representing a total change of 54.1% correctly predicted values to 64.0% (9.9% increase) with workplace contributing a 3.9% increase.

When data for both regions was combined into a pooled group, retail FAR at the 15 minute transit shed level was found to be statistically negatively significant, whereby for every 0.5 unit increase in retail FAR there was an associated 27.75% increase in the likelihood of having less than 30 minutes of sedentary driving time per day (p < 0.05; OR = 0.445; CI = 0.214-0.927) (Table 39). However, it was found that when home environment walkability was added to the model that the explanatory power of worksite retail FAR was not significant. As with Seattle, home-to-work distance was a significant predictor of sedentary time in vehicles both with and without ($p < 0.001$; OR = 1.045; CI = 1.031-1.059) controlling for the home environment. However, average distance to regional accessibility locations from work was not found to be significant. The BLR model for sedentary time in vehicles excluding home environment yielded a Nagelkerke R-square value of 0.143 while the home environment controlled model increased only 1.3% to 0.156 with home environment walkability being significantly negatively associated with sedentary time in vehicles contributing to a 7.8% reduction in the likelihood of having 30 minutes or more spent in a vehicle for every unit increase in walkability within 1 km of the home ($p < 0.001$; OR = 0.922; CI = 0.877-0.969) (Table 40).

Table 39: BLR model summary for sedentary time in vehicles excluding home walkability in both regions.

Variable	*β*	*SE*	*Wald*	*P value*	*Exp(B)*	*95% CI*	
						Lower	*Upper*
Age	.010	.007	2.321	.128	1.010	.997	1.023
Caucasian, non-Hispanic ethnicity	-.423	.166	6.524	.011	.655	.473	.906
Children	.049	.143	.119	.730	1.051	.794	1.391
Vehicles in household	2.763	.751	13.530	.000	15.853	3.636	69.118
Annual Household Income	-.027	.024	1.199	.273	.974	.928	1.021
Retail FAR – 15 min.	-.809	.374	4.679	.031	.445	.214	.927
Land Use Mix 6 – 15 min.	.329	.417	.621	.431	1.389	.613	3.145
Home-Work – Distance	.044	.007	41.941	.000	1.045	1.031	1.059
Regional Accessibility – Distance	.019	.008	5.150	.023	1.019	1.003	1.035
Convenience Store Count – 1km	.021	.013	2.522	.112	1.021	.995	1.047
Constant (y-intercept)	-3.706	.893	17.215	.000	.025		

Table 40: BLR model summary for sedentary time in vehicles including home walkability in both regions.

Variable	*β*	*SE*	*Wald*	*P value*	*Exp(B)*	*95% CI*	
						Lower	*Upper*
Age	.006	.007	.703	.402	1.006	.992	1.019
Caucasian, non-Hispanic ethnicity	-.397	.167	5.665	.017	.673	.485	.932
Children	-.045	.147	.094	.760	.956	.717	1.274
Vehicles in household	2.671	.755	12.508	.000	14.451	3.289	63.487
Annual Household Income	-.032	.025	1.674	.196	.969	.923	1.016
Home – Walkability Index Mix 4 – 1 km	-.081	.026	10.092	.001	.922	.877	.969
Retail FAR – 15 min.	-.674	.379	3.168	.075	.510	.243	1.071
Land Use Mix 6 – 15 min.	.315	.417	.569	.451	1.370	.605	3.104
Home-Work – Distance	.038	.007	29.544	.000	1.039	1.024	1.053
Regional Accessibility – Distance	.016	.008	3.878	.049	1.016	1.000	1.033
Convenience Store Count – 1km	.021	.013	2.663	.103	1.022	.996	1.048
Constant (y-intercept)	-3.266	.907	12.953	.000	.038		

7. Limitations & Considerations

Since this was a cross-sectional study, no direct causation between worksite environment and health outcomes could be determined (Frank et al., 2004, 2015, 2007; Glass, Goodman, Hernán, & Samet, 2013). Issues of self-selection of workplace environment including individual preferences make it challenging to assess causation among urban form, human behaviour and associated health outcomes. Despite isolating the effect of worksite built environment by controlling for demographics and home walkability, additional unknown unadjusted confounding variables may be impacting participant health. Objectively measured MVPA of working adults was measured over two weekdays, so even though it was not known where all the MVPA took place, it was assumed that some was attributed to physical activity achieved during regular work schedules. Similarly, sedentary time was measured over seven days to include weekday and weekend time spent in vehicles, however, it was estimated that much of this travel was related to commuting for work. To better understand the direct effects of neighbourhood environment around workplaces, a longitudinal study must be performed tracking participants at various time stages in combination with built environment interventions to fully realize impacts on health. Given the substantial costs and resources associated with longitudinal studies, cross-sectional studies are widely performed and considered a legitimate method of advancing scholarship in public health. Data acquired for the NQLS Prime study offered the tremendous ability to examine in-depth health characteristics for a relatively large sample using both objectively measured and self-reported outcomes.

The potential exists to further study the built environment characteristics of NQLS Prime worksites located outside of the original home-based project study area. A relatively large number of NQLS Prime participants (n = 97) worked in Washington D.C. and 25% of all participant worksites in the Baltimore region had to be discarded from this study because they were located outside of the study area. Further research could be performed adding built environment data from the District of Columbia and Northern Virginia to better encompass the entire metropolitan area with a second major urban area and downtown (beyond Baltimore) within the same region. As a result of these limitations on the participants available in the Baltimore region, the sample could only be 57.6% the size of the sample in the Seattle region. When comparing two geographic regions as well as the pooled data block, it is important to utilize two representative samples of similar sizes for analysis and comparison. The participant home samples for the NQLS Prime study regions are more closely aligned in this way than the worksite locations with 935 original participants in Baltimore and 1287 in Seattle. This difference represents only a 27.4% increase in sample in Seattle for home locations in comparison to a 42.4% increase for places of employment. The difference in sample sizes for both regions did affect the analysis and meant that the difference between the R-square adjusted R-squared in the linear regression models was always larger for Baltimore than Seattle since the adjusted R-square corrects for sample size.

Built environment measures were developed in a GIS using widely tested and accepted methods upholding rigorous quality assurance/quality control (QA/QC) standards to ensure consistency and spatial accuracy across both regions (Ewing & Cervero, 2010; Feng et al., 2010; Frank et al., 2009; Matson-Koffman et al., 2005). It should be recognized that because of the nature of the study data, not all datasets could be aligned with the timing of original collection in the 2000s as these datasets were not available or did not exist. Efforts were made to ensure that geospatial data, especially those primary data collected as part of the NQLS Prime study including parks, private recreation and food environment aligned in close proximity with the study period. The quality and extent of coverage of sidewalks are important features in the microscale built environment that support active transportation and transit use (Frank et al., 2012; Lachapelle & Frank, 2009; Schwartz et al., 2009). Unfortunately, sidewalk data was not available for the two regions under investigation, however, as local government authorities continue to expand databases on sidewalk inventories, sidewalk coverage around workplaces should be incorporated in future studies examining NQLS worksites. Lastly, future studies should assess the built environment using larger transit catchment areas beyond 15 minutes. For this study, 30 minute transit shed buffers were developed for participant work locations, however, the aggregation of built environment measures was discovered to be too processing intensive to be generated within the constraints of the study.

Additionally, a more comprehensive analysis of worksite locations would include an evaluation of the microscale environment including streetscape layout, pedestrian-based features such as crosswalk safety and alignment and the urban design of neighbourhoods surrounding employment locations. The Microscale Audit of Pedestrian and Streetscapes (MAPS) instrument has been utilized to examine home environments for a similar NQLS study on seniors (SNQLS) in Baltimore and Seattle and could be further extended to analyze physical activity and other health outcomes for NQLS Prime worksites (Cain et al., 2014; Millstein et al., 2013). Cain et al. (2014) found that 15.7% of all MAPS scores evaluated were significantly associated with objectively measured physical activity presenting evidence that improving microscale features as a potential way to create activity-friendly environments.

8. Conclusions

Besides the home, the place of employment is where the average adult spends a majority of their time during weekdays. Therefore, it is important to understand the extent to which the environment nearby worksites and the location of workplaces influence transportation mode choice and travel patterns including commute trips and trips from work elsewhere. By studying the effect of urban form near worksites, researchers may better understand how these non-home locations impact behaviour. By developing policies that promote walkable environments nearby places of employment that encourage transit use, public health officials may be able to increase physical activity while reducing the prevalence of overweight or obese employees and reducing sedentary time in vehicles.

To the knowledge of the author, this study successfully demonstrated for the first time the use of individual transit-based environmental surfaces to measure the impact of local built environment on health. Workplace participant catchment areas based on 15 minute travel time on all transit modes or by foot were found to be a suitable method for representing built environment exposure near places of employment. Furthermore, this study has established the potential importance of directly integrating transit access into participant urban form metrics underscoring the explicit link between opportunities for physical activity and positive health outcomes and transit use. Given the widespread availability of high quality GTFS transit data, future observational health studies examining participant outcomes should consider measuring the built environment based on transit access. The utilization of transit-based buffers may also preclude the need to include transit variables such as counts of bus stops or rail stops or a transit index in model development due to collinear associations with the buffers.

The results of this study indicate that environments near workplaces that contain more walkable characteristics, measured through retail FAR, land use mix, net residential density and intersection density (comprising the walkability index), are associated with employees who achieve more MVPA than those employment locations that do not support walking. To a lesser extent, increased time spent for home-to-work travel on transit and cul-de-sac density was also negatively associated with the likelihood of achieving the recommended 30 minutes of daily physical activity. BMI and the likelihood of not being overweight or obese were shown to be significantly related with walkability near the home environment, but not the worksite environment. Logically, travel patterns including home-work distance and transit time to regional activity centres were found to be important predictors of sedentary time spent in vehicles, whereby the further distance and travel time traversed, the less opportunity for physical activity because of time spent driving. Additionally, worksite retail FAR was found to be the most important component of the walkability index with regards to the ability to predict sedentary time in vehicles denoting decreased time spent in cars for worksites that support more neighbourhood retail or multi-level shopping.

Given the observed differences between the two study sites analyzed as a part of this project, it is evident that generalizations about the impact of workplace built environment on health cannot be extended carelessly. Differences in results between the two regions may be at least partially explained by the reduction in sample size in Baltimore due to the exclusion of participant worksites located outside of the study area. Nevertheless, the study demonstrates significant correlations between work location and associated environment type and public health indicators of importance. Effective health interventions may be implemented through strategies that decrease home-work distance and transit travel time while increase workplace commercial FAR. Public health policies and programs that aim to foster more walkable urban form near workplaces should also be encouraged as a method of promote more active-friendly environments for the labour force.

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11.4 Statistical Package

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12. Glossary

General Transit Feed Specification (GTFS): A standardized data format used to store public transit schedule, stop, route information and geospatial referencing for public use. GTFS data is made available by transit authorities in North American and worldwide in text data format.

NQLS Prime: The Neighborhood Quality of Life Study is an NIH-funded observational study of adults aged 18 to 66 in the Baltimore and Seattle regions.

Pedestrian-Enhanced Walkable Network: A walkable road network that only contains roads where pedestrians are permitted as well as non-motorized paths such as multi-use trails, cut-throughs and park trails. A pedestrian-enhanced walkable network may or may not include alleys and lanes depending on use.

Sausage buffer: A type of polygon vector feature that extrudes from the walkable road network based on a specified trim distance that is utilized to model a walking surface selecting all intersecting urban form features being points, polylines or polygons.

Walkable Network: A pedestrian-based road network used to model walk environments which as excluded roads where pedestrians are not permitted such as limited access freeways, highway ramps and interchanges.

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14. Appendices

14.1 Methods

Table 41: All buffer-based built environment measures developed at 500 m, 1 km and 15 minute transit trip.

Type	*Subclass*	*Variable*
Macroscale Built Environment	Parcel-based	Parcel count by land use type
		Parcel land area by land use type
		Parcel building floor area by land use type
		Net-Residential Density (dwelling unit/acre)
		Land Use Mix 4
		Land Use Mix 6
		Retail FAR
	Walkable Network-based	Intersection Count
		Intersection Density (intersections/square kilometre)
		Cul-de-sac Count
		Cul-de-sac Gross Density (intersections/square kilometre)
	Parcel-based	Walkability Index – Land Use Mix 4
		Walkability Index – Land Use Mix 6
Parks	Parks (any size)	Park Counts
		Park Area (acres)
	Park Size 1 (< 1 acre)	Park Counts
		Park Area (acres)
	Park Size 2 (1- < 50 acres)	Park Counts
		Park Area (acres)
	Park Size 3 (> 50 acres)	Park Counts
		Park Area (acres)
Private Recreation	Private Recreation	Private Recreation Establishment Counts
		Private Recreation Establishment Gross Density (per sq. km.)
Food Environment	Convenience Store	Convenience Store Count
		Convenience Store Gross Density (per sq. km.)
	Market/Produce	Market/Produce Store Count
		Market/Produce Store Gross Density (per sq. km.)
	Supermarket	Supermarket Count
		Supermarket Gross Density (per sq. km.)
	Fast Food (limited service)	Fast Food (limited service) Count
		Fast Food (limited service) Gross Density (per sq. km.)
	Restaurant (full service)	Restaurant (full service) Count
		Restaurant (full service) Gross Density (per sq. km.)
	Specialty Foods	Specialty Foods Count
		Specialty Foods Gross Density (per sq. km.)
	Pharmacy	Pharmacy Count
		Pharmacy Gross Density (per sq. km.)
	Dollar Store	Dollar Store Count
		Dollar Store Gross Density (per sq. km.)
	Farmers' Market	Farmers' Market Count
		Farmers' Market Gross Density (per sq. km.)
	Healthy Food	Healthy Food Count
		Healthy Food Gross Density (per sq. km.)
Public Transit	Bus Stop	Bus Stop Count
		Bus Stop Gross Density (per sq. km.)
	Rail Station	Rail Station Count
		Rail Station Gross Density (per sq. km.)
	Transit Stop	Transit Stop Count
		Transit Stop Gross Density (per sq. km.)
	Transit Index	Transit Index - Normalized 0-1 range based on weighted stops
	Transit Index	Transit Index - Normalized z-Score range based on weighted stops

Table 42: Regional accessibility locations by destination type for both regions.

Region	*Destination*	*Destination Type*	*Inside Study Area*
Baltimore	Downtown Baltimore/St. Charles Station	Downtown, CBD, Transit Centre	Yes
	Baltimore Inner Harbor	Tourism Centre	Yes
	Johns Hopkins University – Homewood	University	Yes
	University of Maryland – Baltimore	University, Hospital	Yes
	Johns Hopkins University – East Baltimore	University, Hospital	Yes
	BWI Airport	Airport	No
	Towson University	University, Hospital	Yes
	Arundel Mills Mall	Shopping Centre	No
	Security Square Mall	Shopping Centre	Yes
	University of Maryland – Baltimore County	University	Yes
	Snowden Square Shopping Mall	Shopping Centre	Yes
	University of Maryland – College Park	University	Yes
	Downtown Washington D.C./McPherson Square Station	Downtown, CBD, Transit Centre	No
	Union Station	Transit Centre	No
	George Washington University	University	No
	Silver Spring Station	Transit Centre	Yes
	Gaithersburg Mall	Shopping Centre	Yes
	Dulles International Airport	Airport	No
	Downtown Arlington/Rosslyn Station	Downtown, Transit Centre	No
	The Mall In Columbia	Shopping Centre	Yes
	Hunt Valley	Suburban Employment Centre	Yes
	Shady Grove	Suburban Employment Centre	Yes
	Greenbelt	Suburban Employment Centre	Yes
	Rock Spring Park	Suburban Employment Centre	Yes
Seattle	Downtown Seattle/	Downtown, CBD, Transit Centre, Tourist Centre	Yes
	King Street Station	Transit Centre	Yes
	Seattle University	University	Yes
	Seattle Central Community College/Capitol Hill	University, Hospital	Yes
	Seattle Center	Tourist Centre	Yes
	University of Washington – University District	University, Hospital	Yes
	Northgate Mall	Shopping Centre	Yes
	SeaTac International Airport	Airport	Yes
	Southcenter Mall	Shopping Centre	Yes
	Tacoma Dome Station	Downtown, Transit Centre, Tourist Centre	Yes
	Downtown Bellevue/Lincoln Square	Downtown, Transit Centre, Shopping Centre	Yes
	Downtown Everett/Everett Station	Downtown, Transit Centre	No
	Bellevue College – Eastgate	University, Suburban Employment Centre	Yes
	Overlake	Suburban Employment Centre	Yes
	Downtown Kent	Suburban Employment Centre,	Yes

		Transit Centre, University	

Source: Baltimore Metropolitan Council (BMC), 2004; Washington Metropolitan Council of Governments (WMCOG), 2007; Puget Sound Regional Council (PSRC), 2013.

14.2 Statistical Analysis

14.2.1 Dependent Variable Descriptives

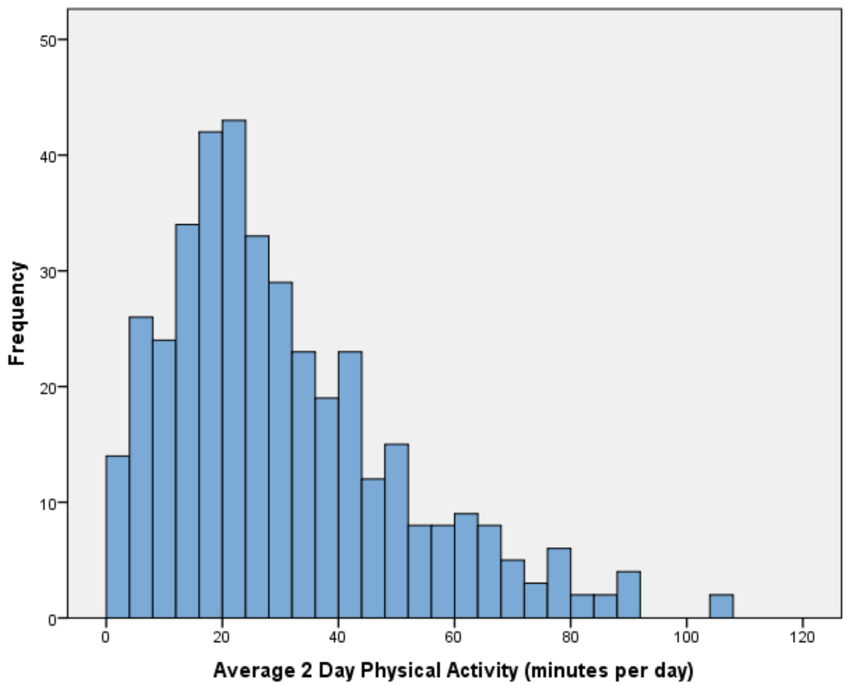

Figure 23: Histogram of mean two day physical activity in minutes per day in the Baltimore region.

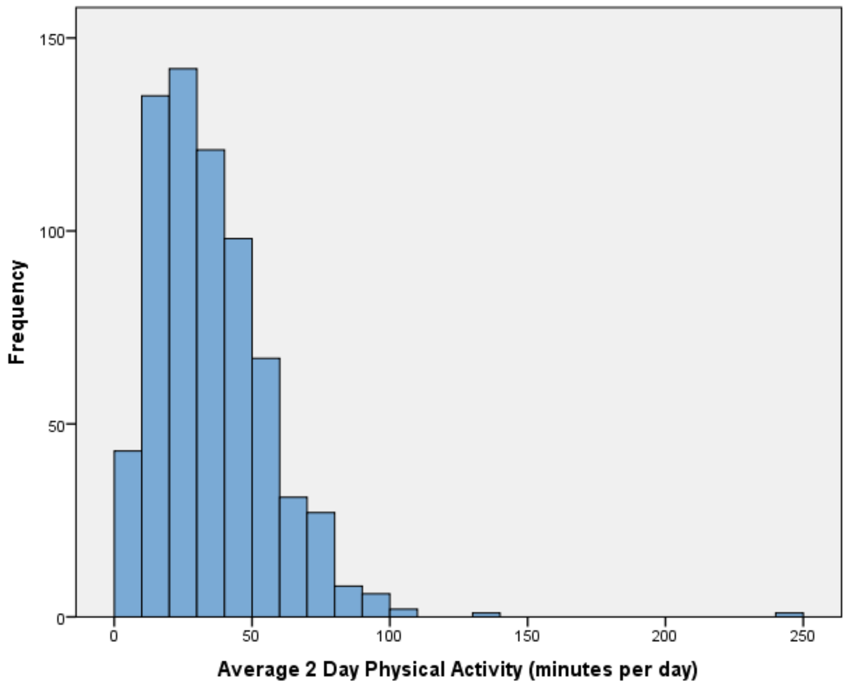

Figure 24: Histogram of mean two day physical activity in minutes per day in the Seattle region.

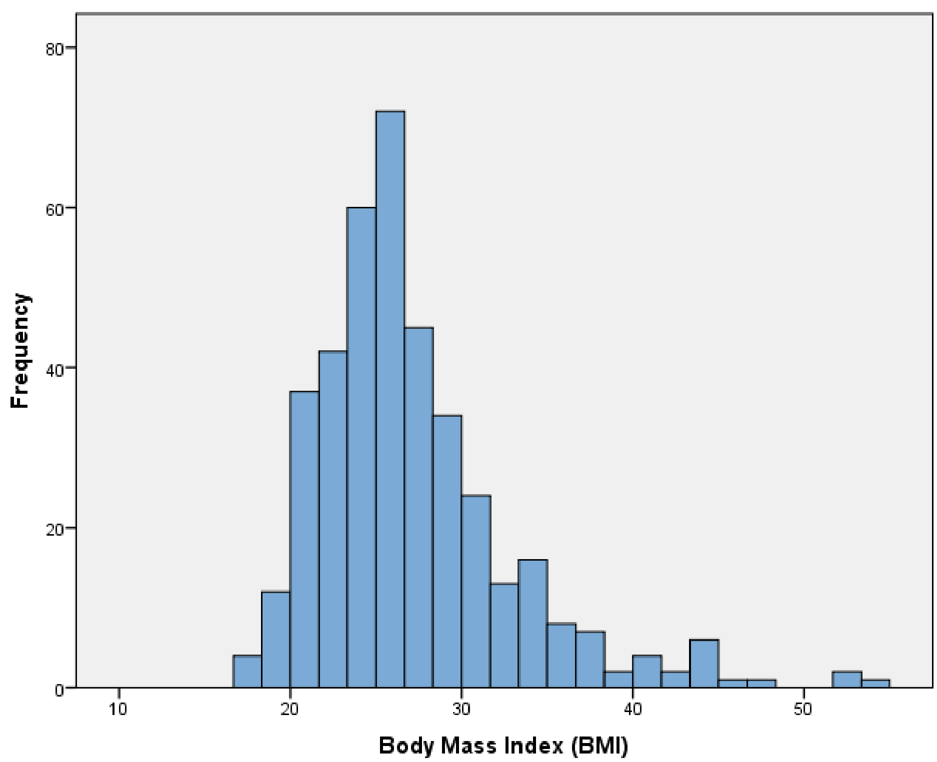

Figure 25: Histogram of participant self-reported BMI in the Baltimore region.

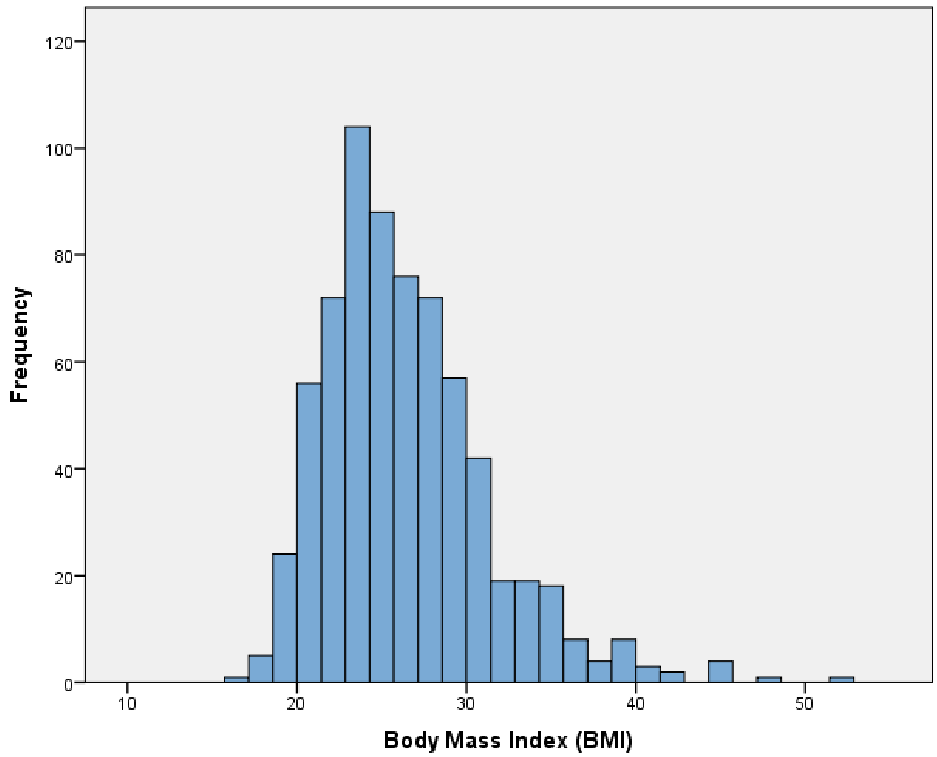

Figure 26: Histogram of participant self-reported BMI in the Seattle region.

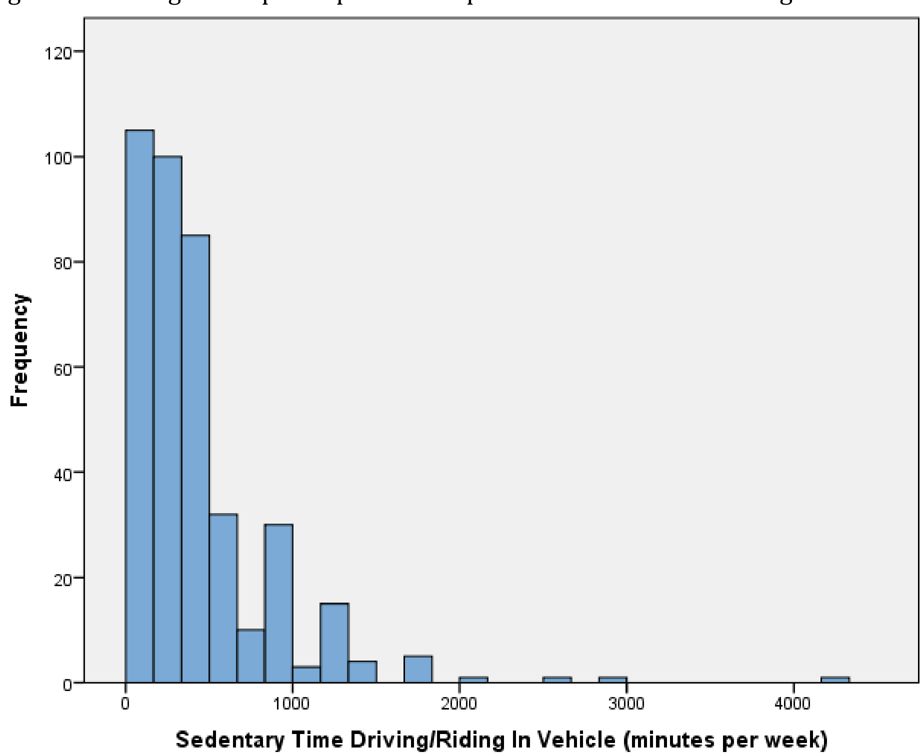

Figure 27: Histogram of sedentary time (weekly minutes) spent driving/riding in vehicles in Baltimore.

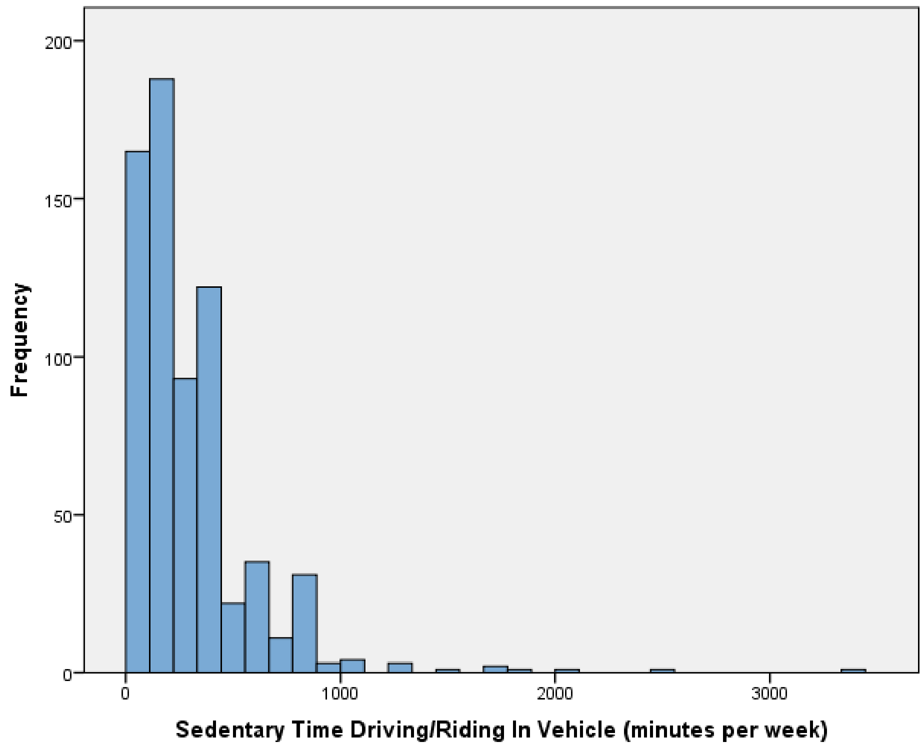

Figure 28: Histogram of sedentary time (weekly minutes) spent driving/riding in vehicles in Seattle.

14.2.2 MLR – BMI

Table 43: MLR BMI model summary statistics for Baltimore.

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Collinearity Tolerance*
Constant (y-intercept)	23.900		.000**	
Age	.114		.000**	.927
Caucasian, non-Hispanic Ethnicity	-3.047		.000**	.843
Children	.736		.259	.813
Household Vehicle	2.213		.434	.326
Annual Household Income	-.074		.542	.670
Valid Driver's License[64]	-2.158		.392	.330
Married/Living with Partner[65]	-.756		.275	.738
Own Household[66]	.666		.418	.916
Walkability Index – Mix 4 – 500 m	.117	×	.482	.424
Regional Accessibility – Average Distance	.002	✓	.805	.584
Convenience Store/Gasoline Station Count – 1 km	.003	✓	.951	.392
Nearest Distance – Fast Food	.001	✓	.198	.699
R-Square	*Adjusted R-Square*		*ANOVA: F-Statistic*	*ANOVA: P-Value*
.123	.093		4.144	.000

[64] Binary valid driver's license variable where 0 = no license and 1 = license.
[65] Binary Married/living with partner variable where 0 = not married/living with partner and 1 = married/living with partner.
[66] Binary household ownership variable where 0 = does not own household and 1 = owns household.

Dependent Variable	Mean		Standard Deviation	N
BMI	27.06		5.76	367

Table 44: MLR BMI model summary statistics for Seattle.

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Collinearity Tolerance*
Constant (y-intercept)	22.951		.000**	
Age	.076		.000**	.852
Caucasian, non-Hispanic Ethnicity	.415		.406	.947
Children	.890		.033*	.857
Household Vehicle	.867		.463	.808
Annual Household Income	-.221		.005**	.639
Valid Driver's License	-1.288		.286	.810
Married/Living with Partner	.158		.747	.652
Own Household	-.566		.293	.682
Walkability Index – Mix 4 – 500 m	.124	✗	.242	.422
Regional Accessibility – Average Distance	.020	✓	.040*	.466
Convenience Store/Gasoline Station Count – 1 km	-.080	✗	.388	.718
Nearest Distance – Fast Food	.000	✓	.721	.661
R-Square	*Adjusted R-Square*		*ANOVA: F-Statistic*	*ANOVA: P-Value*
.060	.042		3.415	.000
Dependent Variable	*Mean*		*Standard Deviation*	*N*
BMI	26.47		4.89	659

Table 45: MLR BMI model summary statistics for both regions (pooled).

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Collinearity Tolerance*
Constant (y-intercept)	23.737		.000**	
Age	.096		.000**	.899
Caucasian, non-Hispanic Ethnicity	-.992		.011*	.928
Children	.948		.008**	.851
Household Vehicle	1.087		.322	.673
Annual Household Income	-.196		.003**	.666
Valid Driver's License	-1.296		.222	.682
Married/Living with Partner	-.155		.699	.693
Own Household	-.147		.742	.784
Walkability Index – Mix 4 – 500 m	.029	✗	.722	.537
Regional Accessibility – Average Distance	.005	✓	.155	.728
Convenience Store/Gasoline Station Count – 1 km	.019	✓	.503	.730
Nearest Distance – Fast Food	.000	✓	.149	.726
R-Square	*Adjusted R-Square*		*ANOVA: F-Statistic*	*ANOVA: P-Value*
.062	.051		5.618	.000
Dependent Variable	*Mean*		*Standard Deviation*	*N*
BMI	26.68		5.23	1026

14.2.3 MLR – Sedentary time in Vehicles

Table 46: MLR Sedentary time in vehicles model summary statistics for Baltimore.

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Collinearity Tolerance*
Constant (y-intercept)	64.270		.782	
Age	2.138	✓	.256	.929
Caucasian, non-Hispanic Ethnicity	-258.474	✓	.000**	.835
Children	17.373	✓	.679	.869
Household Vehicle	444.347	✓	.000**	.871
Annual Household Income	-7.496	✓	.322	.769
Retail FAR – 15 min.	-4.815	✓	.963	.468
Land Use Mix 6 – 15 min.	22.842	×	.846	.785
Home-Work Trip - Distance	.008	✓	.000**	.913
Regional Accessibility – Distance	-.002	×	.610	.838
Convenience Store/Gasoline Station Count – 1 km	.940	✓	.743	.490
R-Square	*Adjusted R-Square*		*ANOVA: F-Statistic*	*ANOVA: P-Value*
.173	.150		7.439	.000
Dependent Variable	*Mean*		*Standard Deviation*	*N*
Sedentary time in vehicles	411.29		396.25	366

Table 47: MLR Sedentary time in vehicles model summary statistics for Seattle.

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Collinearity Tolerance*
Constant (y-intercept)	-32.497		.777	
Age	2.728	✓	.017*	.954
Caucasian, non-Hispanic Ethnicity	-16.651	✓	.579	.956
Children	17.427	✓	.470	.936
Household Vehicle	206.392	✓	.002**	.913
Annual Household Income	-5.118	✓	.207	.875
Retail FAR – 15 min.	-158.684	✓	.027*	.534
Land Use Mix 6 – 15 min.	30.547	×	.681	.855
Home-Work Trip - Distance	.005	✓	.000**	.952
Regional Accessibility – Distance	.002	✓	.363	.593
Convenience Store/Gasoline Station Count – 1 km	-6.973	✓	.196	.779
R-Square	*Adjusted R-Square*		*ANOVA: F-Statistic*	*ANOVA: P-Value*
.094	.080		6.734	.000
Dependent Variable	*Mean*		*Standard Deviation*	*N*
Sedentary time in vehicles	303.49		301.76	659

Table 48: MLR Sedentary time in vehicles model summary statistics for both regions (pooled).

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Collinearity Tolerance*
Constant (y-intercept)	-59.438		.527	
Age	2.683	✓	.008**	.950
Caucasian, non-Hispanic Ethnicity	-126.228	✓	.000**	.934
Children	23.498	✓	.277	.921
Household Vehicle	269.570	✓	.000**	.906
Annual Household Income	-6.524	✓	.079	.852
Retail FAR – 15 min.	-117.314	✓	.038*	.569

Land Use Mix 6 – 15 min.	7.624	×	.903	.865
Home-Work Trip - Distance	.006	✓	.000**	.947
Regional Accessibility – Distance	.003	✓	.006**	.736
Convenience Store/Gasoline Station Count – 1 km	3.591	✓	.067	.609
R-Square	*Adjusted R-Square*		*ANOVA: F-Statistic*	*ANOVA: P-Value*
.120	.112		13.860	.000
Dependent Variable	*Mean*		*Standard Deviation*	*N*
Sedentary time in vehicles	341.99		342.27	1025

14.2.4 BLR – MVPA

Table 49: BLR MVPA model summary statistics for Baltimore.

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Exp (B)*
Constant (y-intercept)	.917		.504	2.503
Age	-.048	✓	.000**	.953
Gender	-1.057	✓	.000**	.347
Caucasian, non-Hispanic Ethnicity	.948	✓	.001**	2.581
Children	-.126	✓	.628	.882
Household Vehicle	.681	✓	.418	1.976
Annual Household Income	.082	✓	.081	1.085
Walkability Index – Mix 4 – 15 min.	.139	✓	.016*	1.149
Home-Work Trip - Transit Travel Time	-.001	✓	.540	.999
Cul-de-sac Density – 1 km	.025	×	.078	1.026
Regional Accessibility – Average Distance	.000	✓	.535	1.000
Healthy Food Count – 500 m	-.008	×	.652	.992
Cox & Snell R-Square	*Nagelkerke R-Square*	*Hosmer & Lemeshow Test: Chi-square*		*Hosmer & Lemeshow Test: P-Value*
.178	.239	10.249		.248
Dependent Variable	*Initial % Correct*	*Model % Correct*		*% Change*
MVPA	57.5	69.2		11.7

Table 50: BLR MVPA model summary statistics for Seattle.

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Exp (B)*
Constant (y-intercept)	3.196		.000**	24.428
Age	-.040	✓	.000**	.960
Gender	-.702	✓	.000**	.495
Caucasian, non-Hispanic Ethnicity	.660	✓	.003**	1.934
Children	-.137	✓	.439	.872
Household Vehicle	-.959	✓	.076	.383
Annual Household Income	.025	✓	.418	1.025
Walkability Index – Mix 4 – 15 min.	-.110	×	.019*	.896
Home-Work Trip - Transit Travel Time	-.007	✓	.007**	.993
Cul-de-sac Density – 1 km	-.019	✓	.027*	.981
Regional Accessibility – Average Distance	.000	✓	.444	1.000
Healthy Food Count – 500 m	.064	✓	.006**	1.066
Cox & Snell R-Square	*Nagelkerke R-Square*	*Hosmer & Lemeshow Test: Chi-square*		*Hosmer & Lemeshow Test: P-Value*
.100	.133	7.208		.514

Dependent Variable	*Initial % Correct*	*Model % Correct*	*% Change*
MVPA	53.2	63.2	10.0

Table 51: BLR MVPA model summary statistics for both regions (pooled).

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Exp (B)*
Constant (y-intercept)	2.134		.000**	8.452
Age	-.041	✓	.000**	.960
Gender	-.793	✓	.000**	.452
Caucasian, non-Hispanic Ethnicity	.816	✓	.000**	2.262
Children	-.147	✓	.306	.864
Household Vehicle	-.389	✓	.330	.677
Annual Household Income	.041	✓	.103	1.042
Walkability Index – Mix 4 – 15 min.	.004	✓	.906	1.004
Home-Work Trip - Transit Travel Time	-.003	✓	.066	.997
Cul-de-sac Density – 1 km	-.006	✓	.421	.994
Regional Accessibility – Average Distance	.000	✓	.152	1.000
Healthy Food Count – 500 m	.021	✓	.123	1.021
Cox & Snell R-Square	*Nagelkerke R-Square*	*Hosmer & Lemeshow Test: Chi-square*		*Hosmer & Lemeshow Test: P-Value*
.112	.149	5.332		.722
Dependent Variable	*Initial % Correct*	*Model % Correct*		*% Change*
MVPA	50.6	64.6		14.0

14.2.5 BLR – BMI

Table 52: BLR BMI model summary statistics for Baltimore.

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Exp (B)*
Constant (y-intercept)	-.813		.467	.502
Age	.036		.001**	1.037
Caucasian, non-Hispanic Ethnicity	-.391		.127	.676
Children	.225		.364	1.253
Household Vehicle	-.156		.889	.856
Annual Household Income	-.014		.762	.986
Valid Driver's License	-.368		.708	.692
Married/Living with Partner	-.108		.686	.898
Own Household	.259		.419	1.296
Walkability Index – Mix 4 – 500 m	.047	×	.471	1.048
Regional Accessibility – Average Distance	.001	✓	.818	1.001
Convenience Store/Gasoline Station Count – 1 km	.012	✓	.512	1.012
Nearest Distance – Fast Food	.000	✓	.552	1.000
Cox & Snell R-Square	*Nagelkerke R-Square*	*Hosmer & Lemeshow Test: Chi-square*		*Hosmer & Lemeshow Test: P-Value*
.053	.071	7.611		.472
Dependent Variable	*Initial % Correct*	*Model % Correct*		*% Change*
BMI	58.9	62.7		3.8

Table 53: BLR BMI model summary statistics for Seattle.

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Exp (B)*
Constant (y-intercept)	-1.035		.223	.355
Age	.029		.001**	1.030
Caucasian, non-Hispanic Ethnicity	.065		.761	1.067
Children	.217		.229	1.242
Household Vehicle	.580		.280	1.786
Annual Household Income	-.029		.397	.972
Valid Driver's License	-1.322		.027*	.267
Married/Living with Partner	.251		.231	1.286
Own Household	-.267		.248	.765
Walkability Index – Mix 4 – 500 m	.082	✗	.076	1.086
Regional Accessibility – Average Distance	.009	✓	.033*	1.009
Convenience Store/Gasoline Station Count – 1 km	-.034	✗	.391	.966
Nearest Distance – Fast Food	.000	✓	.982	1.000
Cox & Snell R-Square	*Nagelkerke R-Square*	*Hosmer & Lemeshow Test: Chi-square*		*Hosmer & Lemeshow Test: P-Value*
.052	.070	7.140		.522
Dependent Variable	*Initial % Correct*	*Model % Correct*		*% Change*
BMI	56.0	62.7		6.7

Table 54: BLR BMI model summary statistics for both regions (pooled).

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Exp (B)*
Constant (y-intercept)	-.813		.166	.444
Age	.034	✓	.000**	1.034
Caucasian, non-Hispanic Ethnicity	-.096	✓	.544	.908
Children	.244	✓	.090	1.277
Household Vehicle	.538	✓	.250	1.713
Annual Household Income	-.028	✓	.291	.972
Valid Driver's License	-1.047	✓	.030	.351
Married/Living with Partner	.131	✓	.419	1.140
Own Household	-.102	✓	.573	.903
Walkability Index – Mix 4 – 500 m	.029	✗	.379	1.029
Regional Accessibility – Average Distance	.001	✓	.429	1.001
Convenience Store/Gasoline Station Count – 1 km	.011	✗	.366	1.011
Nearest Distance – Fast Food	.000	✓	.410	1.000
Cox & Snell R-Square	*Nagelkerke R-Square*	*Hosmer & Lemeshow Test: Chi-square*		*Hosmer & Lemeshow Test: P-Value*
.040	.054	10.304		.244
Dependent Variable	*Initial % Correct*	*Model % Correct*		*% Change*
BMI	57.0	61.7		4.7

14.2.6 BLR – Sedentary Time in Vehicles

Table 55: BLR Sedentary time in vehicles model summary statistics for Baltimore.

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Exp (B)*
Constant (y-intercept)	-.753		.601	.471
Age	.007	✓	.524	1.007
Caucasian, non-Hispanic Ethnicity	-.714	✓	.008**	.489

Children	.449	✓	.071	1.566
Household Vehicle	2.119	✓	.012*	8.319
Annual Household Income	-.021	✓	.632	.979
Retail FAR – 15 min.	-.750	✓	.216	.472
Land Use Mix 6 – 15 min.	.047	✗	.945	1.048
Home-Work Trip - Distance	.000	✓	.000**	1.000
Regional Accessibility – Average Distance	.000	✓	.148	1.000
Convenience Store/Gasoline Station Count – 1 km	.021	✓	.207	1.022
Cox & Snell R-Square	*Nagelkerke R-Square*	*Hosmer & Lemeshow Test: Chi-square*		*Hosmer & Lemeshow Test: P-Value*
.118	.159	11.203		.190
Dependent Variable	*Initial % Correct*	*Model % Correct*		*% Change*
Sedentary time in vehicles	58.2	66.4		8.2

Table 56: BLR Sedentary time in vehicles model summary statistics for Seattle.

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Exp (B)*
Constant (y-intercept)	-22.741		.998	.000
Age	.012	✓	.138	1.012
Caucasian, non-Hispanic Ethnicity	-.147	✓	.507	.864
Children	-.184	✓	.296	.832
Household Vehicle	20.965	✓	.998	1273557151.110
Annual Household Income	-.033	✓	.261	.967
Retail FAR – 15 min.	-.347	✓	.520	.707
Land Use Mix 6 – 15 min.	.682	✗	.206	1.979
Home-Work Trip - Distance	.000	✓	.000**	1.000
Regional Accessibility – Average Distance	.000	✓	.016*	1.000
Convenience Store/Gasoline Station Count – 1 km	-.080	✓	.047	.923
Cox & Snell R-Square	*Nagelkerke R-Square*	*Hosmer & Lemeshow Test: Chi-square*		*Hosmer & Lemeshow Test: P-Value*
.121	.161	9.384		.311
Dependent Variable	*Initial % Correct*	*Model % Correct*		*% Change*
Sedentary time in vehicles	51.6	64.8		13.2

Table 57: BLR Sedentary time in vehicles model summary statistics for both regions (pooled).

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Exp (B)*
Constant (y-intercept)	-3.616		.000**	.027
Age	.011	✓	.108	1.011
Caucasian, non-Hispanic Ethnicity	-.394	✓	.016*	.675
Children	.080	✓	.568	1.084
Household Vehicle	2.759	✓	.000**	15.791
Annual Household Income	-.029	✓	.224	.971
Retail FAR – 15 min.	-.903	✓	.015*	.405
Land Use Mix 6 – 15 min.	.308	✗	.451	1.361
Home-Work Trip - Distance	.000	✓	.000**	1.000
Regional Accessibility – Average Distance	.000	✓	.042*	1.000
Convenience Store/Gasoline Station Count – 1 km	.021	✓	.096	1.022
Cox & Snell R-Square	*Nagelkerke R-Square*	*Hosmer & Lemeshow Test: Chi-square*		*Hosmer & Lemeshow Test: P-Value*
.104	.139	7.803		.453

Dependent Variable	*Initial % Correct*	*Model % Correct*	*% Change*
Sedentary time in vehicles	51.9	63.2	11.3

14.2.7 MLR – MVPA – Controlled

Table 58: MLR MVPA model controlling for home environment summary for Baltimore.

Model Independent Variables		*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Collinearity Tolerance*
Constant (y-intercept)		54.285		.000**	
Age		-.390		.000**	.902
Gender		-10.276		.000**	.932
Caucasian, non-Hispanic Ethnicity		10.568		.000**	.809
Children		-.404		.855	.830
Household Vehicle		.353		.868	.908
Annual Household Income		.485		.211	.780
Home – Walk Index Mix 4 – 1 km		.649	✓	.081	.743
Work - Walk Index – Mix 4 – 15 min.		.220	✓	.614	.675
Home-Work Trip - Transit Travel Time		-.013	✓	.463	.752
Cul-de-sac Density – 1 km		.155	✗	.207	.961
Regional Accessibility – Average Distance		.000	✓	.146	.866
Healthy Food Count – 500 m		-.046	✗	.769	.733
B	*R-Square*	*Adjusted R-Square*	*R-Square Change*	*F-Change*	*F Change P-Value*
1	.182	.168	.182	13.103	.000**
2	.193	.177	.011	4.923	.027*
3	.204	.177	.011	.999	.418
Dependent Variable		*Mean*		*Standard Deviation*	*N*
MVPA		30.78		20.65	385

Table 59: MLR MVPA model controlling for home environment summary for Seattle.

Model Independent Variables		*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Collinearity Tolerance*
Constant (y-intercept)		57.278		.000**	
Age		-.290		.001**	.910
Gender		-7.240		.000**	.906
Caucasian, non-Hispanic Ethnicity		3.359		.125	.940
Children		-1.263		.481	.896
Household Vehicle		-4.763		.010*	.869
Annual Household Income		.290		.337	.834
Home – Walk Index Mix 4 – 1 km		.716	✓	.024*	.673
Work - Walk Index – Mix 4 – 15 min.		-.581	✗	.212	.323
Home-Work Trip - Transit Travel Time		-.055	✓	.056	.745
Cul-de-sac Density – 1 km		-.159	✓	.071	.820
Regional Accessibility – Average Distance		-5.90E-05	✓	.728	.560
Healthy Food Count – 500 m		.260	✓	.224	.463

B	R-Square	Adjusted R-Square	R-Square Change	F-Change	F Change P-Value
1	.072	.063	.072	8.109	.000**
2	.089	.079	.018	12.342	.000**
3	.102	.085	.012	1.722	.127
Dependent Variable		Mean		Standard Deviation	N
MVPA		35.28		21.69	662

Table 60: MLR MVPA model controlling for home environment summary for both regions.

Model Independent Variables	Unstandardized Coefficients	Expected Direction	P-Value	Collinearity Tolerance
Constant (y-intercept)	51.691		.000**	
Age	-.324		.000**	.913
Caucasian, non-Hispanic Ethnicity	-8.242		.000**	.920
Children	6.667		.000**	.923
Household Vehicle	-1.161		.406	.881
Annual Household Income	-2.629		.060	.898
Home – Walk Index – Mix 4 – 1 km	.396	✓	.093	.841
Retail FAR – 15 min.	.784	✓	.001**	.709
Land Use Mix 6 – 15 min.	-.040	×	.891	.528
Regional Accessibility – Transit Travel Time	-.019	✓	.205	.754
Home-Work Trip – Transit Travel Time	-.050	✓	.474	.897
Convenience Store/Gasoline Station Count – 1 km	.000	✓	.144	.833

B	R-Square	Adjusted R-Square	R-Square Change	F-Change	F Change P-Value
1	.101	.096	.101	18.665	.000**
2	.119	.113	.018	20.068	.000**
3	.125	.114	.006	1.250	.284
Dependent Variable		Mean		Standard Deviation	N
MVPA		33.62		21.41	1047

14.2.8 MLR – BMI– Controlled

Table 61: MLR BMI model controlling for home environment summary for Baltimore.

Model Independent Variables	Unstandardized Coefficients	Expected Direction	P-Value	Collinearity Tolerance
Constant (y-intercept)	24.502		.000**	
Age	.109		.000**	.904
Caucasian, non-Hispanic Ethnicity	-2.936		.000**	.825
Children	.609		.357	.788
Household Vehicle	2.172		.442	.326
Annual Household Income	-.079		.516	.669
Valid Driver's License	-2.341		.354	.329
Married/Living with Partner	-.834		.231	.730
Own Household	.700		.395	.915
Home – Walk Index – Mix 4 – 1 km	-.112	✓	.266	.831

Work Walk Index – Mix 4 – 500 m		.125	✗	.454	.423
Regional Accessibility – Average Distance		.001	✓	.924	.573
Convenience Store/Gasoline Station Count – 1 km		.004	✗	.928	.392
Nearest Distance – Fast Food		.001	✓	.213	.698
B	*R-Square*	*Adjusted R-Square*	*R-Square Change*	*F-Change*	*F Change P-Value*
1	.117	.098	.117	5.958	.000**
2	.121	.099	.003	1.401	.237
3	.126	.094	.005	.535	.710
Dependent Variable		*Mean*		*Standard Deviation*	*N*
BMI		27.06		5.76	367

Table 62: MLR BMI model controlling for home environment summary for Seattle.

Model Independent Variables		*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Collinearity Tolerance*
Constant (y-intercept)		23.609		.000**	
Age		.070		.001**	.828
Caucasian, non-Hispanic Ethnicity		.436		.381	.946
Children		.767		.070	.832
Household Vehicle		.503		.675	.782
Annual Household Income		-.226		.004**	.638
Valid Driver's License		-1.155		.340	.807
Married/Living with Partner		.150		.758	.652
Own Household		-.422		.438	.665
Home – Walk Index – Mix 4 – 1 km		-.115	✓	.090	.770
Work Walk Index – Mix 4 – 500 m		.138	✗	.192	.419
Regional Accessibility – Average Distance		.019	✓	.060	.461
Convenience Store/Gasoline Station Count – 1 km		-.075	✗	.421	.717
Nearest Distance – Fast Food		.000	✓	.663	.659
B	*R-Square*	*Adjusted R-Square*	*R-Square Change*	*F-Change*	*F Change P-Value*
1	.050	.038	.050	4.236	.000**
2	.056	.043	.006	4.220	.040*
3	.064	.045	.008	1.405	.231
Dependent Variable		*Mean*		*Standard Deviation*	*N*
BMI		26.47		4.89	659

Table 63: MLR BMI model controlling for home environment summary for both regions.

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Collinearity Tolerance*
Constant (y-intercept)	24.492		.000**	
Age	.090		.000**	.872
Caucasian, non-Hispanic Ethnicity	-.924		.018*	.922
Children	.798		.027*	.824
Household Vehicle	.721		.514	.660

Annual Household Income	-.201		.002**	.665
Valid Driver's License	-1.222		.248	.681
Married/Living with Partner	-.199		.619	.692
Own Household	-.025		.956	.773
Home – Walk Index – Mix 4 – 1 km	-.132	✓	.019*	.790
Work Walk Index – Mix 4 – 500 m	.046	✗	.572	.533
Regional Accessibility – Average Distance	.004	✓	.297	.711
Convenience Store/Gasoline Station Count – 1 km	.020	✓	.471	.729
Nearest Distance – Fast Food	.000	✓	.141	.725

B	*R-Square*	*Adjusted R-Square*	*R-Square Change*	*F-Change*	*F Change P-Value*
1	.057	.049	.057	7.621	.000
2	.063	.055	.007	7.106	.008
3	.067	.055	.004	1.179	.319

Dependent Variable	*Mean*		*Standard Deviation*	*N*
BMI	26.68		5.23	1026

14.2.9 MLR – Sedentary Time in Vehicles– Controlled

Table 64: MLR Sedentary time in vehicles model controlling for home environment summary for Baltimore.

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Collinearity Tolerance*
Constant (y-intercept)	309.264		.130	
Age	2.381		.211	.909
Caucasian, non-Hispanic Ethnicity	-234.664		.000**	.814
Children	21.572		.613	.840
Household Vehicle	121.650		.003**	.906
Annual Household Income	-6.598		.378	.784
Home – Walk Index – Mix 4 – 1 km	-7.210		.300	.794
Retail FAR – 15 min.	18.766	✗	.855	.478
Land Use Mix 6 – 15 min.	-11.754	✓	.920	.798
Home-Work Trip - Distance	.007	✓	.000**	.853
Regional Accessibility – Distance	-.001	✗	.785	.847
Convenience Store/Gasoline Station Count – 1 km	1.230	✓	.671	.494

B	*R-Square*	*Adjusted R-Square*	*R-Square Change*	*F-Change*	*F Change P-Value*
1	.123	.110	.123	9.937	.000**
2	.132	.117	.009	3.762	.053
3	.171	.145	.039	3.285	.007**

Dependent Variable	*Mean*		*Standard Deviation*	*N*
Sedentary time in vehicles	413.51		392.63	384

Table 65: MLR Sedentary time in vehicles model controlling for home environment summary for Seattle.

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Collinearity Tolerance*
Constant (y-intercept)	122.817		.224	

Age	1.297		.263	.916
Caucasian, non-Hispanic Ethnicity	-24.629		.406	.951
Children	9.125		.708	.898
Household Vehicle	49.172		.050*	.870
Annual Household Income	-4.048		.308	.893
Home – Walk Index – Mix 4 – 1 km	-7.590		.065	.747
Retail FAR – 15 min.	-93.911	×	.190	.526
Land Use Mix 6 – 15 min.	51.014	✓	.492	.862
Home-Work Trip - Distance	.005	✓	.000**	.884
Regional Accessibility – Distance	.002	×	.269	.590
Convenience Store/Gasoline Station Count – 1 km	-5.769	✓	.280	.780

B	*R-Square*	*Adjusted R-Square*	*R-Square Change*	*F-Change*	*F Change P-Value*
1	.030	.022	.030	3.868	.002**
2	.051	.042	.021	14.041	.000**
3	.099	.083	.048	6.638	.000**

Dependent Variable	*Mean*		*Standard Deviation*	*N*
Sedentary time in vehicles	297.54		295.05	664

Table 66: MLR Sedentary time in vehicles model controlling for home environment for both regions.

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Collinearity Tolerance*
Constant (y-intercept)	131.478		.098	
Age	1.705		.094	.916
Caucasian, non-Hispanic Ethnicity	-124.482		.000**	.921
Children	15.964		.466	.885
Household Vehicle	75.060		.001**	.896
Annual Household Income	-6.179		.089	.875
Home – Walk Index – Mix 4 – 1 km	-8.656		.018*	.759
Retail FAR – 15 min.	-54.566	×	.331	.569
Land Use Mix 6 – 15 min.	11.245	✓	.857	.871
Home-Work Trip - Distance	.006	✓	.000**	.881
Regional Accessibility – Distance	.004	✓	.003**	.738
Convenience Store/Gasoline Station Count – 1 km	3.282	✓	.091	.613

B	*R-Square*	*Adjusted R-Square*	*R-Square Change*	*F-Change*	*F Change P-Value*
1	.060	.055	.060	12.624	.000**
2	.080	.075	.021	22.183	.000**
3	.134	.125	.054	12.308	.000**

Dependent Variable	*Mean*		*Standard Deviation*	*N*
Sedentary time in vehicles	340.03		338.59	1048

14.2.10 BLR – MVPA– Controlled

Table 67: Summary of the BLR MVPA controlling for home environment model in Baltimore.

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Exp (B)*
Constant (y-intercept)	.636		.657	1.888
Age	-.044		.000**	.957
Gender	-1.076		.000**	.341
Caucasian, non-Hispanic Ethnicity	.940		.001**	2.560
Children	-.016		.951	.984
Household Vehicle	.925		.280	2.523
Annual Household Income	.081		.091	1.084
Home – Walk Index – Mix 4 – 1 km	.107	✓	.017*	1.113
Work – Walkability Index – Mix 4 – 15 min.	.138	✓	.020*	1.148
Home-Work Trip - Transit Travel Time	.000	✓	.833	1.000
Cul-de-sac Density – 1 km	.026	✗	.075	1.027
Regional Accessibility – Average Distance	.000	✓	.403	1.000
Healthy Food Count – 500 m	-.014	✓	.479	.986

B	*Cox & Snell R-Square*	*Nagelkerke R-Square*	*Hosmer & Lemeshow Test: Chi-square*	*Hosmer & Lemeshow Test: P-Value*
1	.152	.205	6.284	.615
2	.171	.230	6.774	.561
3	.196	.263	11.821	.159

	Dependent Variable	*Demographics % Correct*	*Worksite % Correct*	*% Change*
	MVPA	66.9	67.8	0.9

Table 68: Summary of the BLR MVPA controlling for home environment model for Seattle.

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Exp (B)*
Constant (y-intercept)	2.658		.001**	14.266
Age	-.035		.000**	.966
Gender	-.724		.000**	.485
Caucasian, non-Hispanic Ethnicity	.647		.004**	1.909
Children	-.072		.697	.931
Household Vehicle	-.754		.184	.471
Annual Household Income	.034		.281	1.035
Home – Walk Index – Mix 4 – 1 km	.089	✓	.012*	1.093
Work – Walkability Index – Mix 4 – 15 min.	-.123	✗	.010*	.884
Home-Work Trip - Transit Travel Time	-.006	✓	.056	.994
Cul-de-sac Density – 1 km	-.015	✓	.093	.985
Regional Accessibility – Average Distance	.000	✓	.351	1.000
Healthy Food Count – 500 m	.061	✓	.009	1.063

B	*Cox & Snell R-Square*	*Nagelkerke R-Square*	*Hosmer & Lemeshow Test: Chi-square*	*Hosmer & Lemeshow Test: P-Value*
1	.071	.094	8.953	.346
2	.092	.123	4.081	.850

3	.113	.151	4.335	.826
	Dependent Variable	*Demographics % Correct*	*Worksite % Correct*	*% Change*
	MVPA	61.0	64.4	3.4

Table 69: Summary of the BLR MVPA controlling for home environment model for both regions.

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Exp (B)*
Constant (y-intercept)	1.458		.012*	4.297
Age	-.036		.000**	.965
Gender	-.788		.000**	.455
Caucasian, non-Hispanic Ethnicity	.774		.000**	2.169
Children	-.046		.756	.956
Household Vehicle	-.177		.674	.838
Annual Household Income	.048		.058	1.049
Home – Walk Index – Mix 4 – 1 km	.103	✓	.000**	1.108
Work – Walkability Index – Mix 4 – 15 min.	-.006	×	.850	.994
Home-Work Trip - Transit Travel Time	-.001	✓	.747	.999
Cul-de-sac Density – 1 km	-.003	✓	.649	.997
Regional Accessibility – Average Distance	.000	✓	.181	1.000
Healthy Food Count – 500 m	.020	✓	.150	1.021
B	*Cox & Snell R-Square*	*Nagelkerke R-Square*	*Hosmer & Lemeshow Test: Chi-square*	*Hosmer & Lemeshow Test: P-Value*
1	.097	.130	7.537	.480
2	.120	.159	7.320	.502
3	.125	.167	7.554	.478
	Dependent Variable	*Demographics % Correct*	*Worksite % Correct*	*% Change*
	MVPA	62.0	64.6	2.6

14.2.11 BLR – BMI– Controlled

Table 70: Summary of the BLR BMI controlling for home environment model in Baltimore.

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Exp (B)*
Constant (y-intercept)	-.252		.797	.777
Age	.033		.003**	1.034
Caucasian, non-Hispanic Ethnicity	-.316		.236	.729
Children	.072		.780	1.074
Household Vehicle	-.240		.831	.786
Annual Household Income	-.007		.878	.993
Valid Driver's License	-.543		.582	.581
Married/Living with Partner	-.177		.518	.838
Own Household	.238		.469	1.269
Home – Walk Index – Mix 4 – 1 km	-.096	✓	.014*	.908
Work – Walkability Index – Mix 4 – 500 m	.053	×	.425	1.054
Regional Accessibility – Transit Travel Time	.000	✓	.977	1.000
Convenience Store/Gasoline Station Count – 1 km	.014	✓	.455	1.014
Nearest Distance – Fast Food	.000	✓	.508	1.000

B	*Cox & Snell R-Square*	*Nagelkerke R-Square*	*Hosmer & Lemeshow Test: Chi-square*	*Hosmer & Lemeshow Test: P-Value*
1	045	.061	3.602	.891
2	.058	.079	3.896	.866
3	.069	.093	5.595	.693
	Dependent Variable	*Demographics % Correct*	*Worksite % Correct*	*% Change*
	BMI	61.9	62.8	0.9

Table 71: Summary of the BLR BMI controlling for home environment model in Seattle.

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Exp (B)*
Constant (y-intercept)	-.530		.556	.589
Age	.025		.006**	1.025
Caucasian, non-Hispanic Ethnicity	.054		.803	1.055
Children	.171		.357	1.186
Household Vehicle	.572		.308	1.772
Annual Household Income	-.033		.340	.968
Valid Driver's License	-1.509		.021*	.221
Married/Living with Partner	.264		.213	1.302
Own Household	-.230		.328	.794
Home – Walk Index – Mix 4 – 1 km	-.027	✓	.354	.973
Work – Walkability Index – Mix 4 – 500 m	.085	×	.071	1.089
Regional Accessibility – Transit Travel Time	.008	✓	.062	1.008
Convenience Store/Gasoline Station Count – 1 km	-.034	✓	.406	.967
Nearest Distance – Fast Food	.000	✓	.856	1.000

B	*Cox & Snell R-Square*	*Nagelkerke R-Square*	*Hosmer & Lemeshow Test: Chi-square*	*Hosmer & Lemeshow Test: P-Value*
1	.042	.056	2.366	.968
2	.043	.058	8.925	.349
3	.050	.067	7.733	.460
	Dependent Variable	*Demographics % Correct*	*Worksite % Correct*	*% Change*
	BMI	59.6	59.5	-0.1

Table 72: Summary of the BLR BMI controlling for home environment model in both regions.

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Exp (B)*
Constant (y-intercept)	-.346		.575	.707
Age	-.076		.000**	1.029
Caucasian, non-Hispanic Ethnicity	.157		.639	.927
Children	.450		.291	1.170
Household Vehicle	-.029		.359	1.569
Annual Household Income	-1.178		.284	.971
Valid Driver's License	.114		.021*	.308
Married/Living with Partner	-.059		.489	1.121
Own Household	-.057		.748	.942
Home – Walk Index – Mix 4 – 1 km	.041	✓	.014*	.945
Work – Walkability Index – Mix 4 – 500 m	.001	×	.218	1.042
Regional Accessibility – Transit Travel Time	.011	✓	.523	1.001
Convenience Store/Gasoline Station Count – 1 km	.000	✓	.373	1.011
Nearest Distance – Fast Food	.029	✓	.489	1.000

B	Cox & Snell R-Square	Nagelkerke R-Square	Hosmer & Lemeshow Test: Chi-square	Hosmer & Lemeshow Test: P-Value
1	.037	.049	6.406	.602
2	.042	.056	6.702	.569
3	.046	.062	16.972	.030
	Dependent Variable	*Demographics % Correct*	*Worksite % Correct*	*% Change*
	BMI	61.1	60.9	-0.2

14.2.12 BLR – Sedentary Time in Vehicles– Controlled

Table 73: Summary of the BLR sedentary time in vehicles controlling for home environment in Baltimore.

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Exp (B)*
Constant (y-intercept)	-.896		.540	.408
Age	.008		.500	1.008
Caucasian, non-Hispanic Ethnicity	-.721		.010*	.486
Children	.423		.098	1.526
Household Vehicle	2.153		.011*	8.609
Annual Household Income	-.024		.587	.976
Home – Walk Index – Mix 4 – 1 km	-.013	✓	.744	.987
Work – Retail FAR – 15 min.	-.695	✓	.253	.499
Land Use Mix 6 – 15 min.	.115	×	.870	1.121
Home-Work Trip - Distance	.000	✓	.001**	1.000
Regional Accessibility – Average Distance	.000	✓	.191	1.000
Convenience Store/Gasoline Station Count – 1 km	.021	✓	.218	1.021

B	Cox & Snell R-Square	Nagelkerke R-Square	Hosmer & Lemeshow Test: Chi-square	Hosmer & Lemeshow Test: P-Value
1	.067	.091	14.670	.066
2	.073	.098	1.090	.998
3	.116	.156	10.955	.204
	Dependent Variable	*Demographics % Correct*	*Worksite % Correct*	*% Change*
	Sedentary time in vehicles	62.7	66.3	3.6

Table 74: Summary of the BLR sedentary time in vehicles controlling for home environment in Seattle.

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Exp (B)*
Constant (y-intercept)	-22.163		.998	.000
Age	.005		.538	1.005
Caucasian, non-Hispanic Ethnicity	-.197		.382	.821
Children	-.365		.048*	.694
Household Vehicle	20.738		.998	1014550945.826
Annual Household Income	-.038		.209	.963
Home – Walk Index – Mix 4 – 1 km	-.121	✓	.000**	.886
Work – Retail FAR – 15 min.	.021	×	.970	1.021
Land Use Mix 6 – 15 min.	.698	×	.208	2.009
Home-Work Trip - Distance	.000	✓	.000**	1.000
Regional Accessibility – Average Distance	.000	✓	.015*	1.000
Convenience Store/Gasoline Station Count – 1 km	-.079	✓	.058	.924

B	Cox & Snell R-Square	Nagelkerke R-Square	Hosmer & Lemeshow Test: Chi-square	Hosmer & Lemeshow Test: P-Value
1	.048	.064	3.570	.894
2	.094	.125	4.087	.849
3	.143	.191	6.890	.549
	Dependent Variable	*Demographics % Correct*	*Worksite % Correct*	*% Change*
	Sedentary time in vehicles	54.1	64.0	9.9

Table 75: Summary of the BLR sedentary time in vehicles controlling for home environment in both regions.

Model Independent Variables	*Unstandardized Coefficients*	*Expected Direction*	*P-Value*	*Exp (B)*
Constant (y-intercept)	-3.266		.000**	.038
Age	.006		.402	1.006
Caucasian, non-Hispanic Ethnicity	-.397		.017*	.673
Children	-.045		.760	.956
Household Vehicle	2.671		.000**	14.451
Annual Household Income	-.032		.196	.969
Home – Walk Index – Mix 4 – 1 km	-.081	✓	.001**	.922
Work – Retail FAR – 15 min.	-.674	✓	.075	.510
Land Use Mix 6 – 15 min.	.315	×	.451	1.370
Home-Work Trip - Distance	.000	✓	.000**	1.000
Regional Accessibility – Average Distance	.000	✓	.049*	1.000
Convenience Store/Gasoline Station Count – 1 km	.021	✓	.103	1.022

B	Cox & Snell R-Square	Nagelkerke R-Square	Hosmer & Lemeshow Test: Chi-square	Hosmer & Lemeshow Test: P-Value
1	.042	.056	7.649	.468
2	.074	.099	3.661	.886
3	.117	.156	6.209	.624
	Dependent Variable	*Demographics % Correct*	*Worksite % Correct*	*% Change*
	Sedentary time in vehicles	55.4	64.2	8.8

14.2.13 Dependent Bivariate Correlates

Table 76: Pearson correlation coefficients testing physical activity with demographics.

Variable	*Correlation*	*Physical Activity*	*Age*	*Gender Binary (% Female)*	*Ethnicity (% Caucasian, non-Hispanic)*	*Children Binary*	*Household Ownership Binary*	*Valid Driver's License*	*Number of Vehicles in Household*	*Number of Vehicles per Adult in Household*	*Married/Living with Partner*	*Annual Household Income*
Physical Activity	Pearson Correlation	1	-.160**	-.202**	.156**	-.018	.066*	-.028	-.072*	-.056	-.040	.067*
	Sig. (2-tailed)		.000	.000	.000	.555	.032	.354	.018	.065	.185	.031
	N	1076	1075	1076	1073	1075	1076	1076	1076	1074	1076	1028
Age	Pearson Correlation	-.160**	1	-.044	.063*	-.150**	-.231**	-.003	.061*	.041	.010	.099**
	Sig. (2-tailed)	.000		.146	.038	.000	.000	.926	.046	.175	.754	.001
	N	1075	1077	1077	1074	1076	1077	1077	1077	1075	1077	1029
Gender Binary (% Female)	Pearson Correlation	-.202**	-.044	1	-.143**	-.069*	.115**	-.072*	-.151**	-.100**	-.246**	-.234**
	Sig. (2-tailed)	.000	.146		.000	.023	.000	.017	.000	.001	.000	.000
	N	1076	1077	1078	1075	1077	1078	1078	1078	1076	1078	1029
Ethnicity (% Caucasian, non-Hispanic)	Pearson Correlation	.156**	.063*	-.143**	1	-.029	-.109**	.131**	.122**	.124**	.144**	.192**
	Sig. (2-tailed)	.000	.038	.000		.343	.000	.000	.000	.000	.000	.000
	N	1073	1074	1075	1075	1074	1075	1075	1075	1073	1075	1027
Children Binary	Pearson Correlation	-.018	-.150**	-.069*	-.029	1	-.171**	.026	.182**	.063*	.320**	.178**
	Sig. (2-tailed)	.555	.000	.023	.343		.000	.396	.000	.038	.000	.000
	N	1075	1076	1077	1074	1077	1077	1077	1077	1076	1077	1029
Household Ownership Binary	Pearson Correlation	.066*	-.231**	.115**	-.109**	-.171**	1	-.155**	-.286**	-.229**	-.272**	-.368**
	Sig. (2-tailed)	.032	.000	.000	.000	.000		.000	.000	.000	.000	.000
	N	1076	1077	1078	1075	1077	1078	1078	1078	1076	1078	1029
Valid Driver's License	Pearson Correlation	-.028	-.003	-.072*	.131**	.026	-.155**	1	.247**	.307**	.092**	.225**
	Sig. (2-tailed)	.354	.926	.017	.000	.396	.000		.000	.000	.003	.000
	N	1076	1077	1078	1075	1077	1078	1078	1078	1076	1078	1029
Number of Vehicles in Household	Pearson Correlation	-.072*	.061*	-.151**	.122**	.182**	-.286**	.247**	1	.648**	.438**	.330**
	Sig. (2-tailed)	.018	.046	.000	.000	.000	.000	.000		.000	.000	.000
	N	1076	1077	1078	1075	1077	1078	1078	1078	1076	1078	1029
Number of Vehicles per Adult in Household	Pearson Correlation	-.056	.041	-.100**	.124**	.063*	-.229**	.307**	.648**	1	.060*	.189**
	Sig. (2-tailed)	.065	.175	.001	.000	.038	.000	.000	.000		.049	.000
	N	1074	1075	1076	1073	1076	1076	1076	1076	1076	1076	1028

Married/Living with Partner	Pearson Correlation	-.040	.010	-.246**	.144**	.320**	-.272**	.092**	.438**	.060*	1	.478**
	Sig. (2-tailed)	.185	.754	.000	.000	.000	.000	.003	.000	.049		.000
	N	1076	1077	1078	1075	1077	1078	1078	1078	1076	1078	1029
Annual Household Income	Pearson Correlation	.067*	.099**	-.234**	.192**	.178**	-.368**	.225**	.330**	.189**	.478**	1
	Sig. (2-tailed)	.031	.001	.000	.000	.000	.000	.000	.000	.000	.000	
	N	1028	1029	1029	1027	1029	1029	1029	1029	1028	1029	1029

**. Correlation is significant at the 0.001 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 77: Pearson correlation coefficients testing body mass index (BMI) with demographics.

Variable	*Correlation*	*BMI*	*Age*	*Gender Binary (% Female)*	*Ethnicity (% Caucasian, non-Hispanic)*	*Children Binary*	*Household Ownership Binary*	*Valid Driver's License*	*Number of Vehicles in Household*	*Number of Vehicles per Adult in Household*	*Married/Living with Partner*	*Annual Household Income*
BMI	Pearson Correlation	1	.157**	.034	-.105**	.034	-.013	-.061*	.015	.041	-.061*	-.093**
	Sig. (2-tailed)		.000	.262	.001	.271	.667	.045	.634	.174	.047	.003
	N	1077	1076	1077	1074	1076	1077	1077	1077	1075	1077	1028
Age	Pearson Correlation	.157**	1	-.044	.063*	-.150**	-.231**	-.003	.061*	.041	.010	.099**
	Sig. (2-tailed)	.000		.146	.038	.000	.000	.926	.046	.175	.754	.001
	N	1076	1077	1077	1074	1076	1077	1077	1077	1075	1077	1029
Gender Binary (% Female)	Pearson Correlation	.034	-.044	1	-.143**	-.069*	.115**	-.072*	-.151**	-.100**	-.246**	-.234**
	Sig. (2-tailed)	.262	.146		.000	.023	.000	.017	.000	.001	.000	.000
	N	1077	1077	1078	1075	1077	1078	1078	1078	1076	1078	1029
Ethnicity (% Caucasian, non-Hispanic)	Pearson Correlation	-.105**	.063*	-.143**	1	-.029	-.109**	.131**	.122**	.124**	.144**	.192**
	Sig. (2-tailed)	.001	.038	.000		.343	.000	.000	.000	.000	.000	.000
	N	1074	1074	1075	1075	1074	1075	1075	1075	1073	1075	1027
Children Binary	Pearson Correlation	.034	-.150**	-.069*	-.029	1	-.171**	.026	.182**	.063*	.320**	.178**
	Sig. (2-tailed)	.271	.000	.023	.343		.000	.396	.000	.038	.000	.000
	N	1076	1076	1077	1074	1077	1077	1077	1077	1076	1077	1029
Household Ownership Binary	Pearson Correlation	-.013	-.231**	.115**	-.109**	-.171**	1	-.155**	-.286**	-.229**	-.272**	-.368**
	Sig. (2-tailed)	.667	.000	.000	.000	.000		.000	.000	.000	.000	.000
	N	1077	1077	1078	1075	1077	1078	1078	1078	1076	1078	1029
Valid Driver's License	Pearson Correlation	-.061*	-.003	-.072*	.131**	.026	-.155**	1	.247**	.307**	.092**	.225**
	Sig. (2-tailed)	.045	.926	.017	.000	.396	.000		.000	.000	.003	.000
	N	1077	1077	1078	1075	1077	1078	1078	1078	1076	1078	1029

Number of Vehicles in Household	Pearson Correlation	.015	.061*	-.151**	.122**	.182**	-.286**	.247**	1	.648**	.438**	.330**
	Sig. (2-tailed)	.634	.046	.000	.000	.000	.000	.000		.000	.000	.000
	N	1077	1077	1078	1075	1077	1078	1078	1078	1076	1078	1029
Number of Vehicles per Adult in Household	Pearson Correlation	.041	.041	-.100**	.124**	.063*	-.229**	.307**	.648**	1	.060*	.189**
	Sig. (2-tailed)	.174	.175	.001	.000	.038	.000	.000	.000		.049	.000
	N	1075	1075	1076	1073	1076	1076	1076	1076	1076	1076	1028
Married/Living with Partner	Pearson Correlation	-.061*	.010	-.246**	.144**	.320**	-.272**	.092**	.438**	.060*	1	.478**
	Sig. (2-tailed)	.047	.754	.000	.000	.000	.000	.003	.000	.049		.000
	N	1077	1077	1078	1075	1077	1078	1078	1078	1076	1078	1029
Annual Household Income	Pearson Correlation	-.093**	.099**	-.234**	.192**	.178**	-.368**	.225**	.330**	.189**	.478**	1
	Sig. (2-tailed)	.003	.001	.000	.000	.000	.000	.000	.000	.000	.000	
	N	1028	1029	1029	1027	1029	1029	1029	1029	1028	1029	1029

**. Correlation is significant at the 0.001 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 78: Pearson correlation coefficients testing sedentary time driving or riding in vehicles with demographics.

Variable	*Correlation*	*Sedentary Time Driving/ Riding in Vehicles*	*Age*	*Gender Binary (% Female)*	*Ethnicity (% Caucasian, non-Hispanic)*	*Children Binary*	*Household Ownership Binary*	*Valid Driver's License*	*Number of Vehicles in Household*	*Number of Vehicles per Adult in Household*	*Married/Living with Partner*	*Annual Household Income*
Sedentary Time Driving/Riding in Vehicles	Pearson Correlation	1	.065*	-.003	-.153**	.066*	-.082**	.125**	.137**	.136**	.027	-.010
	Sig. (2-tailed)		.034	.918	.000	.031	.007	.000	.000	.000	.381	.752
	N	1077	1076	1077	1074	1076	1077	1077	1077	1075	1077	1028
Age	Pearson Correlation	.065*	1	-.044	.063*	-.150**	-.231**	-.003	.061*	.041	.010	.099**
	Sig. (2-tailed)	.034		.146	.038	.000	.000	.926	.046	.175	.754	.001
	N	1076	1077	1077	1074	1076	1077	1077	1077	1075	1077	1029
Gender Binary (% Female)	Pearson Correlation	-.003	-.044	1	-.143**	-.069*	.115**	-.072*	-.151**	-.100**	-.246**	-.234**
	Sig. (2-tailed)	.918	.146		.000	.023	.000	.017	.000	.001	.000	.000
	N	1077	1077	1078	1075	1077	1078	1078	1078	1076	1078	1029
Ethnicity (% Caucasian, non-Hispanic)	Pearson Correlation	-.153**	.063*	-.143**	1	-.029	-.109**	.131**	.122**	.124**	.144**	.192**
	Sig. (2-tailed)	.000	.038	.000		.343	.000	.000	.000	.000	.000	.000
	N	1074	1074	1075	1075	1074	1075	1075	1075	1073	1075	1027
Children Binary	Pearson Correlation	.066*	-.150**	-.069*	-.029	1	-.171**	.026	.182**	.063*	.320**	.178**
	Sig. (2-tailed)	.031	.000	.023	.343		.000	.396	.000	.038	.000	.000
	N	1076	1076	1077	1074	1077	1077	1077	1077	1076	1077	1029

Household Ownership Binary	Pearson Correlation	-.082**	-.231**	.115**	-.109**	-.171**	1	-.155**	-.286**	-.229**	-.272**	-.368**
	Sig. (2-tailed)	.007	.000	.000	.000	.000		.000	.000	.000	.000	.000
	N	1077	1077	1078	1075	1077	1078	1078	1078	1076	1078	1029
Valid Driver's License	Pearson Correlation	.125**	-.003	-.072*	.131**	.026	-.155**	1	.247**	.307**	.092**	.225**
	Sig. (2-tailed)	.000	.926	.017	.000	.396	.000		.000	.000	.003	.000
	N	1077	1077	1078	1075	1077	1078	1078	1078	1076	1078	1029
Number of Vehicles in Household	Pearson Correlation	.137**	.061*	-.151**	.122**	.182**	-.286**	.247**	1	.648**	.438**	.330**
	Sig. (2-tailed)	.000	.046	.000	.000	.000	.000	.000		.000	.000	.000
	N	1077	1077	1078	1075	1077	1078	1078	1078	1076	1078	1029
Number of Vehicles per Adult in Household	Pearson Correlation	.136**	.041	-.100**	.124**	.063*	-.229**	.307**	.648**	1	.060*	.189**
	Sig. (2-tailed)	.000	.175	.001	.000	.038	.000	.000	.000		.049	.000
	N	1075	1075	1076	1073	1076	1076	1076	1076	1076	1076	1028
Married/Living with Partner	Pearson Correlation	.027	.010	-.246**	.144**	.320**	-.272**	.092**	.438**	.060*	1	.478**
	Sig. (2-tailed)	.381	.754	.000	.000	.000	.000	.003	.000	.049		.000
	N	1077	1077	1078	1075	1077	1078	1078	1078	1076	1078	1029
Annual Household Income	Pearson Correlation	-.010	.099**	-.234**	.192**	.178**	-.368**	.225**	.330**	.189**	.478**	1
	Sig. (2-tailed)	.752	.001	.000	.000	.000	.000	.000	.000	.000	.000	
	N	1028	1029	1029	1027	1029	1029	1029	1029	1028	1029	1029

**. Correlation is significant at the 0.001 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).