Urban transport and health indicators: a literature review.

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Abstract

Introduction: Transport plays a central role in shaping cities' economic and social development. City planners are interested in expert input to include health evidence and indicators into their urban and mobility planning processes.

Objective: To identify evidence-based transport and health indicators to be included in urban planning processes.

Methods: A systemized literature review following the PRISMA guidelines. Review was performed in PubMed, Science Direct, Scopus and Google scholar, and complemented by hand search. Inclusion criteria were scientific publications in either English or Spanish, any year of publication, type of publication, and report any transport indicators or measures linking urban transport elements to health determinants or outcomes. Quality assessment of selected studies was based on study design and risk of bias.

Results: Forty-five studies were included published between 2001 and 2017, predominantly from the United States, Australia, Europe, Latin America and Asia. Selected studies though presenting overall low risk of bias, were mostly cross sectional in design. The primary health-related outcome was an increase in physical activity. The broad indicators which serve as the stronger predictors of active and public transportation among the studied population were: access, defined as the availability of walk-able destinations, or public transportation; population density; street connectivity; land use-mix; pedestrian and cycling infrastructure; aesthetics; safety from traffic and crime; and greens spaces.

Conclusion: There is a large body of literature on topic of urban environment and health. However, there's still limited scientific evidence linking clearly defined urban transport-related indicators to concrete health outcomes. Future studies in this field should explore opportunities to conduct more rigorous scientific studies with larger samples and with more diverse study settings and population.

Keywords: Active transportation, public transport, transport and health indicators, urban planning, urban health.

1. Introduction

Cities have long been known to be society's predominant engine of commercial, scientific, political and cultural development; urbanization as one of the most significant social processes plays a key role on a local and global scales (Mapar et al., 2017). Over half the world's population lives in cities and this proportion is expected to increase to over 70% in the next 20 years. However, along with population growth and rapid urbanization, significant global health challenges are being confronted, including increases in physical inactivity, non-communicable diseases (NCDs), unhealthy diets, injuries from road trauma, and obesity (Giles-Corti et al., 2016). Unplanned urban growth, leading to continued expansion of slums and substandard living; and unsustainable transportation systems; were identified as key un-sustainable urban development trends known to exacerbate the burden of non- communicable disease from risks related to physical inactivity, out-door air pollution and injuries; from exposures to excessive heat, cold, damp, or extreme weather; and water-borne and vector-borne communicable diseases (Dora et al., 2015).

Furthermore, the horizontal expansion of cities (urban sprawl) has been associated with more motor vehicle travel, physical inactivity, obesity, and injury risks, and more extreme urban heat events, also affecting health. Recognition of health as an outcome and indicator of sustainable development is increasing. Indicators integrating health and environmental sustainability deserve more attention in view of increased awareness that many of the planet's ills and those of individuals have common sources and solutions (Dora et al., 2015).

Transport plays a central role in shaping cities' economic and social development (Khreis et al., 2017); however contemporary car-ownership, and the vast network of roadway systems to accommodate it has led to reduced dependence on physically-demanding travel while simultaneously increasing sedentary time spent (Mueller et al., 2015). As technology, lifestyle, and land use patterns have changed over the last years, so too has the physical activity of our population. Routine exercise is no longer tied to our employment or home life, but is a choice we must make daily in order to maintain physical fitness. There is good ecological evidence that obesity rates are increasing in countries and settings in which 'active travel' (primarily walking and cycling) is declining. Given that transport is normally a necessity of everyday life, whereas leisure exercise such as going to a gym may be an additional burden, and is difficult to sustain long term, encouraging active travel may be a feasible approach to increasing levels of physical activity (Saunders et al., 2013).

Transportation investments have the potential to substantially improve health, directly and indirectly affecting the rates of non-communicable diseases, and other adverse health and environmental outcomes. Strategies that promote active transportation not only can reduce levels of sedentary behavior, but also reduce traffic-related injuries and fatalities, reduce emissions of traffic-related air pollutants, and increase access to health-promoting destinations (Boehmer et al., 2017).

City planners are interested in expert input to include health evidence and indicators into their urban and mobility planning processes, with an emphasis on sustainable land use and transportation. This represents an important opportunity to link scientific evidence with policy and decision making at the local and regional levels. The objective of this study is to identify, evidence based transport and health indicators to be included in urban planning process.

2. Methodology

A systemized literature review was performed in order to identify indicators linking urban-transport and health. The systemized review approach incorporates all elements of a systematic review process while stopping short of claiming that the resultant output is a systematic review because of the inability to draw upon the resources required for a full systematic review (Grant and Booth, 2009); specifically exhaustion of all literature, and time. Regardless, this review was performed following the PRISMA guidelines for the reporting of systematic review; with the aim to identify published evidence on urban health indicators linking urban transport planning and health, and to identify which indicators are most appropriate and feasible to be included in transport planning processes.

The literature review was performed in: PubMed, Science Direct, Scopus and Google scholar, and complemented by hand search. Keyword combinations of “transportation / cycling / walking / car / public transport / transit / active transport / active travel / active transportation” and “health indicators / urban health indicators / health measures / health recommendations” and “Air pollution / lead / air quality / motor vehicle emissions / particular matter or PM_{10} or $PM_{2.5}$ / NO_2 or nitrogen dioxide / ozone or O_3 / NO_x / noise or traffic noise / physical activity / traffic accidents or traffic incidents or traffic injuries or traffic fatality or traffic safety / social capita or social interaction” were used for the PubMed database. Simpler word combinations of “transportation / cycling / walking / car / public transport /

transit / active transport / active travel / active transportation" and "health indicators / urban health indicators / health measures / health recommendations" were used for the Google Scholar, Scopus, and Science Direct databases; for the Google Scholar engine first 98 pages of results was selected as cut-off point based on relevance of screened titles up from this point. The online search was updated until the 20th of March, 2018. Inclusion criteria were scientific publications in either English or Spanish, any year of publication, type of publication, and report any transport indicators or measures linking urban transport elements to health determinants or outcomes. All prompted titles were screened, and selected based on relevance for the topic on the link between urban transport and health; selected titles were then screened by abstract, and selected if inclusion criteria were met. Finally, selected articles underwent full-text review, and were kept for data extraction and analysis if all above criteria were kept.

All literature maintained after the screening process underwent data extraction using data extraction tool and quality assessment (see supplemental material). Reference, year of publication, mode of transportation addressed (walking, cycling, bus, rail etc…), study population, number of participants and participants characteristics (sex, age, SES, others), setting, study location (city/ies, country/ies) and setting characteristics (urban, sub-urban, rural), study period, and study design were captured for each (table 1).

Indicators identified in each study were presented as measure of exposure to which a clearly defined health determinant or outcome is linked. Within the tool each indicator was identified, defined and benchmarked in order to clearly establish the measure of exposure for each and accordingly relate the observed change in health. Changes in health determinants and outcomes were assessed using the measure of effects utilized in each study, whether it was odds ratio, β coefficient, hazard ratio, relative risk ratio etc, preferably with its according confidence interval value. Additionally, data on whether an exposure response gradient was tested in the study (in order to identify a potential dose-response relationship) was also collected. The magnitude in the measure of effect that represent the changes in health outcomes were classified in each study either as "high" if the measure of effect exceeded a positive ratio of 1.5 or a negative ratio of 0.75, and "low" if the measure of effect remained under a positive ratio of 1.5 or a negative ratio of 0.75. Furthermore, changes in health outcomes maybe classified as imprecise if sample size studied was fewer than 200 cases and the 95% CI included an important effect (measure of effect: > 1.25 ratio / < 0.75 ratio).

Overall risk of bias was assessed identifying within each scientific paper's methods and discussion sections potential risk of bias regarding how exposure was assessed; potential risk of bias due to confounders; potential risk of bias due to selection of participants; potential risk of bias due to health outcome assessment; and potential risk bias due to not blinding outcome assessments; all dichotomized into either high or low risk of bias. Total risk of bias was then classified as low risk if at least four of the aforementioned were identified at low risk, if not, any more would translate into an overall high risk of bias (see supplemental material).

Overall study quality was then assessed based on the certainty of the evidence regarding study design, the overall risk of bias, whether an exposure response gradient was identified, the magnitude of the measure of effect, and the presence of imprecisions. Certainty of evidence based on study design was classified as high: if the study design was a clinical trial, quasi-experimental study, case-control study, longitudinal cohort, or meta-analysis of any of these; or low: if the study design was a cross-sectional study, an ecological study, or a meta-analysis of any of these. In the context of this work, a high study quality would be a study with high certainty of evidence, an overall low risk of bias, which successfully captured an exposure response gradient, with a high magnitude of effect and no imprecisions. While a moderate study quality would be studies that although possesses a high certainty of evidence, has high risk of bias or could not successfully identify an exposure response gradient. A low or very low study quality would be based simply off the study design: cross-sectional studies and ecological studies accordingly (see supplemental material).

Policy implications and recommendations were generated based on the synthesized results. Additionally, inconsistencies between results between references were identified and assessed, if multiple studies with the same transport indicator (exposure) and health outcome presented different direction of the effect.

3. Results

3.1 Literature Review

The literature search produced a total list of 10,100 articles across all databases (Figure 1). From this screening process a total of 893 were selected to be reviewed by abstract, and 130 articles were reviewed full text; finally, 45 articles were kept for data extraction and analysis on the basis of presenting clear transport indicators or measures linking urban transport elements to health outcomes.

3.2 Study characteristics

The 45 selected studies were published between 2001 and 2017. The majority addressed walking as the main mode of transportation (n = 39), whether by exploring walking for transportation specifically or included with other modes of active travel such as cycling. Cycling was the second most common mode of transportation explored in the selected studies (n = 18), in the same manner. Other modes of transportation explored in the selected studies to a lesser degree included: public bus (n = 3), light rail (n = 3), and subway (n = 2).

The number of participants in the selected studies ranged from 170 to 453,927. Most of the participants in each of the studies selected were adults (n = 37). Additionally, three of the selected studies address specifically the elderly over 55 years of age; while two of the selected studies explored transportation behavior in children between the ages of two and thirteen. With the exception of one study (Perchoux et al., 2017) which explored transport behavior specifically on women; none other of the selected studies specified inclusion or exclusion criteria based on sex, socio-economic status or other characteristics; rather these were treated as covariates on each of the included studies' analysis. Exceptionally, (Lovasi et al., 2009) compared advantaged and disadvantaged neighborhood on the basis of income and education in their analysis of built environment characteristic in relation with body max index (BMI).

87% of study setting were developed countries (n=39). The most common study setting was the United States (n = 15); followed by Australia (n = 10). In the European context, the most common study setting was the United Kingdom (n = 4). Canada was the setting for two of the studies, and a total of seven studies were in the Asian context; two in China; Taiwan; Japan; Singapore; and Korea; and a total of three studies were in the Latin-American context: two in Brazil; one in Colombia. In terms of setting characteristics most were urban or sub-urban settings of cities in developed countries.

Cross-sectional design was the most common study design between the studies (n = 32). Seven studies were quasi-experimental in design, while four constituted longitudinal cohort studies. One study employed a mixed design, integrating cross-sectional, longitudinal and quasi-experimental data into their analysis (MacDonald, John M, Stokes, Robert J, Cohen, Deborah A, Kofner, Aaron, Ridgeway, 2010). While (Chiang and Lei, 2016) conducted an expert-opinion analysis with experts from the government sector, as well as the academic disciplines of urban planning, transportation, architecture, and landscape design.

3.3 Indicators and Health Outcomes

The majority of selected studies presented quantitative change in terms of health determinants (n = 33), and less reported changes in concrete health outcomes (n = 14). The most predicted outcome in terms of health determinants was an increase in physical activity as a result of the shift from sedentary to active modes of transportation (n= 42). Only (Frank et al., 2006) addressed a reduction in air pollutants as a predicted outcome related to an increase in active transportation and only as a secondary objective in their assessment, an increase in physical activity was still the predicted primary outcome in their analysis.

For studies that predicted a change directly in health outcomes, a decrease in Body Mass Index (BMI) and incident overweight and obesity was the most commonly predicted outcome (n = 8); followed by a decrease in the prevalence of non-communicable disease (n = 5), where hypertension and diabetes were main protagonists. (Sarmiento et al., 2010) predicted an increase in self-perceived physical and mental health among participants; with positive expected changes in the World Health Organization Quality of Life (WHO-QOL) Score as the primary outcome in relation with “Ciclovia” participation, a cycling-lane intervention implemented in Bogotá, Colombia. (Reinhard et al., 2018) also addressed mental health in their study, specifically in older adults over the age of sixty, with an expected increase in social cohesion and decrease in social isolation in relation with public transit use.

3.4 Indicators

Transport indicators which represent the link between urban built environment and health with moderate to high evidence are presented in Table 1 (See supplemental material for full table). The most frequently used broad indicators in the selected studies, which served as the stronger predictors of active transportation were access (n = 24); density (n = 14); connectivity (n = 13); land use-mix (n = 11); pedestrian infrastructure (n=8); aesthetics (n=6); safety (=8); and green spaces (n=2).

3.4.1 Density

Density was defined for the most part as either population density, the number of resident per km^2 within participant's buffer area; or residential density the number of dwellings per km^2 within participant's buffer area. Walking was positive associated to increase in density in nine studies ((Liao et al., 2017)(Buck et al., 2015)(Christiansen et al., 2016)(Lee and Moudon, 2006)(Turrell et al., 2013)(MacDonald et al., 2010)(Lachapelle and Frank, 2009)(Hooper et al., 2015)(Bentley et al., 2014)). For cycling one study identified a positive association with density (Christiansen et al., 2016). In relation with public transport no studies found a positive association with increased density. In terms of health outcomes density was associated to moderate-to-vigorous physical activity (Buck et al., 2015), a reduction in BMI (Koohsari et al., 2018; Lovasi et al., 2009)(MacDonald et al., 2010), and a reduction in incident overweight, obesity, and diabetes mellitus (Glazier, Richard H., Creatore, 2014). Up to 12,000 dwellings/km^2 was reported as density benchmark to increase active transport (Christiansen et al., 2016).

3.4.2 Connectivity

Connectivity was defined for the most part as street connectivity, the number of intersections (usually three-way or more) per km^2 within participants' buffer area. Walking was positively associated to increase in connectivity in nine studies (Liao et al., 2017)(Shay et al., 2009)(Rachele et al., 2018)(Christiansen et al., 2016)(Koohsari et al., 2016)(Turrell et al., 2013)(Hooper et al., 2015)(Knuiman et al., 2014)(Bentley et al., 2014). For cycling one study identified a positive association with increased street connectivity (Christiansen et al., 2016). In relation with public transport no studies found a positive association with increased connectivity. In terms of health outcomes connectivity was associated to moderate-to-vigorous physical activity (Buck et al., 2015) a decrease in BMI (Koohsari et al., 2018)(Smith et al., 2008), and a reduction in incident overweight, obesity, and diabetes mellitus (Glazier, Richard H., Creatore, 2014). 200–250 intersections/km^2 was reported as street connectivity benchmark to increase active transport (Christiansen et al., 2016).

3.4.3 Access

Access served as one of the strongest predictors of active transport. Access was defined as either distance to or the presence of public transport elements; or the availability of walk-able destinations. Walking was positively associated to an increase in access in thirteen studies (Cerin et al., 2007)(Krizek and Johnson, 2005)(Lachapelle and Frank, 2009)(Goodman et al., 2014)(Kim and Hyun, 2018)(Liao et al., 2017)(Koohsari et al., 2016)(Liao et al., 2017)(Lee and Moudon, 2006)(Lachapelle and Frank, 2009)(Hooper et al., 2015)(Knuiman et al., 2014)(Hino et al., 2014). For cycling four studies identify a positive association with access (Krizek and Johnson, 2005)(Troped et al., 2001)(Florindo et al., 2018)(Rissel et al., 2015). In relation with public transport one study found a positive association with increased access (Panter et al., 2016). In terms of health outcomes access was associated to moderate to vigorous physical activity (Kim and Hyun, 2018), a reduction in BMI (Lovasi et al., 2009)(Koohsari et al., 2018)(Brown et al., 2015) and a reduction in incident overweight, obesity, and diabetes mellitus (Glazier, Richard H., Creatore, 2014). Distance to bicycle paths, bus stations, and subway stations from less than 400 meters to up to two kilometers were reported as access benchmarks to increase active and public transport (Florindo et al., 2018; Rissel et al., 2015)(Goodman et al., 2014; Krizek and Johnson, 2005; Troped et al., 2001)(Brown et al., 2017; Lovasi et al., 2009; Panter et al., 2016). Additionally, distances to at least eight types of destinations from less than 200 meter to up to 800 meters, were also reported as access benchmarks to increase active transport. (Cerin et al., 2007; Knuiman et al., 2014; Krizek and Johnson, 2005)(Glazier, Richard H., Creatore, 2014; Koohsari et al., 2016)(Liao et al., 2017)(Hooper et al., 2015)(Lachapelle and Frank, 2009) (Chiu et al., 2016) , (Su et al., 2017).

3.4.4 Land use mix

Land use mix was also reported as predictors of active transportation. Land use mix is defined as land uses that are located together in a balanced mix, including residential development, shops, employment community and recreation facilities and parks and open space. Most of the selected studies used an entropy score from 0-1 in their analysis to represent land use mix; 0 representing a completely homogenous land use and 1 representing a completely heterogeneous land use. Walking was positively associated to heterogeneous land use in seven studies (Christiansen et al., 2016)(Cerin et al., 2007)(Turrell et al., 2013)(Hino et al., 2014)(Knuiman et al., 2014)(Bentley et al., 2014)(Lee and Moudon, 2006). For cycling two study identify a positive association with land use mix (Christiansen et al., 2016)(Hino et al., 2014). In relation with public transport no studies found a positive association with heterogeneous land use. In terms of health outcomes land use mix was associated to a reduction in BMI (Lovasi et al., 2009), and an increase in self-perceived physical and mental health (Hino et al., 2014). Entropy scores from 0.5 to 0.59, translating to residential land use of no more than 53% to 68% and commercial land use of at least 6% to 17% were reported as land use mix benchmarks to increase active transport and improve health (Hino et al., 2014).

3.4.5 Pedestrian Infrastructure

The presence of pedestrian infrastructures, mainly sidewalks, for the population to walk and cycle on, acts as another predictor of active travel in the selected studies. Walking infrastructure was positively associated to increase walking in four studies (Liao et al., 2017)(Shay et al., 2009)(Troped et al., 2003)(Hooper et al., 2015). Cycling infrastructure was positively associated to increase cycling in one studies (Troped et al., 2003). In terms of health outcomes pedestrian infrastructure was associated to a reduction in BMI (Jensen et al., 2017). However, no infrastructure benchmarks were reported to increase active transport and public transport.

3.4.6 Safety

Safety, defined as participants' perceived safety from traffic and crime was also reported as a predictor of active transport. Walking was positively associated with safety in three studies (Jensen et al., 2017)(Troped et al., 2003). Cycling was positively associated with safety in one study (Troped et al., 2001). Safety was not positively associated with public transport use in the studies. No safety benchmarks were reported to increase active transport (see supplemental material).

3.4.7 Aesthetics

Aesthetic was another indicator employed as a predictor of active transport in the selected studies. Aesthetics was positively associated to increase walking in one studies (Troped et al., 2003). Aesthetics was not positively associated with cycling and public transport in any of the studies. No aesthetics benchmarks were reported to increase active transportation.

3.4.8 Green Space

Green space, defined as the presence of parks within participants' buffer area, was another indicator reported as a predictor of active transportation. Walking was positively associated to access to green space in two studies (Christiansen et al., 2016)(Hooper et al., 2015). Cycling and public transport were not positively associated to green space in the studies. Distance to parks from less 400 meters to up to 2.5 kilometers were reported as green space benchmarks to increase active transport (Hooper et al., 2015)

3.4.9 Composite Indicators

Nine studies utilized composite indicators, which take into account various indicators or elements of the built environment to estimate neighborhood walkability into a single score (see supplemental material).

3.5 Risk of bias and study quality

From the 45 selected articles for analysis majority presented an overall low risk bias (n=33). In terms of overall quality (bias and strength of evidence), four studies presented a high quality, eight moderate quality; 33 were low quality studies and one presented very low quality (see supplemental material).

3.6 Inconsistencies

Four inconsistencies were identified throughout the selected studies (see supplemental material).

4. Discussion

Eight indicators (access, density, connectivity, land use mix, transport infrastructure, safety, aesthetics, and green spaces) were identified through this review to be relevant for health and transport planning. From these indicators distances to at least eight types of destinations from less than 200 meter to up to 800 meters and distance to bicycle paths, bus stations, and subway stations from less than 400 meters to up to two kilometers; 12,000 dwellings/km^2; 200–250 intersections/km^2; residential land use of no more than 53% to 68% and commercial land use of at least 6% to 17%; and distance to parks from less 400 meters to up to 2.5 kilometers were reported as benchmarks to increase active transportation and improved health.

Access defined as either distance to or the presence of public transport elements; or the availability of walk-able destinations, appears to be the broad indicator which more strongly predicts population engaging in active modes of transport. Proximity to bike paths, bus stations, subway stations and other public transport access points were significantly associated with active transportation among participants in the selected studies, at distances from less than 400 meters to up to two kilometers (Florindo et al., 2018; Rissel et al., 2015)(Goodman et al., 2014; Krizek and Johnson, 2005; Troped et al., 2001)(Brown et al., 2017; Lovasi et al., 2009; Panter et al., 2016). Not only proximity, but the number of access points to public transportation was also associated with population engaging in active travel

(Koohsari et al., 2018; Lovasi et al., 2009); with evidence for more than fifteen bus stops within 1600 meters radius to be associated with participants engaging in active travel (Knuiman et al., 2014). Access to destinations were significantly associated with active transportation and positive health outcomes among participants in the selected studies, at distances from less than 200 meter to up to 800 meters (Cerin et al., 2007; Knuiman et al., 2014; Krizek and Johnson, 2005)(Glazier, Richard H., Creatore, 2014; Koohsari et al., 2016)(Liao et al., 2017)(Hooper et al., 2015)(Lachapelle and Frank, 2009) (Chiu et al., 2016)(Su et al., 2017); and with up to fifteen different types of available destinations including commercial destinations (local shops, supermarket, greengrocer, laundry/dry cleaners, etc.), schools and workplace, and recreational destinations (park, nature reserve, sports field, fitness center) (Cerin et al., 2007; Knuiman et al., 2014).

Population density was the second indicator more often reported as a predictor of population engaging in active transport (Buck et al., 2015; Christiansen et al., 2016)(Bentley et al., 2014)(Lachapelle and Frank, 2009)(Lee and Moudon, 2006; Turrell et al., 2013) (Chiu et al., 2016) (Kerr et al., 2016) (Frank et al., 2006). Notably, (Christiansen et al., 2016) found on their internationally multi-centered study that the odds of walking for transport were only positively associated with residential density up to a density of 12,000 dwellings/km^2, but negatively thereafter.

Net population and residential density, however, are not the only indicators of density associated with active transport. (Hooper et al., 2015) used block density as an indicator in their study and also found an association with population engaging in active modes of transportation. Exceptionally they proposed the Walk-able Block ratio defined as the number of blocks that are less than or equal to 620 meters in perimeter divided by the total amounts of block.

Street connectivity was the third most common of active transport. Well-connected streets, defined as streets with increased numbers of intersection per km^2 was strongly associated with participants engaging in active modes of transportation and with positive health outcomes throughout the selected study (Bentley et al., 2014; Koohsari et al., 2018)(Buck et al., 2015; Christiansen et al., 2016; Glazier, Richard H., Creatore, 2014; Koohsari et al., 2016; Rachele et al., 2018; Smith et al., 2008)(Knuiman et al., 2014; Turrell et al., 2013)(Kerr et al., 2016)(Frank et al., 2006). (Christiansen et al., 2016) found the odds of walking for transport positively related to intersection density only up to values of 200–250 intersections/km^2 within a 1-km buffer and negatively thereafter (OR: 1.71 (CI: 1.42, 2.04)), this is likely due to exceeding intersection density resulting in increased and complex vehicular traffic which is less friendly for pedestrians and cyclist (Troped et al., 2001).

Land use-mix was the fourth most common indicator used to predict active transport. Heterogeneous land use was strongly associated with participants engaging in active travel and positive health outcomes throughout the selected studies (Cerin et al., 2007; Hino et al., 2014; Knuiman et al., 2014; Lee and Moudon, 2006; Troped et al., 2001; Turrell et al., 2013)(Christiansen et al., 2016)(Bentley et al., 2014; Lovasi et al., 2009) (Kerr et al., 2016) (Frank et al., 2006). However, how heterogeneous; and which land-use types is ideal for promoting active travel remains unclear. Entropy scores of 0.5 or more, which translate to less than 50% of land use dedicated to residential use and around 50% for commercial and other uses appears to be the ideal scenario based on a few of the studies ((Hino et al., 2014; Turrell et al., 2013). (Chiang and Lei, 2016) ranked land-mix as the fourth most important indicator out of four in their expert-opinion analysis of indicators of urban friendliness for walking environments.

The presence of pedestrian infrastructure is another indicator which acts as a predictor of population engaging in active transport. The mere availability of sidewalks was strongly associated with participants engaging in active modes of transport in a few of the selected studies (Liao et al., 2017)(Troped et al., 2003)(Hooper et al., 2015) (Kerr et al., 2016). The presence of crossing aids and good sidewalk conditions was also associated with active transport (Shay et al., 2009)(Zhu and Yoon, 2017). (Chiang and Lei, 2016) ranked the availability of sidewalks as the second most important indicator in their expert-opinion analysis of indicators of urban friendliness for walking environments, giving special importance to sidewalk maintenance, width and a barrier free design.

Aesthetics and safety from traffic and crime as indicators, were only predictors of population engaging in active modes of transport in just a few of the selected studies (Troped et al., 2003, 2001)(Jensen et al., 2017). Although safety was addressed in as many studies as pedestrian infrastructure, positive association was only found in two. However, (Chiang and Lei, 2016) in their expert-opinion analysis of indicators of urban friendliness for walking environments, ranked safety and aesthetics as the first and the third most important indicator, respectively, for walking environments. Studies in this review relied on subjective assessment of perceived aesthetics and safety by participants. Though it would seem aesthetic and safety, are weaker predictors of active travel than other indicators from participants' point of view; it does not necessarily mean aesthetic and safety are not necessary for population to engage in active modes transport. Future studies should explore both perceived and objective measures of aesthetics and safety in relation with urban planning, healthy living and the promotion active transport.

Green space as an indicator was another uncommon predictor of population engaging in active modes of transport in the selected studies. However, in both of the studies where green spaces were addressed a positive association with active transport was found (Christiansen et al., 2016)(Hooper et al., 2015). This calls for future research to explore this potentially neglected pathway for more people to engage in active modes of transport.

4.1 Strengths and limitations

This is the first review to recompile transport-related indicators in relation with observed quantitative changes in health determinants and outcomes; while at the same time assessing the quality of the evidence based on study design and risk of bias. However, several limitations need to be taken into account.

This is not a systematic review, so it is not exempt from publication bias. Another bias is the external validity of the literature presented in the studies included in this review. Potential incompleteness of evidence about certain indicators is also a limitation of this analysis. More specifically, the lack of clearly defined benchmarks for some of the indicators identified poses a limitation at the time of assessing applicability of these indicators to different settings.

Majority of the associations between transport-related indicators and health outcomes from the selected studies were a result from cross-sectional data, therefore evidence regarding causal relationship between the two is low. (Bentley et al., 2014)(Hooper et al., 2015) in their longitudinal assessments were able to demonstrate causal relationship between street connectivity; population density; and land-use mix with participants' odds of engaging in active transportation; nonetheless, stronger longitudinal evidence is needed across the board. Additionally, data on participants' active transportation was derived, for the most part, from self-reported surveys; this approach is evidently more prone to bias. (Shay et al., 2009)(Brown et al., 2015) and (Jensen et al., 2017) were a few of the studies which measured objective transportation physical activity through accelerometer in their intervention studies from Salt Lake City, Utah. Future research in the field calls for more objectives measures of health determinants and outcomes.

Another limitation of this review was that the only health determinant thoroughly explored was an increase in physical activity as a result of the shift from sedentary to active modes of transportation; evidently there are many other health pathways linking urban transport with health, including air and noise pollution; traffic injuries and fatalities; mental health; among others. Future studies and reviews should focus on gathering scientific evidence which explore these potentially neglected pathways.

5. Conclusion

There is a significant body of research that links urban environmental exposures to health. However, scientific evidence linking clearly defined transport-related indicators to concrete health outcomes remains limited. Eight indicators were identified through this review to be relevant for health and transport planning: population density; street connectivity; access; land use-mix; transport infrastructure; green spaces; aesthetics; and safety.

Indicators identified through this review are likely to be relevant for cities but they require further contextualization to be applied directly into mobility and city planning process in different cities. However, paying attention and fitting policy measures within the broad indicators identified through this review, may set the ideal setting for current and future policy and interventions to be successful at promoting active and public transportation among the population.

Overall, this review lends support to calls for interventions to change the built environments of cities and neighborhoods in ways that promote walking and improve population health. Nonetheless, future studies in this field should explore opportunities to conduct more rigorous scientific studies with stronger longitudinal evidence; exploring not just one but multiple health pathways; with larger samples sizes and with more diverse study settings and populations.

Ethical approval

This review recompiles secondary data, where no personal information of participants' involved in the studies is disclosed. Ethical approval is not required.

Table 1. Urban transport indicators and health (moderate-to-high evidence)

		Population		Setting		Indicator/exposure			Outcome		Change			
Reference (Author, Year)	Mode of transport (walking, cycling, car, motorcycle, bus, metro, tram, train, gondola, etc)	Number of participants	Participants characteristics (sex, age, SES, other)	Study location (City/s, country/s)	Setting characteristics (urban, sub-urban, rural / deprived communities / other)	Indicator	Indicator definition	Benchmark indicator	Health outcome & definition (disease, injury, mortality, life expectancy, quality of life, other)	Health determinant & definition (physical activity, accidents, air pollution, noise pollution, other)	Change in health outcome or health determinants (central point and ranges/confidence intervals)	Unit of change (%, Cases, RR, HR, others)	Study design (Expert recommendation, Ecological, Cross-sectional, longitudinal, quasi-experiential, trial, meta-analysis)	Study quality (high, moderate, low, very low)
Rebecca Bentley, Tony Blakely, Anne Kavanagh, Zoe Aitken, Tania King, Paul McElwee, Billie Giles-Corti, Gavin Turrell 2017	Walking	11035	Middle aged adults (40-65 years old)	Brisbane, Australia	Urban	**Street connectivity**	number of four-way intersections within 1-km buffer	1-unit increase in street connectivity (representing 10 additional intersections)		Increase in walking for transportation - physical activity	**Any walking for transport** **Minutes of walking for transport**	OR: 1.49 (CI: 1.42, 1.56) OR: 6.20 (CI: 5.13, 7.28)	Longitudinal cohort	Moderate
						Density	number of dwellings per hectare of residential land in within 1-km buffer	1-unit increase (5 dwelling/hectare increase in residential density)			**Any walking for transport** **Minutes of walking for transport**	OR: 1.20 (CI: 1.42, 1.56) OR: 3.90 (CI: 3.31, 4.49)		
						Land-use mix	based on five types of land use within each 1-km buffer	0 (homogenous) - 1 (heterogeneous)			**Any walking for transport** **Minutes of walking for transport**	OR: 1.39 (CI: 1.31, 1.46) OR: 5.59 (CI: 4.28, 6.90)		

Barbara B. Brown Carol M. Wemer Calvin P. Tribby Harvey J. Miller Ken R. Smith 2015	Light Rail	537	adults over 18 years of age	Salt Lake City, Utah, USA	Urban	**Access to light-rail line (intervention)**	Increased access to a light-rail line after the creation of 5 additional stops	within 2 km	BMI	Active transportation - physical activity	**Change in physical activity**	Former riders: β: -49.35 (CI: -78.75, -19.94) Continuing riders: β: -6.25 (CI: -34.62, 22.12) New riders: β: 37.40 (CI: 10.41, 64.39)	Quasi-experimental Longitudinal	Moderate
											Change in BMI	Former riders: β: 0.64 (CI: -0.18, 1.11) Continuing riders: β: 0.03 (CI: -0.42, 0.48) New riders: β: -0.50 (CI: -0.93, -0.08)		
Barbara B. Brown Ken R. Smith Wyatt A. Jensen Doug Tharp 2015	Light Rail	170	adults over 18 years of age	Salt Lake City, Utah, USA	Urban	**Access to light-rail line (intervention)**	Increased access to a light-rail line after the creation of 5 additional stops	within 2 km	BMI	Increase in active transportation - physical activity	**Change in BMI**	Former riders: β: 0.82 (CI: 0.13, 1.50) Continuing riders: β: -0.36 (CI: -0.91, 0.20) New riders: β: -0.38 (CI: -0.89, 0.13)	Quasi-experimental	Moderate
Maria Chiu, Mohammad-Reza Rezai, et al. 2016	Walking	2,114	adults age >/= 20	Ontario, Canada	low-walkability neighborhood → high walkability neighborhood	**Walk Score (Walkability)**	Walkability of any address using a patented system.	90–100 - Daily errands do not require a car. 0–24 Car-Dependent Almost all errands require a car	Hypertension	Increase walking for transportation - physical activity	**Incident hypertension**	HR: 0.46; (CI: 0.26, 0.81)	Longitudinal cohort	High

Anna Goodman, Shannon Sahlqvist, David Ogilvie 2014	Walking	1465	adults 18 or older	Cardiff / Kenilworth / Southampton, U.K.	Urban	**Proximity to Connect2 (intervention)**	distance to the nearest access point to a completed section of the Connect2 project	living far (2 - 5 km) [reference] living close (<1 km)		Increase in walking for transportation - physical activity	**walking for transport (min/week)**	1-y change β: 5.8 (CI: -0.7, 12.3) 2-y change β: 8.8 (CI: 2.8, 14.8)	Quasi-experimental	Moderate
	Cycling									Increase in cycling for transportation - physical activity	**Cycling for transport (min/week)**	1-y change β: 0.4 (CI: -1.9, 2.7) 2-y change β: -0.2 (CI: -2.2, 1.8)		
											Total walking and cycling (min/week)	1-y change β: 4.6 (CI: -4.2,13.4) 2-y change β: 15.3 (CI: 6.5, 24.2)		
Paula Hooper, Matthew Knuimanb, Sarah Foster, Billie Giles-Corti 2015	Walking	664	adults age 18 or older	Metropolitan Perth, Western Australia	suburban	**Destination diversity of center**	score- number of different destination types present within the center (score 1–8)	OR for every additional destination type present		Increase in walking for transportation - physical activity	**Walking for transport**	Any: OR: 1.22 (CI: 1.01, 1.49) ≥: 60 min: OR: 1.36 (CI: 1.11, 1.68)	Longitudinal cohort	High
											Total walking	≥: 150 min: OR: 1.16 (CI: 1.05, 1.27)		
						Block density	number of blocks ÷ constructed land area within the development	OR for 1 unit increases in block density			**Total walking**	≥: 60 min: OR: 5.05 (CI: 2.10, 12.1)		

				Walkable block ratio	number of blocks ≤ 620m perimeter ÷ total number of blocks	OR for 1 unit increases in walkable block density		**Total walking**	Any: OR: 4.38 (CI: 3.24, 5.91) ≥: 150 min: OR: 2.27 (CI: 1.40, 3.68)	
				Number of external access points	number of pedestrian-friendly access points along the development perimeter ÷ perimeter of development boundary	OR for 1 unit increase in number of access points		**Walking for transport**	Any: OR: 1.35 (CI: 1.06, 1.73)	
				Length of footpath (km)	length of all footpaths ÷ constructed land area of housing development	OR for 1 unit increase in length of footpaths		**Walking for transport**	Any: OR: 1.02 (CI: 1.01, 1.02) ≥ 60 min: OR: 1.02 (CI: 1.00, 1.03)	
				Sidewalk: road ratio	length of all footpath segments adjacent to roads ÷ length of all roads	OR for 1 unit increase in sidewalk: road ratio		**Total walking**	≥ 60 min: OR: 3.14 (CI: 1.89, 11.1)	
				Tree density along footpath	number of trees along footpaths ÷ length (km) of footpaths within the development	OR for 1 unit increase in number of trees per km of footpath		**Walking for transport**	Any: OR: 1.04 (1.03, 1.06)	
								Total walking	≥ 60 min: OR: 1.02 (CI: 1.01, 1.04)	
				% residential land area occupied by small lot	% of lots less than 350 m2	OR for 1 unit increase in % residential land area		**Walking for transport**	Any: OR: 1.04 (CI: 1.01, 1.09)	
				Medium neighborhood park	Medium neighborhood park (0.5–1.5 ha) accessible within 400m	≤ 400 m (no park reference)		**Walking for transport**	≥ 60 min: OR: 1.09 (CI: 1.05, 1.12)	

				Number of parks	Total number of parks within the development	OR for 1 unit increase in number of parks present within the development		**Walking for transport**	Any: OR: 1.08 (CI: 1.03, 1.13)	
				Regional parks	Number of regional parks	OR yes vs. reference group no regional park ≤2.5 km		**Walking for transport**	Any: 3.97 (CI: 2.46, 6.41) ≥ 60 min: OR: 1.99 (1.83, 2.17)	
								Total walking	Any: 1.58 (CI: 1.35, 1.84) ≥ 60 min: OR: 1.85 (CI: 1.23, 2.50)	
				Number of small neighborhood parks	number of small neighborhood park (0.3–0.5 ha)	OR for 1 unit increase in number of parks present within the development		**Walking for transport**	Any: OR: 1.13 (CI: 1.02, 1.25)	
				Number of medium neighborhood parks	number of medium neighborhood park (0.5–1.5 ha)	OR for 1 unit increase in number of parks present within the development		**Walking for transport**	Any: OR: 1.17 (CI: 1.06, 1.28)	
								Total walking	Any: OR: 1.06 (CI: 1.02, 1.10) ≥ 60 min: OR: 1.09 (CI: 1.04, 1.13)	
				Number of parks with sport surface, marking or equipment		OR for 1 unit increase in number of parks present		**Walking for transport**	≥ 60 min: OR: 1.26 (CI: 1.18, 1.34)	

Wyatt Jensen Barbara B. Brown Ken R. Smith Simon C. Brewer et al. 2017	Active transportation (Walking, cycling or public transportation)	536	adults over 18 years of age	Salt Lake City, Utah, USA	Urban	**Access to a <u>complete street</u> (intervention)**	Roadway designed or altered to accommodate active transport by pedestrians, cyclists, and transit users	within 2 km	Increase walking and cycling for transport - physical activity	**Active transportation on the complete street**	OR: 0.99 (CI: 0.95, 1.03)	Quasi-experimental longitudinal	Moderate
						Pedestrian Infrastructure	street lighting	Perceived			OR: 0.95 (CI: 0.91, 1.00)		
						Aesthetic	interesting things to look at and natural sights				OR: 0.95 (CI: 0.91, 0.99)		
						Protection from Traffic Hazards	Quantity of traffic nearby				OR: 1.07 (CI: 1.03, 1.11)		
						Protection from Crime	Crime rate				OR: 1.05 (CI: 1.01, 1.09)		
Matthew W. Knuiman, Hayley E. Christian, Mark L. Divitini, Sarah A. Foster, Fiona C. Bull, Hannah M. Badland, Billie Giles-Corti 2013	Walking	1703	adults age of 18 years or older	Metropolitan Perth, Western Australia	suburban	**Connectivity z score**	# of Intersections per square km	within 1600 m of participants home	Increase in walking for transportation - physical activity	**Transport walking over time**	OR: 1.13 (CI: 1.01, 1.26)	Longitudinal cohort	High
						Residential density	# dwelling per square km	within 1600 m of participants home			OR: 0.96 (CI: 0.80, 1.15)		
						Land use-mix z score	Entropy score	0 – 1			OR: 1.33 (CI: 1.16, 1.52)		
						No. of bus stop	within 1600 m of participants' home	0 - 14 (ref) 15-29 ≥ 30			15 - 29: OR: 1.99 (CI: 1.46, 2.71) ≥ 30: OR: 2.33 (CI: 1.57, 3.45)		

						Railway station	within 1600 m of participants' home	Present Not present (ref)				OR: 1.79 (CI: 1.02, 3.16)		
						Total number of types of destinations	within 1600 m of participants' home	0 - 3 (ref) 4 - 7 8 – 15				4 - 7: OR: 1.08 (CI: 0.80, 1.45) 8 - 15: OR: 1.40 (CI: 0.93, 2.10)		
						Access to bus stop		Perceived				OR: 1.31 (CI: 0.92, 1.87)		
						Access to railway station		Perceived				OR: 1.80 (CI: 1.13, 2.85)		
						Total no. of types of destinations (perceived)	number of destinations within 15-minute walki from home	0-2 (ref) 3-6 7-11				3 - 6: OR: 2.35 (CI: 1.81, 3.05) 7 - 11: OR: 3.11 (CI: 2.28, 4.25)		
John M. MacDonald, Robert J. Stokes, Deborah A. Cohen, Aaron Kofner, Greg K. Ridgeway 2010	Light rail	498	adults over the age of 18	Charlotte, North Carolina, USA	urban	**Social and physical environment**	Perception of neighborhood social and physical environment within 15 min walk of each participants' home	N/A	Moderate to vigorous physical activity Decrease in BMI and obesity incidence	Increase in active transportation - physical activity	**BMI**	OR: - 0.358 (p<0.05)	Cross-sectional Longitudinal Quasi-experimental	Moderate
											Obesity	OR: 0.85 (CI: 0.77, 0..94)		
											Reported physical activity (RPA) - vigorous	OR: 1.11 (CI: 1.01, 1.22)		
						Density of food and alcohol outlets	density of establishments that sell food and alcohol within a half-mile of respondents' household	N/A			**RPA - walking**	OR: 1.25 (CI: 1.04, 1.51)		
											BMI	OR: - 0.281 (t=-1.07)		

						Public transit use	how often participants took public transportation (bus or rail)	at least once a week		**BMI**	OR: -1.01 (t=-1.24)		
						LRT use (intervention)	use of the light rail train for commute to work	N/A		**BMI (change in time)**	β: -1.18 (CI: -2.22, -0.13)		
										Obesity (change in time)	OR: 0.19 (CI: 0.04, 0.92)		
										RPA - walking (change in time)	OR: 1.36 (CI: 0.39, 4.73)		
										RPA - vigorous (change in time)	OR: 3.32 (CI: 0.81, 13.63)		
Jenna Panter Eva Heine Roger Mackett David Ogilvie 2016	Active transportation (Walking, cycling, running, and public transport)	469	adults 20-71 years	Cambridge, United Kingdom	Urban	**Access to The Cambridgeshire Guided Busway (intervention)**	distance from each participant's home to the nearest stop or path access point to guided bus.	N/A	Increase in active transportation - physical activity	**<u>Active commuting</u>** **No change** **Increase** **Decrease**	Ref RRR: 1.14 (CI: 0.90, 1.45) RRR: 1.07 (CI: 0.83, 1.37)	Quasi-Experimental	Moderate
	Walking									**<u>Walking on the commute</u>** **No change** **Increase** **Decrease**	Ref. RRR: 0.90 (CI: 0.69, 1.18) RRR: 1.13 (CI: 0.83, 1.55)		
	Cycling									**<u>Cycling on the commute</u>** **No change** **Increase** **Decrease**	Ref. RRR: 1.34 (CI: 1.03, 1.76) RRR: 1.00 (CI: 0.73, 1.37)		

Erica Reinhard Emilie Courtin Frank J. van Lethen Mauricio Avenado 2018	Bus	18453	Older adults over the age of 60	England	Urban	**Public bus - use (intervention)**	public bus use as a result of free bus travel passes for the eldery	1 - users of public bus 0 - non-users	Decrease in depresive symptom - Mental health	increase in social cohesion, and decrease in social isolation	**Lonliness**	β: −0.794 (CI: −1.528, −0.061)	Quasi-experimental	Moderate
											Social Isolation	β: −0.437 (CI: −0.941, 0.067)		
Chris Rissel Stephen Greaves Li Ming Wen Melanie Crane Chris Standen 2015	Cycling	512	Adults age 18 to 55	Sydney, Australia	High-end urban	**Access to bicycle path**	Percieved access to bicycle path	Percieved		Increase cycling for transporta tion - physical activity	**Use of bicycle path**	OR: 3.58 (CI: 2.01, 6.40)	Quasi-Experimental	Moderate
							distance of participant's residence to the nearest point of the bicycle path	100 m 500 m				OR: 1.04 (CI: 1.02, 1.06) OR: 1.24 (CI: 1.13, 1.37)		

β: beta coefficient; CI: Confidence interval; HR: Hazard risk ratio; IRR: Incidence risk ratio ; NO_x: Nitrate oxide OR: Odd ratio; p: p-significance value; R^2: coefficient of multiple determination for multiple regression; VOC: volatile organic compound.

Figure 1. Flow chart for study selection

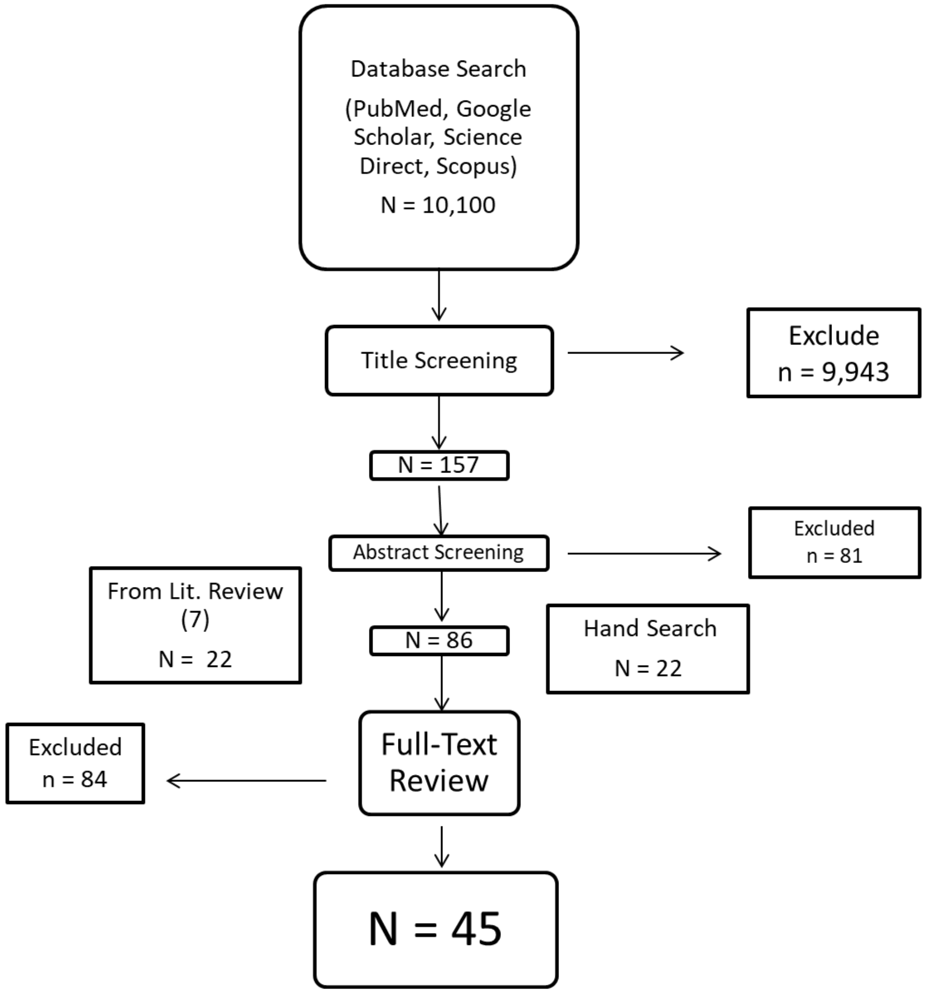


Figure 2. Indicators relevant for transport planning

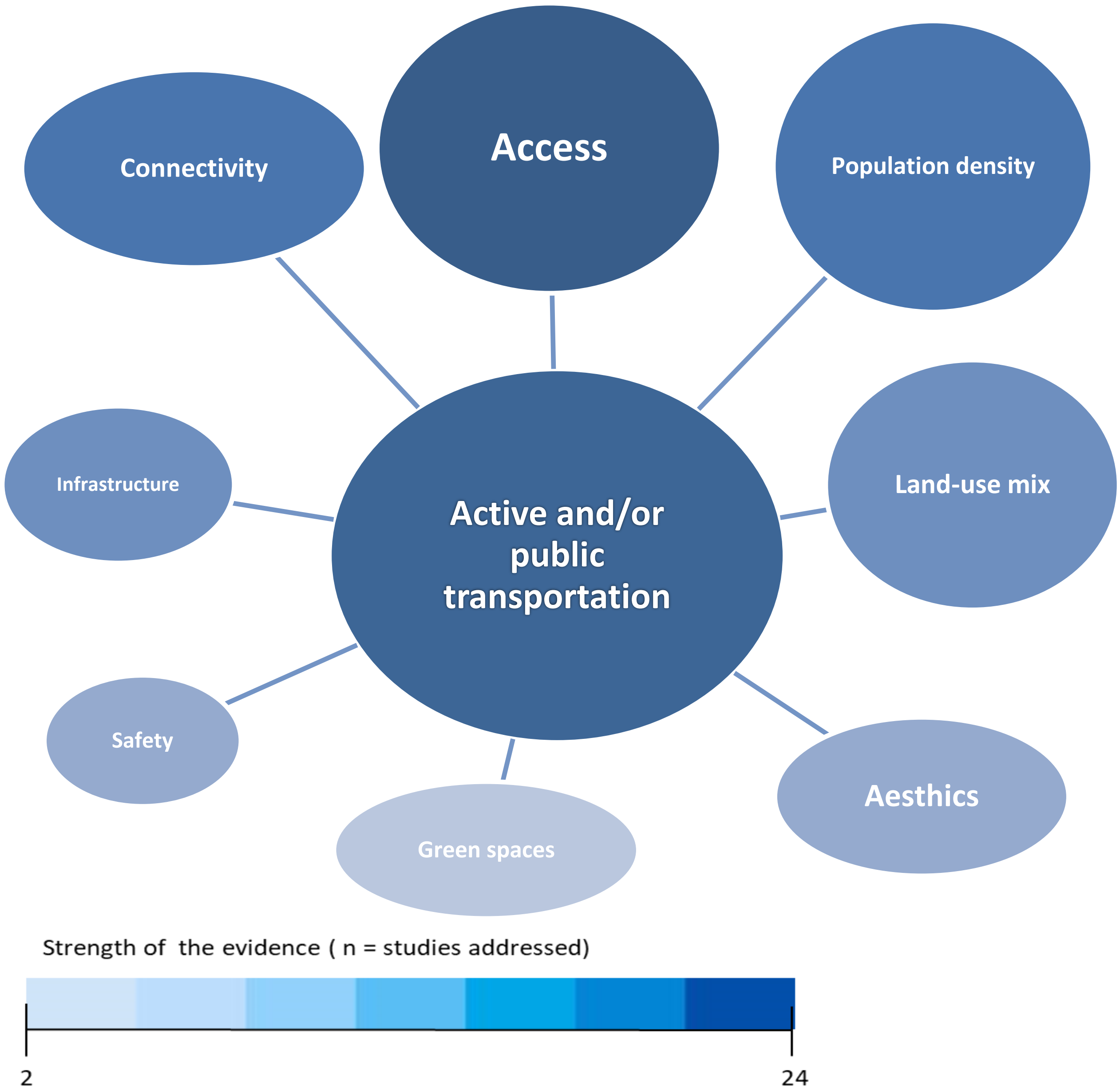
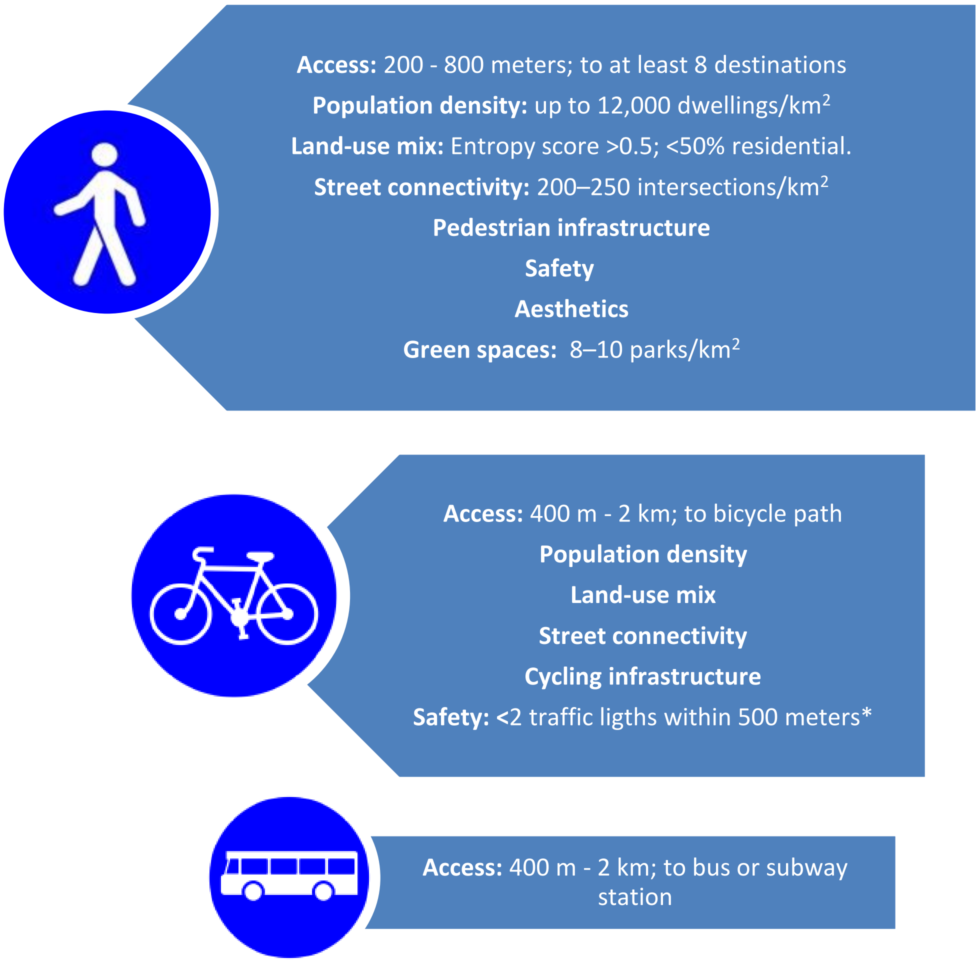


Figure 3. Indicators and benchmarks by mode of transportation



*see supplemental material

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Supplemental Material

Urban transport and health indicators: a literature review.

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Section 1. Methods

Table S1. Risk of bias

	Bias due to exposure assessment	Bias due to confounding	Bias due to selection of participants	Bias due to health outcome assessment	Bias due to not blinded outcome assessment	Total risk of bias
Low	A clear description of the exposure assessment and exposure unit; based on measurements or modeling.	All important confounders are taken into account either through matching or, restriction or in the analysis. (e.g., age, gender, etc.)	Participants randomly sampled from a known population, AND response rate higher than 60%, AND attrition rate less than 20% in follow-up studies.	The health outcome of interest is objectively measured OR taken from medical records OR taken from questionnaire or interview using a known scale or validated assessment method.	The health outcome of interest is assessed blind for exposure information in cohort and cross-sectional studies or exposure is assessed blind for being a case in case-control studies	At least 4 at low risk of bias. One “high” or “unclear” out of five is allowed.
High	Not clear description of the exposure assessment or exposure unit OR/AND performed by unqualified staff	Only 1 or no confounder is taken into account; OR subjects in exposed and unexposed groups differ for one or more important confounders and there is no adjustment in the analysis	No random sampling OR response rate less than 60% OR attrition rate higher than 20%.	The health outcome of interest is self-reported and not assessed using a known scale or validated assessment method	The health outcome and/or exposure assessment is not blinded.	Any other.
Unclear	If not enough information is available to judge the above	Less then all to > 1 important confounders taken into account, OR Insufficient information to decide on one of the above.	No information to judge the above.	Not sufficient information reported to assess the above.	Not sufficient information reported to assess the above.	
Not Apply		NA	NA		NA	

Table S2. Certainty of the evidence

Certainty of the evidence	Study design
High certainty	Meta-analysis from trials, quasi-experimental or longitudinal studies
High certainty	Trial
High certainty	Quasi-experimental
High certainty	Cohort study
High certainty	Case-control study
Low certainty	Mata-analysis from cross-sectional
Low certainty	Cross-sectional study
Very low certainty	Ecological study

Table S3. Study Quality

Study quality	Certainty of the evidence	Risk of Bias	Exposure response gradient (yes / no)	Magnitude of effect (High [RR>1.5 OR <0.75] / Low [any other])	Imprecision (Yes (sample size was fewer than 200 cases AND the 95% CI included an important effect [When the 95% CI includes no effect OR when RR > 1.25 or RR < 0.75 OR standard deviation > mean]) / No (any other))
High	High certainty	Low	Yes	High	No
Moderate	High certainty	High	Any	Any	Any
Low	Low certainty	Any	Any	Any	Any
Very low	Very low certainty	Any	Any	Any	Any

Table S4. Quality of the evidence

Quality of evidence	Definition	Examples of when this is the case
High	Further research is very unlikely to change our confidence in the estimate of effect	Several high-quality studies with consistent results
Moderate	Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate	One high-quality study / Several studies with some limitations (non-high quality)
Low	Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate	One or more studies with severe limitations (non-high quality)
Very low	Any estimate of effect is very uncertain	No direct research evidence / One or more studies with very severe limitations (non-high quality)

Section 2. Results

Density

Density was defined for the most part as either population density, the number of resident per km^2 within participant's buffer area; or residential density the number of dwellings per km^2 within participant's buffer area. Walking was positive associated to increase in density in nine studies ((Liao et al., 2017)(Buck et al., 2015)(Christiansen et al., 2016)(Lee and Moudon, 2006)(Turrell et al., 2013)(MacDonald et al., 2010)(Lachapelle and Frank, 2009)(Hooper et al., 2015)(Bentley et al., 2014)). For cycling one study identified a positive association with density (Christiansen et al., 2016). Additionally one study identified a positive association between density and participants' engaging in moderate-to-vigorous physical activity (Buck et al., 2015). In relation with public transport no studies found a positive association with increased density. In terms of health outcomes density was associated to moderate-to-vigorous physical activity (Buck et al., 2015), a reduction in BMI (Koohsari et al., 2018; Lovasi et al., 2009)(MacDonald et al., 2010), and a reduction in incident overweight, obesity, and diabetes mellitus (Glazier, Richard H., Creatore, 2014). 12,000 dwellings/km^2 was reported as density benchmark to increase active transport (Christiansen et al., 2016).

(Bentley et al., 2014) found that for every 5 dwelling/hectare increase in residential density, within a 1-km buffer area, participants engaged in almost four additional minutes of walking for transport (OR: 3.90 (CI: 3.31, 4.49)) and were twenty percent more likely to engage in any walking for transportation (OR: 1.20 (CI: 1.42, 1.56)). (Christiansen et al., 2016) found on their multi-centered study that for every unit increase in residential dwellings within 1-km buffer area, participants were three percent more likely to engage in cycling for transport (OR: 1.03 (CI: 1.01, 1.04)). Additionally, (Christiansen et al., 2016) was exceptional in finding on their study that the odds of walking for transport were positively associated with residential density up to a density of 12,000 dwellings/km^2, within 500 m buffer, but negatively thereafter (OR: 2.51 (CI: 1.19, 5.34)).

Distinctively, (Hooper et al., 2015) used block density as an indicator in their study instead of residential or population density, and found that for a one unit increase in block density participants were five times more likely to engage in more than 60 minutes of walking for transport weekly (OR: 5.05 (CI: 2.10, 12.1)). Additionally, (Hooper et al., 2015) proposed the walk-able block ratio, defined as the number of blocks that are less than or equal to 620 meters in perimeter divided by the total amounts of block; and found that for every one unit increase in the walk-able block ratio participants were more than four times as likely to engage in any walking for transport (OR: 4.38 (CI: 3.24, 5.91)) and more than twice as likely to engage in more than 150 minutes of walking for transport weekly (OR: 2.27 (CI: 1.40, 3.68)). (Hooper et al., 2015) used density of food and alcohol outlets within a half mile buffer from participants' home as predictor of walking for transport and also found a positive association (OR: 1.25 (CI: 1.04, 1.51)). Additionally, (Buck et al., 2015) found public transport density to be associated with a 3% increase in participants engaging in moderate-to-vigorous physical activity (β: 0.03 (p value = 0.02)).

In terms of health outcome, an increase population density was associated with a decrease in BMI (β: -0.34 (CI: -0.54, -0.15), (Koohsari et al., 2018)). Additionally, (Glazier, Richard H., Creatore, 2014) found in their study that participants living in the lower quartiles of both residential and population density were more likely to be overweight (OR: 1.31 (CI: 1.16, 1.47)/ OR: 1.26 (CI: 1.11, 1.41)), obese (OR: 1.44 (CI: 1.02, 1.85)/ OR: 1.42 (CI: 1.01, 1.83)), and to suffer from diabetes mellitus (OR: 1.16 (CI: 1.16–1.16)/ OR: 1.33 (CI: 1.33, 1.33)) than those living in higher quartiles of residential and population density.

Connectivity

Connectivity was defined for the most part as street connectivity, the number of intersections (usually three-way or more) per km^2 within participants' buffer area. Walking was positively associated to increase in connectivity in nine studies (Liao et al., 2017)(Shay et al., 2009)(Rachele et al., 2018)(Christiansen et al., 2016)(Koohsari et al., 2016)(Turrell et al., 2013)(Hooper et al., 2015)(Knuiman et al., 2014)(Bentley et al., 2014). For cycling one study identified a positive association with increased street connectivity (Christiansen et al., 2016). In relation with public transport no studies found a positive association with increased connectivity. In terms of health outcomes connectivity was associated to moderate-to-vigorous physical activity (Buck et al., 2015) a decrease in BMI (Koohsari et al., 2018)(Smith et al., 2008), and a reduction in incident overweight, obesity, and diabetes mellitus (Glazier, Richard H., Creatore, 2014). 200–250 intersections/km2 was reported as street connectivity benchmark to increase active transport (Christiansen et al., 2016)

(Bentley et al., 2014) in their study found that for 1 unit increase in the number of four-way intersections within 1-km buffer area, participants were almost fifty percent more likely to engage in any walking for transportation (OR: 1.49 (CI: 1.42, 1.56)) and engaged in more than six additional minutes of walking for transport weekly (OR: 6.20 (CI: 5.13, 7.28). (Koohsari et al., 2016) also found an increase in intersection density to be associated with a four percent increase in participants' frequency of walking for transport (β: 0.04 (CI: 0.00, 0.09)). (Christiansen et al., 2016) found the increase in number of three or more intersections per km^2 within 500 m of participants home to be associated with increased odds of cycling for transport (OR: 1.32 (CI: 1.01, 1.73)). Notably, (Christiansen et al., 2016) found the odds of walking for transport positively related to intersection density up to values of 200–250 intersections/km^2 within a 1-km buffer and negatively thereafter (OR: 1.71 (CI: 1.42, 2.04)).

Distinctively, (Rachele et al., 2018) used the number of walking catchments within a 400 meter buffer area of participant's home to define street connectivity; and found that participants living in neighborhoods with high number of walking catchments were more likely to engage in one to sixty minutes of walking for transport (OR: 1.76 (CI: 1.37, 2.28)) and to engage in sixty to one hundred and fifty minutes of walking for transport (OR: 1.40 (CI: 1.10, 1.78)) than those living in in neighborhoods with low number of walking catchments. On another hand, (Hooper et al., 2015) utilized number of pedestrian-friendly access points along a housing development perimeter in Perth, Western Australia, as a measure of connectivity for the RESIDE project, a five-year research project that aims to evaluate the impact of urban design on health and found that for every unit increase in the number of access points participants were over 30% more likely to engage in walking for transportation (OR: 1.35 (CI: 1.06, 1.73)).

In terms of health outcomes, an increase in intersection density was associated with a decrease in BMI (β: -0.26 (CI: -0.46, -0.06), (Koohsari et al., 2018)). Additionally, (Glazier, Richard H., Creatore, 2014) found in their study that participants living in low quartiles of street connectivity were more likely to suffer from diabetes mellitus (OR: 1.38 (CI: 1.38, 1.38)) than those living in higher quartiles of street connectivity.

Access

Access served as one of the strongest predictors of active transport. Access was defined as either distance to or the presence of public transport elements; or the availability of walk-able destinations. Walking was positively associated to an increase in access in thirteen studies (Cerin et al., 2007)(Krizek and Johnson, 2005)(Lachapelle and Frank, 2009)(Goodman et al., 2014)(Kim and Hyun, 2018)(Liao et al., 2017)(Koohsari et al., 2016)(Liao et al., 2017)(Lee and Moudon, 2006)(Lachapelle and Frank, 2009)(Hooper et al., 2015)(Knuiman et al., 2014)(Hino et al., 2014). For cycling four studies identify a positive association with access (Krizek and Johnson, 2005)(Troped et al., 2001)(Florindo et al., 2018)(Rissel et al., 2015). In relation with public transport one study found a positive association with increased access (Panter et al., 2016). In terms of health outcomes access was associated to moderate to vigorous physical activity (Kim and Hyun, 2018), a reduction in BMI (Lovasi et al., 2009)(Koohsari et al., 2018)(Brown et al., 2015) and a reduction in incident overweight, obesity, and diabetes mellitus (Glazier, Richard H., Creatore, 2014). Distance to bicycle paths, bus stations, and subway stations from less than 400 meters to up to two kilometers were reported as access benchmarks to increase active and public transport (Florindo et al., 2018; Rissel et al., 2015)(Goodman et al., 2014; Krizek and Johnson, 2005; Troped et al., 2001)(Brown et al., 2017; Lovasi et al., 2009; Panter et al., 2016). Additionally, distances to at least eight types of destinations from less than 200 meter to up to 800 meters, were also reported as access benchmarks to increase active transport. (Cerin et al., 2007; Knuiman et al., 2014; Krizek and Johnson, 2005)(Glazier, Richard H., Creatore, 2014; Koohsari et al., 2016)(Liao et al., 2017)(Hooper et al., 2015)(Lachapelle and Frank, 2009) (Chiu et al., 2016) , (Su et al., 2017).

(Florindo et al., 2018) found access to a bike path up to 500 meters from participant's residential address to be associated with a significant increase in participants' cycling for transportation (OR: 2.54 (CI: 1.16,5.54)). In the same study access to bus or subway station between 500 meter and 1500 meters from participants' residential address was also associated with an increase in participants' cycling for transport (2.07 (CI: 1.1, 3.86)). Additionally, (Krizek and Johnson, 2005) found in their study that a distance to the nearest bicycle path of less than 400 m also increased the odds of overall cycling by participants by more than twice (OR: 2.23 ($p<0.05$)).

Furthermore, (Troped et al., 2001) in their study of the use of a community rail-trail named "Minuteman Bikeway" in Arlington County, Virginia, found both perceived and objectively measure distances from the rail-trail to be inversely associated with participants use of the trail (perceived: OR: 0.65 (CI: 0.54, 0.79 / objective: OR: 0.58 (CI: 0.45, 0.73)). Similarly, (Goodman et al., 2014) as part of their study of the Connect2 project, brand-new walking and cycling roads constructed in Cardiff, Kenilworth, and Southampton, U.K.; found participants living closer to the project (< 1 km) engaged in more minutes of walking and cycling for transport weekly at one year and at two year post-intervention than participants living farther away (1-y: b: 4.6 (CI: -4.2,13.4), 2-y: b: 15.3 (CI: 6.5, 24.2)). Notably (Rissel et al., 2015) in their study of another new bicycle path developed in Sidney, Australia found perceived access to bicycle path to be more strongly associated with participants odds of using the bicycle path (OR: 3.58 (CI: 2.01, 6.40)) than objective distance at 100 and 500 meters from the bicycle path (OR: 1.04 (CI: 1.02, 1.06) / OR: 1.24 (CI: 1.13, 1.37)). Distinctively (Brown et al., 2015) in her study of a light rail line extension in

Salt Lake city, Utah; found that increased access to rail line through creation of 5 additional stops increased new riders of the line's objectively measured (accelerometer) physical activity (β: 37.40 (CI: 10.41, 64.39)) and was associated with a decrease in BMI (β: -0.50 (CI: -0.93, -0.08)).

(Knuiman et al., 2014) was exceptional exploring access on a housing development in Perth Western, Australia as part of the RESIDE project. In their study they found having access to 15 to 29 bus stops within 1,600 meter of participants' home increased their odds of walking for transport over time by nearly twice OR: 1.99 (CI: 1.46, 2.71) and even more so for 30 bus stops or more (OR: 2.33 (CI: 1.57, 3.45)). Additionally, in the same study, researchers found the presence of a railway station within in the same buffer area to also increased participant's odds of walking for transport over time (OR: 1.79 (CI: 1.02, 3.16)). In a different setting, (Hino et al., 2014) found access to 2 or more bus rapid transit station within 500 m of participants' home to be associated with a 50% increase in any walking transport done by participants weekly (OR: 1.50 (CI: 1.22, 1.84). Furthermore, (Heinen et al., 2014) found proximity to a bus-way stop of at most 4 km to be associated with more than a 50% increase in bus use (OR: 1.53 (CI: 1.15, 1.02)) in adults who worked in areas of Cambridge to be served by The Cambridgeshire Guided Busway. While, (Lachapelle and Frank, 2009) found in adults living in urban Atlanta, Georgia, that a distance from 450 meters to 1 km to the nearest transit stop increased over six time the likelihood of participants walking up to 2.4 km daily (OR: 6.54 ($p=0.000$)). Distinctively (Lachapelle and Frank, 2009) found increased access to public transportation through employer sponsored transit passes to be associated with participants' meeting recommended levels of physical activity. (OR: 4.96 ($p=0.000$)).

(Cerin et al., 2007) utilized perceived proximity to destinations in their analysis and found proximity to workplace to be associated with participants engaging in 15 additional minutes of transport related walking, weekly (b: 7.1 (CI -4.6, 18.8)). (Liao et al., 2017) also used the presence of destination as a predictor active transport and found an association between the increase of available destination and the odds of participants engaging in more than 150 minutes of walking for transport weekly (OR: 2.39 (CI: 1.60, 3.58)). (Perchoux et al., 2017) in their study also identified an association between the availability of destinations and a decrease in sedentary modes of transportation among French women (OR: 0.64 (CI: 0.49, 0.82)). Finally, (Krizek and Johnson, 2005) in their study, found a distance of less than 200 meter to the nearest retail establishment (food and beverage services, health and personal care stores etc…) increased the odds of overall walking by participants by more than twice (OR: 2.51 ($p<0.05$)).

Finally in terms of health outcomes, (Koohsari et al., 2018) found an increase in access to public transportation, defined as the number of train stations and bus stops per km^2 within 800 m buffer around participant's home, to be associated with a decrease in participants' BMI (β: -0.22 (CI: -0.41, -0.02)). In another study, (Glazier, Richard H., Creatore, 2014) found participants living in neighborhood of low availability of walk-able destinations to be at greater odds of suffering from diabetes mellitus (OR: 1.26 (CI: 1.26, 1.26)) than those with high availability of destinations.

Land use mix

Land use mix was also reported as a predictors of active transportation. Land use mix is defined as land uses that are located together in a balanced mix, including residential development, shops, employment community and recreation facilities and parks and open space. Most of the selected studies used an entropy score from 0-1 in their analysis to represent land use mix; 0 representing a completely homogenous land use and 1 representing a completely heterogeneous land use. Walking was positively associated to heterogeneous land use in seven studies (Christiansen et al., 2016)(Cerin et al., 2007)(Turrell et al., 2013)(Hino et al., 2014)(Knuiman et al., 2014)(Bentley et al., 2014)(Lee and Moudon, 2006). For cycling one study identify a positive association with land use mix (Christiansen et al., 2016). In relation with public transport no studies found a positive association with heterogeneous land use mix. In terms of health outcomes land use mix was associated to a reduction in BMI (Lovasi et al., 2009), and an increase in self-perceived physical and mental health (Hino et al., 2014). Residential land use of no more than 53% to 68% and commercial land use of at least 6% to 17% were reported as land use mix benchmarks to increase active transport and improve health (Hino et al., 2014).

(Bentley et al., 2014) found the more heterogeneous the land use the greater the odds of participants engaging in walking for transportation (OR: 1.39 (CI: 1.31, 1.46)), and found participants to engage in six additional minutes of walking for transport weekly (OR: 5.59 (CI: 4.28, 6.90)). Similarly, (Turrell et al., 2013) in their study found a highly mixed land use to be associated with greater odds of participants engaging in more than 150 minutes of walking weekly (OR: 1.62 (CI: 1.02, 2.58)). (Knuiman et al., 2014) also found in their study high land-use mix to be associated with participants odds of transport walking over time (OR: 1.33 (CI: 1.16, 1.52)). (Christiansen et al., 2016) in their study found highly mix land-use measured at 500 m and at 1 km from participants' homes to be associated in both cases with higher odds of participants walking for transport (OR: 1.48 (CI: 1.17, 1.86)/ OR: 1.52 (CI: 1.17 1.97)); and cycling for transport (OR: 1.26 (CI: 1.09, 1.47)/ OR: 1.35 (CI: 1.11, 1.64)). Inversely, (Troped et al., 2001) found heterogeneous land-use to be negatively associated with odds of cycling for transport (OR: 0.56 (CI: 0.36, 0.86)). However, both studies present low certainty of evidence.

Notably (Hino et al., 2014) explored active transportation at different levels of land-use mix, however found little difference in odds of walking for transport at different levels of land-use mix. Exceptionally, (Hino et al., 2014) found higher levels of land use heterogeneity (entropy scores of 0.48 -0.62 and more than 0.62) to be associated with an increase in participant's self-perceived physical and mental health (OR: 1.1 (CI: 0.8, 1.6) / OR: 1.6 (CI: 1.1, 2.5)); and an increase in WHO-QOL scores, though only statistically significant for an entropy score of 0.48-0.62 (β: 1.8 (p=0.047)/ β: 1.3 (p=0.189)).

(Chiang and Lei, 2016) ranked land-mix as the fourth most important indicator in their expert-opinion analysis of indicators of urban friendliness for walking environments.

Pedestrian infrastructure

The presence of pedestrian infrastructures, mainly sidewalks, for the population to walk and cycle on, acts as another predictor of active travel in the selected studies. Walking infrastructure was positively associated to increase walking in 4 studies (Liao et al., 2017)(Shay et al., 2009)(Troped et al., 2003)(Hooper et al., 2015). Cycling infrastructure was positively associated to increase cycling in one studies (Troped et al., 2003). In terms of health outcomes pedestrian infrastructure was associated to a reduction in BMI (Jensen et al., 2017). However, no infrastructure benchmarks were reported to increase active transport and public transport.

(Chiang and Lei, 2016) in their expert-opinion study ranked the availability of sidewalk facilities as the number two indicator for urban friendliness of walking environments.

(Troped et al., 2003) in their study of physical activity among adults in a New England community, found participants' perceived presence of sufficient sidewalk to be associated with significantly higher transportation physical activity among participants (c: 47.75 (p=0.04)). Similarly, (Liao et al., 2017) found in their study, participants' perceived presence of sidewalks to be associated with higher odds of participants engaging in more than 150 minutes of walking for transport, weekly (OR: 1.93 (CI: 1.37, 2.72)). Notably (Shay et al., 2009) in their study of objective measures of environmental supports for pedestrian travel in adults in Montgomery County, Maryland; found sidewalk conditions, determined visually with a descriptive quality assessment rubric, and the presence of crossing aid, such as stop lights, stop signs, pedestrian island and pedestrian-supportive signage, to be associated with participants engaging in more weekly walking trips for transport (IRR: 1.85 (CI: 1.30, 2.62)) / (IRR: 1.15 (CI: 0.8, 1.65)). Distinctively (Perchoux et al., 2017) in her analysis of active transport behavior in French women, found the presence of bicycle path to be associated with a reduction in sedentary modes of transportation among study participants (OR: 0.70 (CI: 0.53, 0.91)).

Aesthetic

Aesthetic was reported as a predictor of active transport in the selected studies. Aesthetics was positively associated to increase walking in one study (Troped et al., 2003). Aesthetics was not positively associated with cycling and public transport in any of the studies. No aesthetics benchmarks were reported to increase active transportation.

(Chiang and Lei, 2016) in their expert-opinion analysis ranked aesthetics as the third indicator of urban friendliness for walking environments, with emphasis on cleanliness and the presence of trees and natural sights. However, only (Troped et al., 2003) found enjoyable scenery to be a statistically significant predictor of transportation physical activity (c: 48.94 (p=0.03)).

Safety

Safety was reported as a predictor of active transport in the selected studies. Walking was positively associated with safety in two studies (Jensen et al., 2017)(Troped et al., 2003). Cycling was positively associated with safety in one study (Troped et al., 2001). Safety was not positively associated with public transport use in the studies. No safety benchmarks were reported to increase active transport.

(Chiang and Lei, 2016) in their expert-opinion analysis, ranked safety as the most important indicator of urban friendliness for walking environments. (Jensen et al., 2017) on their longitudinal assessment of a "complete street" intervention in Salt Lake City, Utah found participants' perceived safety from crime and traffic to be associated with active transport on the "complete street" (OR: OR: 1.05 (CI: 1.01, 1.09)/ OR: 1.07 (CI: 1.03, 1.11)). Similarly, (Troped et al., 2001) in his study of the use of the Minuteman Bikeway; found that the lack of a busy street barrier to be associated with increased use of the intervention (OR: 2.01 (CI: 1.11, 3.63)). On another study, (Troped et al. 2003) found safety, in this case defined as perceived presence of sufficient street lighting, to be a statistically significant predictor of transportation physical activity from the selected studies (c: 42.7 (p=0.05)). Distinctively (Hino et al., 2014) found in their study that the presence of two or more traffic light within a 500 m buffer of participants home actually decreased odds of engaging in any cycling for transport (OR: 0.27 (CI: 0.09, 0.84)).

Green Space

Green space, defined as the presence of parks within participants' buffer area, was another indicator reported as a predictor of active transportation. Walking was positively associated to access to green space in two studies (Christiansen et al., 2016)(Hooper et al., 2015). Cycling and public transport were not positively associated to green space in the studies. Distance to parks from less 400 meters to up to 2.5 kilometers were reported as green space benchmarks to increase active transport (Hooper et al., 2015).

(Hooper et al., 2015) in their longitudinal cohort study of adults moving to a new housing development in metropolitan Perth, Western Australia, found for every 1 unit increase in number of trees per km of footpath in the development participants were at higher odds of walking for transport (Any walking: OR: 1.04 (1.03, 1.06)/ ≥60 minutes of walking: OR: 1.02 (CI: 1.01, 1.04)). Additionally, researcher founds the number of regular parks (Any walking: OR: 1.08 (CI: 1.03, 1.13); the number of regional parks (Any walking: 3.97 (CI: 2.46, 6.41)/ ≥ 60 minutes of walking: 1.99 (1.83, 2.17); the number medium size parks (0.5 – 1.5 ha)(≥ 60 min: OR: 1.09 (CI: 1.05, 1.12)); and the number of small parks (0.3-0.35 ha)(OR: Any walking: OR: 1.13 (CI: 1.02, 1.25)) to be positively associated with walking for transport.

(Christiansen et al., 2016) in their multi-centered analysis found access to green spaces, defined as the number of parks at 500 meter and at 1 km from participants' home to be positively associated with walking for transport, but without statistical significance (walking: 500 m: OR: 1.03 (CI: 1.00, 1.06); 1 km: OR: 1.00 (CI: 0.97, 1.03). Notably, in this study researchers found the number of parks to be positively associated with walking for transport to up to 8–10 parks/km^2 while a negative gradient in the odds was found for those with more than 20–25 parks/km^2.

Composite Indicators

Nine of the studies utilized composite indicators, which take into account various elements of the built environment to estimate neighborhood walkability into a single score. One example is the "Walk Score" which estimates walkability of any address using a patented system that takes into account amenities within walking distance, and pedestrian friendliness analyzed through population density and road metrics such as block length and intersection density ("Walk Score Methodology," n.d.). (Chiu et al., 2016) demonstrated utilizing the "Walk Score" that moving from a low-walkability neighborhood to a high-walkability neighborhood in accordance to the aforementioned reduced incident hypertension by nearly half in the studied population (hazard ratio (HR) = 0.46; 95% confidence interval (CI): 0.26, 0.81).

Another example is the Neighborhood Environment Walkability Scale (NEWS) which takes into account residential density, land use-mix access, street connectivity, pedestrian infrastructure, aesthetics, traffic and crime safety, and perceived distance to local destination to estimate neighborhood walkability. (Kerr et al., 2016) found all elements of the NEWS to be significantly associated with both cycling and walking for transport, with the exception of perceived traffic safety (OR: 0.92 (CI: 0.86, 0.97)) and crime safety (OR: (OR: 0.99 (CI: 0.93, 1.05)). Notably, (Kerr et al., 2016) much like (Christiansen et al., 2016) found a significant positive association between residential density and walking for transport only up to a perceived density score of approximately 500 (range 0-1044) , and flat or negative for higher scores. (Koohsari et al., 2018) found a high NEWS score to be associated with nearly a 30% reduction in BMI in Japanese adults (β: -0.29 (CI: -0.49, -0.09)). However, (Nyunt et al., 2015) in their study found none of the elements of the NEWS score to be associated with walking for transportation for older adults over 55 years of age.

(Zhu and Yoon, 2017) utilized another Walkability Score this time in elementary school children from Austin, Texas. This score took into account land use, traffic safety and sidewalk conditions en route to school; however only good conditions of sidewalk was found to be associated with a shift from sedentary to active modes of commuting to school (OR: 1.43 (p value = 0.028)).

(Glazier, Richard H., Creatore, 2014) utilized the "Walkability Index" which took into account population density, residential density, availability of walk-able destinations, and street connectivity, and found that participants living in low Walkability Index score neighborhoods were at greater odds of being overweight (OR: 1.18 (CI: 1.05, 1.33)) and suffering from diabetes mellitus (OR: 1.33 (CI: 1.33, 1.33)) compared to those living in high Walkability Index score neighborhoods. (Frank et al., 2006) used another “Walkability Index[2]”, this one only took into account net residential density, street connectivity, and land-use mix. Researchers found a high Walkability Index[2] in this context to be associated with a reduction in participants BMI (β: -0.113 (sig. 0.000)), a reduction in vehicular miles of travel (β: -0.157 (sig. 0.000)); a reduction in grams of transportation-related NO_x emissions per capita (β: -0.140 (sig. 0.000)); and a reduction in grams of transportation-related VOC emissions per capita (β: -0.139 (sig 0.000)).

(MacDonald et al 2010) also utilized a composite indicator of “Social and physical environment” in their study, which took into account overall perception of neighborhood environment within 15 min walk of each participants' home, including litter/trash in the streets, vacant housing or store fronts, poorly maintained property, access to parks or recreational facilities, traffic and crime, among others. Researchers found a lower rates of BMI (OR: -0.358 ($p<0.05$)) and obesity (OR: 0.85 (CI: 0.77, 0.94)) and an increase in reported physical activity (OR: 1.11 (CI: 1.01, 1.22)) in participants living in high quartiles of “social and physical environment” than those in lower quartiles.

(Giles-Corti et al., 2011) proposed the use of a school-specific Walkability Index[3], which took into account street connectivity and vehicular traffic exposure; and found children attending school around poorly connected streets to be less likely to regularly walk to school (OR: 0.32 (CI: 0.22, 0.74)); in the same manner, without statistical significance, high exposure to vehicular traffic was also associated with less walking to school (OR: 0.68 (CI: 0.44, 1.06)).

Finally, (Su et al., 2017) was exceptional in the proposal of the “Adjusted Walk Score”, which took into account amenities and their utilization frequency in accordance to the studied population (Chinese adults), the walking travel time from community to each amenity, and three pedestrian characteristic factors (intersection density, block length, and slope). In their analysis, (Su et al., 2017) found a high “Adjusted Walk Score” to be associated with a reduction in the studied population incident hypertension (R^2: 0.14 ($p<0.01$)), a reduction in incident cardiopathy (R^2: 0.26 ($p<0.01$)), and a reduction in incident liver cancer (R^2: 0.05 ($p<0.01$)).

Risk of bias

From the 46 selected articles for analysis majority presented an overall low risk of bias (n=33) and thirty three were assessed as low quality studies.

Thirty two articles presented an overall low risk of bias. However the majority of the studies (n = 34) were observed as having high risk of bias due to health outcome assessment. Rationale behind this is the overall use of self-reported surveys to gather data on health outcomes, specifically self-reported walking for transportation, and other forms of active travel, which were the most common health outcome assessed in the included studies. The accuracy of questionnaire responses by participants may be subject to recall bias. (Jensen et al., 2017) and (Brown et al., 2015) were a few of the studies which employed mapped GPS and accelerometer data as objective measures that participants indeed engaged in active transportation and thus were of the few which presented low risk of bias due to health outcome assessment.

Virtually no study presented a high risk of bias due to confounding, as each employed significant effort taking into account of all important confounders either through adjusting, matching, or restriction in the analysis. Additionally, risk of bias due to selection of participants was also low throughout the included studies as each employed appropriate methods of sampling and randomization, however, studies which presented a population response rate below 60% were classified as having a risk of bias due to selection of participants. Finally, risk of bias due to a not blinding outcome assessment remained unclear for many of the selected studies, as given the nature of urban environmental research, studies did not sought the need to specify whether their assessment was blinded or not; however, a mode of blinding was applied in majority of the selected studies which entailed geocoding participants' home addresses into a specified buffer area (usually 200 m) as for researchers not to know the exact location of participants home.

Study quality

Overall study quality was low (n=33). Rationale behind this is that these studies were cross-sectional in design, thus regardless of study characteristics the quality of the evidence remains low. Only (Chiu et al., 2016) longitudinal cohort study analyzing the change between low-walkability neighborhood to high walkability neighborhood in accordance to the Walk Score; and (Hooper et al., 2015) and (Knuiman et al., 2014) longitudinal cohort of adults moving to a new housing development in metropolitan Perth, Western Australia were studies with a high quality of evidence; (Brown et al., 2017) was another study of high quality of evidence; (however, this last one do not found statistical significance on its findings). Finally a total of eight from the selected study showed a moderate study quality, although all of them had high quality of evidence based on study design and risk of bias, they fell short of demonstrating a dose-response relationship between indicators and health outcomes. Additionally, (Zhu and Yoon, 2017) presented a very low quality as study design was a simple retrospective survey on elementary school children walking behavior.

Inconsistencies

Four inconsistencies were identified throughout the selected studies. (Jensen et al., 2017) found aesthetics to be negatively associated with participants'' odds of engaging in active transport (OR: 0.95 (CI: 0.91, 0.99)). (Kerr et al., 2016) found perceived traffic safety to be negatively associated with walking for transportation (OR: 0.95 (CI: 0.91, 0.99)). (Nyunt et al., 2015) found various subjective elements of the Neighborhood Environment Walkability Scale (NEWS - modified) to be negatively associated with transport physical activity. While, (Troped et al., 2001) found mix land use to be negatively associated with participants' odds of using the Minuteman Bikeway intervention in Arlington, Massachusetts (OR: 0.56 (CI: 0.36, 0.86)).

Table S5. Literature selection according to database

	Titles Screened	Abstracts Screened	Full-text review	Kept for data extraction/ analysis
PubMed	8,067	48	21	10
Google Scholar	948*	34	17	1
Hand Search	-	-	22	19
Science Direct	94 98	14 7	17	2
Scopus	893	54	31	0
From Literature Reviews			22	13
Total	10,100	157	130	45

*First 98 first pages of the result search for Google Scholar were screened out of a total of 10,008 pages

Table S6. Urban transport indicators and health (full table)

		Population		Setting		Indicator/exposure			Outcome		Change			
Reference (Author, Year)	**Mode of transport (walking, cycling, car, motorcycle, bus, metro, tram, train, gondola, etc)**	**Number of participants**	**Participants characteristics (sex, age, SES, other)**	**Study location (City/s, country/s)**	**Setting characteristics (urban, sub-urban, rural / deprived communities / other)**	**Indicator**	**Indicator definition**	**Benchmark indicator**	**Health outcome & definition (disease, injury, mortality, life expectancy, quality of life, other)**	**Health determinant & definition (physical activity, accidents, air pollution, noise pollution, other)**	**Change in health outcome or health determinants (central point and ranges/confidence intervals)**	**Unit of change (%, Cases, RR, HR, others)**	**Study design (Expert recommendation, Ecological, Cross-sectional, longitudinal, quasi-experiential, trial, meta-analysis)**	**Study quality (high, moderate, low, very low)**
Rebecca Bentley, Tony Blakely, Anne Kavanagh, Zoe Aitken, Tania King, Paul McElwee, Billie Giles-Corti, Gavin Turrell 2017	Walking	11035	Middle aged adults (40-65 years old)	Brisbane, Australia	Urban	**Street connectivity**	number of four-way intersections within 1-km buffer	1-unit increase in street connectivity (representing 10 additional intersections)		Increase in walking for transportation - physical activity	**Any walking for transport** **Minutes of walking for transport**	OR: 1.49 (CI: 1.42, 1.56) OR: 6.20 (CI: 5.13, 7.28)	Longitudinal cohort	Moderate
						Density	number of dwellings per hectare of residential land in within 1-km buffer	1-unit increase (5 dwelling/hectare increase in residential density)			**Any walking for transport** **Minutes of walking for transport**	OR: 1.20 (CI: 1.42, 1.56) OR: 3.90 (CI: 3.31, 4.49)		
						Land-use mix	based on five types of land use within each 1-km buffer	0 (homogenous) - 1 (heterogeneous)			**Any walking for transport** **Minutes of walking for transport**	OR: 1.39 (CI: 1.31, 1.46) OR: 5.59 (CI: 4.28, 6.90)		

Kim Bongjeong Hyun Hye Sun 2018	Cycling	128,735	adults age 19 and older	Korea	rural and urban setting	**Prescence of cycle paths**	N/A	N/A	Moderate to vigorous physical activity (MVPA)	Increase walking - physical activity	**MVPA**	Urban: OR: 0.99 (CI: 0.815, 1.148) Rural: OR: 1.33 (CI: 1.007, 1.751)	Cross-sectional	Low
Christoph Buck Tobias Tkaczicks Yannis Pitsiladis et al. 2014	Walking	400	2-to-9 year old children	Delmenhorst, Germany	urban	**Intersection density**	Number of intersection per km2	within 1 km	Moderate to vigorous physical activity (MVPA)	Increase in active transportation - physical activity	**MVPA**	β: 0.002 (p value = 0.09)	Cross-sectional	Low
						Public transit density	N/A	within 1 km				β: 0.03 (p value = 0.02)		
						Residential density	Number of residents per km2	within 1 km				β: 0.00005 (p value = 0.01)		
						Land use mix	Entropy of land use type	0 - 1				β: -0.197 (p value = 0.049)		
Barbara B. Brown, Ikuho Yamadab, Ken R. Smith, Cathleen D. Zick, Lori Kowaleski-Jones, Jessie X. Fana 2009	Walking	5000	adults aged 25 - 64 years	Salt Lake County, Utah, USA	Urban	**Walkability**	Density	N/A	Decrease in BMI, overweight and obesity	Increase in active transportation - physical activity	**BMI** **Being Overweight** **Being Obese**	β: -0.03 β: -0.02 β: -0.05 (p<0.05)	Cross-sectional	Low
							Street connectivity	N/A			**BMI** **Being Overweight** **Being Obese**	β: 0.04 (p< 0.05) β: 0.02 β: 0.03		

							Distance to train stops	N/A			**BMI**	β: 0.05 (p< 0.01)		
											Being Overweight	β: 0.03		
											Being Obese	β: 0.06 (p< 0.05)		
							Distance to bus stops	N/A			**BMI**	β: 0.01		
											Being Overweight	β: 0.03		
											Being Obese	β: 0.01		
Barbara B. Brown Carol M. Wemer Calvin P. Tribby Harvey J. Miller Ken R. Smith 2015	Light Rail	537	adults over 18 years of age	Salt Lake City, Utah, USA	Urban	**Access to light-rail line (intervention)**	Increased access to a light-rail line after the creation of 5 additional stops	within 2 km	BMI	Active transporta tion - physical activity	**Change in physical activity**	Former riders: β: -49.35 (CI: -78.75, -19.94) Continuing riders: β: -6.25 (CI: -34.62, 22.12) New riders: β: 37.40 (CI: 10.41, 64.39)	Quasi-experimental Longitudinal	Moderate
											Change in BMI	Former riders: β: 0.64 (CI: -0.18, 1.11) Continuing riders: β: 0.03 (CI: -0.42, 0.48) New riders: β: -0.50 (CI: -0.93, -0.08)		

Barbara B. Brown Ken R. Smith Wyatt A. Jensen Doug Tharp 2015	Light Rail	170	adults over 18 years of age	Salt Lake City, Utah, USA	Urban	**Access to light-rail line (intervention)**	Increased access to a light-rail line after the creation of 5 additional stops	within 2 km	BMI	Increase in active transportation - physical activity	**Change in BMI**	Former riders: β: 0.82 (CI: 0.13, 1.50) Continuing riders: β: -0.36 (CI: -0.91, 0.20) New riders: β: -0.38 (CI: -0.89, 0.13)	Quasi-experimental	Moderate
Ester Cerin, Eva Leslieb, Lorinne du Toitc, Neville Owenc, Lawrence D. Frank 2007	Walking	2650	adults age 20 - 65	Adeliaide, Australia	Urban	**Land use mix**	Residential Recreational Commercial / Industrial	N/A		Increase in walking for transportation - physical activity	**Total minutes of walking (weekly) per land use**	193.0 minutes 168.3 minutes 207.9 minutes	Cross-sectional	Low
						Percieved proximity to destinations	Commercial destinations				**Transport related walking (min/weekly)**	b: 8.3 (CI: -4.4, 21.0)		
							Home and auto-oriented commercial destinations					b: 7.1 (CI -4.6, 18.8)		
							Schools					b: 7.7 (CI: -2.5, 17.9)		
							Workplace					b: 15.0 (CI: 3.3, 26.7)		
							Bus/train stop					b: -1.7 (-17.7, 14.3)		
							Recreational destinations					b: -6.5 (CI: -18.5, 5.5)		

							Blue space (sea and river)				b: 4.2 (CI: -7.4, 15.7)		
Lars B. Christiansen, Ester Cerin, Hannah Badland, Jacqueline Kerr, Rachel Davey, Jens Troelsen et al. 2016	Walking	12181	adults aged 18–66 years	Australia; Belgium; Brazil; Colombia; Czech Republic; Denmark; Mexico; New Zealand; United Kingdom (UK); United States (US)	Maximized variability in environmental attributes and socio-economic status	**Net residential density**	number of dwellings per km2	500 m 1 km	Increase in walking for transport - physical activity	**Any walking for transport**	OR: 2.51 (CI: 1.19, 5.34) OR: 1.90 (CI: 0.99, 3.66)	Cross-sectional	Low
						Land use-mix	entropy score of three land-uses: residential, retail and civic	500 m 1 km			OR: 1.48 (CI: 1.17, 1.86) OR: 1.52 (CI: 1.17 1.97)		
						Street connectivity	number of intersections per km2	500 m 1 km			OR: 0.99 (CI: 0.79, 1.25) OR: 1.71 (CI: 1.42, 2.04)		
						Parks	number of parks intersecting participant buffer area	500 m 1 km			OR: 1.03 (CI: 1.00, 1.06) OR: 1.00 (CI: 0.97, 1.03)		
	Cycling					**Net residential density**	number of dwellings per km2	500m 1 km	Increase in cycling for transport - physcial activity	**Any cycling for transport**	OR: 1.01 (CI: 1.00, 1.02) OR: 1.03 (CI: 1.01, 1.04)		
						Land use-mix	entropy score of three land-uses: residential, retail and civic	500m 1 km			OR: 1.26 (CI: 1.09, 1.47) OR: 1.35 (CI: 1.11, 1.64)		

						Street connectivity	number of intersections per km2	500m 1 km			OR: 1.32 (CI: 1.01, 1.73) OR: 1.29 (CI: 1.00, 1.67)		
						Parks	number of parks intersecting participant buffer area	500m 1 km			OR: 0.99 (CI: 0.96, 1.02) OR: 0.99 (CI: 0.98, 1.01)		
Yen-Cheng Chiang, Han-Yu Lei 2016	Walking	17 university proffesors and researchers with doctoral degrees	5 landscape design 4 architechs 4 transportation specialist 4 urban planners + 3 urban development experts	United States	N/A	**Land use mix**	Land use mix-diversity Land use mix-access	**Weight (Rank)** 0.50 (1) 0.50(1)	Increase in walking - physical activity	**Weight (Rank)**	0.07 (4)	Expert opinion	Low
						Availability of sidewalks facilities	Sidewalk material Way finding aids Barrier-free design Sidewalk maintenance Sidewalk width Protective equipment against weather Amenities	0.13 (4) 0.10 (6) 0.20 (2) 0.17 (3) 0.22 (1) 0.10 (5) 0.08 (7)			0.31 (2)		

						Safety	Sidewalk continuity Sidewalk obstruction Sidewalk visibility Street lighting Buffer between road and sidewalk Pedestrian crossing aids Fear of crime	0.21 (1) 0.14 (3) 0.16 (2) 0.14 (4) 0.11 (7) 0.11 (6) 0.12 (5)				0.50 (1)		
						Aesthetic	Green ratio Building attractiveness Historical landscape Cleanliness Prescence of trees Natural sights	0.17 (4) 0.13 (5) 0.12 (6) 0.20 (1) 0.19 (2) 0.18 (3)				0.12 (3)		
Maria Chiu, Mohammad -Reza Rezai, et al. 2016	Walking	2,114	adults age >/= 20	Ontario, Canada	low-walkability neighborhood → high walkability neighborhood	**Walk Score (Walkability)**	Walkability of any address using a <u>patented</u> system.	90–100 - Daily errands do not require a car. 0–24 Car-Dependent Almost all errands require a car	Hypertension	Increase walking for transportation - physical activity	**Incident hypertension**	HR: 0.46; (CI: 0.26, 0.81)	Longitudinal cohort	High
Alex Antonio Florindo Ligia Vizeu Barrozo et al. 2017	Cycling	3111	adults age 18 or more	Sao Paulo, Brazil	Latin American context	**Access to bike path only**	Distance to bike path	Up to 500 m Between 500 - 1500 m		Increase cycling for transportation - physical activity	**Cycling for transportation**	OR: 2.54 (CI: 1.16,5.54) OR: 1.62 (CI: 0.78, 3,36)	Cross-sectional	Low
						Access to bus or subway station only	Distance to bus or subway station	Up to 500 m Between 500 - 1500 m				OR: 1.26 (CI: 0.33, 4.74) OR: 2.07 (CI: 1.1, 3.86)		

						Access to bike paths and bus or subway station	Distance to bike path and bus or subway station	Up to 500 m Between 500 - 1500 m				OR: 0.72 (CI: 0.17, 3.00) OR: 1.15 (CI: 0.54, 2.48		
Lawrence D. Frank, James F. Sallis, Terry L. Conway, James E. Chapman, Brian E. Saelens, and William Bachman 2006	Active transportation (Walking and cycling)	1228	adults between the ages of 20 and 65	King County, Washington, USA	Urban	**Walkability Index**	Net residential density Street connectivity Land use mix Retail floor area ratio	within 1 km network buffer	Decrease in BMI	Increase in active transportation - physical activity	**Active transportation (weekly)**	β: 0.304 (sig, 0.000)	Cross-sectional	Low
		5,766		King County, Washington, USA	Urban						**BMI**	β: -0.113 (sig. 0.000)		
						Walkability Index	Net residential density Street connectivity Land use mix Retail floor area ratio			Reduction in air pollutants	**Vehicular miles of travel**	β: -0.157 (sig. 0.000)	Cross-sectional	Low
											Grams of transportation -related NOx emissions per capita	β: -0.140 (sig. 0.000)		
											Grams of transportation -related VOC emissions per capita	β: -0.139 (sig 0.000)		
Billie Giles-Corti, Gina Wooda, Terri Pikora, Vincent Learnihan, Max Bulsara, et al. 2010	Walking	1314	Children from 5 - 7 years old	Perth, Western Australia	Metropolitan	**School-specific Walkability Index**	Street connectivity	High - Low		Increase in walking for transportation - physical activity	**Regular walking to school (>/= 6 trips/week)**	Low v. High OR: 0.32 (CI: 0.22, 0.74)	Cross-sectional	Low

							Vehicular traffic exposure					High v. Low OR: 0.68 (CI: 0.44, 1.06)		
Richard Glazier, Maria Criatore et al. 2014	Walking	10180	adults over the age of 18	Toronto, Canada	Urban	**Population density**	total number of people per square kilometer	Divided into quartiles (Low v. High (ref))	Increase in overweight, obesity, and diabetes miellitus rates	Decrease in walking for transportation - physical activity	**Overweight** **Obese** **Diabetes Mellitus**	OR: 1.31 (CI: 1.16, 1.47) OR: 1.44 (CI: 1.02, 1.85) OR: 1.16 (CI: 1.16–1.16)	Cross-sectional	Low
						Residential density	total number of occupied residential dwellings per square kilometer				**Overweight** **Obese** **Diabetes Mellitus**	OR: 1.26 (CI: 1.11, 1.41) OR: 1.42 (CI: 1.01, 1.83) OR: 1.33 (CI: 1.33, 1.33)		
						Availability of walkable destinations	the sum of all “retail and service” destinations within 800 m buffer area				**Overweight** **Obese** **Diabetes Mellitus**	OR: 1.16 (CI: 1.02, 1.30) OR: 1.34 (CI: 0.94, 1.74) OR: 1.26 (CI: 1.26, 1.26)		
						Street connectivity	number intersections with at least 3 converging roads or pathways divided by 800 m buffer				**Overweight** **Obese** **Diabetes Mellitus**	OR: 1.11 (CI: 0.97, 1.26) OR: 1.43 (CI: 0.97, 1.89) OR: 1.38 (CI: 1.38, 1.38)		

						Walkability Index	All of the above			**Overweight** **Obese** **Diabetes Mellitus**	OR: 1.18 (CI: 1.05, 1.33) OR: 1.34 (CI: 0.96, 1.71) OR: 1.33 (CI: 1.33, 1.33)		
Anna Goodman, Shannon Sahlqvist, David Ogilvie 2014	Walking	1465	adults 18 or older	Cardiff / Kenilworth / Southampton, U.K.	Urban	**Proximity to Connect2 (intervention)**	distance to the nearest access point to a completed section of the Connect2 project	living far (2 - 5 km) [reference] living close (<1 km)	Increase in walking for transportation - physical activity	**walking for transport (min/week)**	1-y change β: 5.8 (CI: -0.7, 12.3) 2-y change β: 8.8 (CI: 2.8, 14.8)	Quasi-experimental	Moderate
	Cycling								Increase in cycling for transportation - physical activity	**Cycling for transport (min/week)**	1-y change β: 0.4 (CI: -1.9, 2.7) 2-y change β: -0.2 (CI: -2.2, 1.8)		
										Total walking and cycling (min/week)	1-y change β: 4.6 (CI: -4.2,13.4) 2-y change β: 15.3 (CI: 6.5, 24.2)		
Eva Heine Jenna Panter Alice Dalton Andy Jones David Ogilvie 2015	Walking Cycling Bus	453	adults ≥16 years	Cambridge, UK	Urban (within 30 km of city center)	**Proximity to busway stop or path**	distance from a participant's home to the nearest busway stop	7 km (Average) Min. 4 km Max. 9 km	Increase walking and cycling - physical activity	**Use of the guided bus**	OR: 1.53 (CI: 1.15, 1.02)	Cross-sectional	Low
										Use of the walking path	OR: 1.34 (CI: 1.05, 1.7)		
										Use of the cycling path	OR: 2.18 (CI: 1.58, 3.0)		

Adriano A. F. Hino, Rodrigo S. Reis, Olga L. Sarmiento, Diana C. Parra,and Ross C. Brownson 2013	Walking	1206	middle aged adults (35 - 54 years old)	Curitiba, Brazil	High human development in context of developing country	**Distance to Bus Rapid Transit (BRT) Station**	Number of BRT stations within 500 meter radius	1 2 or more	Increase in walking for transportation - physical activity	**Any walking for transport (>10 min/weekly)**	None: ref 1: OR: 0.88 (CI: 0.48, 1.62) 2 or more: OR: 1.50 (CI: 1.22, 1.84)	Cross-sectional	Low
						Land use mix	Proportion of residential area within 500 m buffer	1. 0 -53.8% 2. 53.9-68.7% 3. 68.8-98.1%			1. Ref 2. OR: 1.25 (CI: 1.02, 1.53) 3. OR: 1.28 (CI: 0.95, 1.72)		
							Proportion of commercial area withing 500 m buffer	1. 0 -5.9% 2. 6-17.2% 3. 17.3-75.2%			1. Ref 2. OR: 1.47 (CI: 1.13, 1.91) 3. OR: 1.51 (CI: 0.86, 2.65)		
	Cycling					**Traffic lights**	Number of traffic lights	within 500 m buffer	Increase in cycling for transportation - physical activity	**Any cycling for transport (>10 min/weekly)**	0: ref 1: OR: 1.12 (CI: 0.30,4.12) 2 or more: OR: 0.27 (CI: 0.09, 0.84)		
						Land use mix	Entropy score	1. 0 - 0.49 2. 0.50 - 0.59 3. 0.6 - 0.85			1: ref 2: OR: 1.32 (CI: 0.62, 2.83) 3: OR: 0.52 (CI: 0.31, 0.88)		
							Proportion of residential area within 500 m buffer	1. 0 -53.8% 2. 53.9-68.7% 3. 68.8-98.1%			1: ref 2: OR: 0.53 (CI: 0.34, 0.83) 3: 0.61 (CI: 0.33, 1.14)		

Paula Hooper, Matthew Knuimanb, Sarah Foster, Billie Giles-Corti 2015	Walking	664	adults age 18 or older	Metropolitan Perth, Western Australia	suburban	**Destination diversity of center**	score- number of different destination types present within the center (score 1–8)	OR for every additional destination type present		Increase in walking for transportation - physical activity	**Walking for transport**	Any: OR: 1.22 (CI: 1.01, 1.49) ≥: 60 min: OR: 1.36 (CI: 1.11, 1.68)	Longitudinal cohort	High
											Total walking	≥: 150 min: OR: 1.16 (CI: 1.05, 1.27)		
						Block density	number of blocks ÷ constructed land area within the development	OR for 1 unit increases in block density			**Total walking**	≥: 60 min: OR: 5.05 (CI: 2.10, 12.1)		
						Walkable block ratio	number of blocks ≤ 620m perimeter ÷ total number of blocks	OR for 1 unit increases in walkable block density			**Total walking**	Any: OR: 4.38 (CI: 3.24, 5.91) ≥: 150 min: OR: 2.27 (CI: 1.40, 3.68)		
						Number of external access points	number of pedestrian-friendly access points along the development perimeter ÷ perimeter of development boundary	OR for 1 unit increase in number of access points			**Walking for transport**	Any: OR: 1.35 (CI: 1.06, 1.73)		
						Length of footpath (km)	length of all footpaths ÷ constructed land area of housing development	OR for 1 unit increase in length of footpaths			**Walking for transport**	Any: OR: 1.02 (CI: 1.01, 1.02) ≥ 60 min: OR: 1.02 (CI: 1.00, 1.03)		
						Sidewalk: road ratio	length of all footpath segments adjacent to roads ÷ length of all roads	OR for 1 unit increase in sidewalk: road ratio			**Total walking**	≥ 60 min: OR: 3.14 (CI: 1.89, 11.1)		

				Tree density along footpath	number of trees along footpaths ÷ length (km) of footpaths within the development	OR for 1 unit increase in number of trees per km of footpath		**Walking for transport**	Any: OR: 1.04 (1.03, 1.06)	
								Total walking	≥ 60 min: OR: 1.02 (CI: 1.01, 1.04)	
				% residential land area occupied by small lot	% of lots less than 350 m2	OR for 1 unit increase in % residential land area		**Walking for transport**	Any: OR: 1.04 (CI: 1.01, 1.09)	
				Medium neighborhood park	Medium neighborhood park (0.5–1.5 ha) accessible within 400m	≤ 400 m (no park reference)		**Walking for transport**	≥ 60 min: OR: 1.09 (CI: 1.05, 1.12)	
				Number of parks	Total number of parks within the development	OR for 1 unit increase in number of parks present within the development		**Walking for transport**	Any: OR: 1.08 (CI: 1.03, 1.13)	
				Regional parks	Number of regional parks	OR yes vs. reference group no regional park ≤2.5 km		**Walking for transport**	Any: 3.97 (CI: 2.46, 6.41) ≥ 60 min: OR: 1.99 (1.83, 2.17)	
								Total walking	Any: 1.58 (CI: 1.35, 1.84) ≥ 60 min: OR: 1.85 (CI: 1.23, 2.50)	
				Number of small neighborhood parks	number of small neighborhood park (0.3–0.5 ha)	OR for 1 unit increase in number of parks present within the development		**Walking for transport**	Any: OR: 1.13 (CI: 1.02, 1.25)	

						Number of medium neighborhood parks	number of medium neighborhood park (0.5–1.5 ha)	OR for 1 unit increase in number of parks present within the development		**Walking for transport**	Any: OR: 1.17 (CI: 1.06, 1.28)		
										Total walking	Any: OR: 1.06 (CI: 1.02, 1.10) ≥ 60 min: OR: 1.09 (CI: 1.04, 1.13)		
						Number of parks with sport surface, marking or equipment		OR for 1 unit increase in number of parks present		**Walking for transport**	≥ 60 min: OR: 1.26 (CI: 1.18, 1.34)		
Wyatt Jensen Barbara B. Brown Ken R. Smith Simon C. Brewer et al. 2017	Active transportation (Walking, cycling or public transportation)	536	adults over 18 years of age	Salt Lake City, Utah, USA	Urban	**Access to a <u>complete street</u> (intervention)**	Roadway designed or altered to accommodate active transport by pedestrians, cyclists, and transit users	within 2 km	Increase walking and cycling for transport - physical activity	**Active transportation on the complete street**	OR: 0.99 (CI: 0.95, 1.03)	Quasi-experimental longitudinal	Moderate
						Pedestrian Infrastructure	street lighting	Perceived			OR: 0.95 (CI: 0.91, 1.00)		
						Aesthetic	interesting things to look at and natural sights				OR: 0.95 (CI: 0.91, 0.99)		
						Protection from Traffic Hazards	Quantity of traffic nearby				OR: 1.07 (CI: 1.03, 1.11)		
						Protection from Crime	Crime rate				OR: 1.05 (CI: 1.01, 1.09)		

Jacqueline Kerr, Jennifer A. Edmond et al. 2016	Walking Cycling	13,745	adults age 18 - 66	Australia; Belgium; Brazil; China; Colombia; Czech Republic ; Denmark; Mexico; New Zealand; Spain; the United Kingdom; and the United States (US).	Maximized variability in environmental attributes and socio-economic status	**Neighborhood Environment Walkability Scale (NEWS)**	**Residential density**	0 to 1044	Increase walking and cycling for transport	**≥ 150 min walking for transport** **Any cycling for transport**	Significant nonlinear association Significant nonlinear association	Cross-sectional	Low
							Land use mix–access				OR: 1.33 (CI: 1.24, 1.42) OR: 1.24 (CI: 1.13, 1.36)		
							Street connectivity				OR: 1.15 (CI: 1.09, 1.21) OR: 1.14 (CI: 1.06, 1.22)		
							Pedestrian infrastructure	Perceived			OR: 1.12 (CI: 1.04, 1.21) OR: 1.22 (CI: 1.10, 1.36)		
							Aesthetics				OR: 1.19 (CI: 1.11, 1.27) OR: 1.15 (CI: 1.05, 1.26)		
							Traffic safety				OR: 0.92 (CI: 0.86, 0.97) OR: 1.14 (CI: 1.05, 1.24)		

											OR: 0.99 (CI: 0.93, 1.05)		
						Crime safety					OR: 1.17 (CI: 1.07, 1.28)		
											OR: 1.19 (CI: 1.12, 1.27)		
						Perceived distance to local destinations.					OR: 1.16 (CI: 1.06, 1.27)		
Matthew W. Knuiman, Hayley E. Christian, Mark L. Divitini, Sarah A. Foster, Fiona C. Bull, Hannah M. Badland, Billie Giles-Corti 2013	Walking	1703	adults age of 18 years or older	Metropolitan Perth, Western Australia	suburban	**Connectivity z score**	# of Intersections per square km	within 1600 m of participants home	Increase in walking for transportation - physical activity	**Transport walking over time**	OR: 1.13 (CI: 1.01, 1.26)	Longitudinal cohort	High
						Residential density	# dwelling per square km	within 1600 m of participants home			OR: 0.96 (CI: 0.80, 1.15)		
						Land use-mix z score	Entropy score	0 – 1			OR: 1.33 (CI: 1.16, 1.52)		
						No. of bus stop	within 1600 m of participants' home	0 - 14 (ref) 15-29 ≥ 30			15 - 29: OR: 1.99 (CI: 1.46, 2.71) ≥ 30: OR: 2.33 (CI: 1.57, 3.45)		
						Railway station	within 1600 m of participants' home	Present Not present (ref)			OR: 1.79 (CI: 1.02, 3.16)		

						Total number of types of destinations	within 1600 m of participants' home	0 - 3 (ref) 4 - 7 8 – 15			4 - 7: OR: 1.08 (CI: 0.80, 1.45) 8 - 15: OR: 1.40 (CI: 0.93, 2.10)		
						Access to bus stop		Perceived			OR: 1.31 (CI: 0.92, 1.87)		
						Access to railway station		Perceived			OR: 1.80 (CI: 1.13, 2.85)		
						Total no. of types of destinations (perceived)	number of destinations within 15-minute walki from home	0-2 (ref) 3-6 7-11			3 - 6: OR: 2.35 (CI: 1.81, 3.05) 7 - 11: OR: 3.11 (CI: 2.28, 4.25)		
Mohammad Javad Koohsari, Takemi Sugiyamaa, Suzanne Mavoab, Karen Villanueva, Hannah Badland, Billie Giles-Corti, Neville Owen 2016	Walking	2650	adults age 20 - 65 years	Adelaide, Australia	Urban	**Intersection density**	ratio of the number of intersections (3 way or more) to CCD	CCD, geographical unit comprising about 250 households	Increase in walking for transporta tion - physical activity	**Walking for transport frequency**	β: 0.04 (CI: 0.00, 0.09)	Cross-sectional	Low
						Street integration	integration score considering connections with other street segment				β: 0.08 (CI: 0.03, 0.12)		
						Availability of local destinations	Perceived distance to local destinations				β: 0.09 (CI: 0.05, 0.12)		

Mohammad Javad Koohsari Andrew T. Kaczynski Tomoya Hanibuchi Ai Shibata et al. 2018	Walking	1073	Middle to older age adults (40 - 69)	Nerima Ward and Kanuma City, Japan	Both urban (Nerima Ward) and rural (Kanuma City) setting	**Population density**	Number of residents per km2	within an 800 m buffer	Decrease in Body Mass Index (BMI)	Increase in active transportation - physical activity	**Association with BMI**	β: -0.34 (CI: -0.54, -0.15)	Cross-sectional	Low
						Intersection density	Number of three-way or more intersection per km2	within an 800 m buffer				β: -0.26 (CI: -0.46, -0.06)		
						Density of physical activity facilities	Number of parks, and gym, fitness, and sport facilities per km2	within an 800 m buffer				β: -0.25 (CI: -0.45, -0.06)		
						Access to public transportation	Number of train stations and bus stops per km2	within an 800 m buffer				β: -0.22 (CI: -0.41, -0.02)		
						Availability of sidewalks	the length of roads with sidewalks per km2	within an 800 m buffer				β: -0.38 (CI: -0.57, -0.18)		
						Walk Score (Walkability)		0 - 100				β: -0.29 (CI: -0.49, -0.09)		
Kevin J. Krizek, Pamela Jo Johnson 2006	Walking	1635	adults 20 years of age or older	Mineapolis / St. Paul, Minnesota, USA.	Urban	**Distance to nearest retail establishment**	network distance between each households and retail establishments	from less than 200 meters, to 600 meters or more (ref)		Increase in walking for transport - physical activity	**Overall walking**	<200 m OR: 2.51 (p<0.5)	Cross-sectional	Low
	Cycling					**Distance to nearest bicycle path**	straight-line distance from households to the nearest bicycle path	from less than 400 meters to 1600 meters or more (ref)		Increase in cycling for transport - physical activity	**Overall cycling**	<400 OR: 2.23 (p<0.5)		

Ugo Lachapelle, Lawrence D. Frank 2009	Walking	4156	adults age 16 - 70	Atlanta, Georgia, USA	Urban (wealthier stratum)	**Employer sponsored public transportation pogram access**	if participant received and used ‘‘free or subsidized’’ transit passes	do not use (ref) has access and uses		Increase in walking for transport - physical activity	**Walk 2.4km or more – PA recommendation met**	(v. non-walker) OR: 4.96 (p=0.000) (v. moderate walker) OR: 3.60 (p=0.000)	Cross-sectional	Low
						Net residential density	the number of households per acre of residential land .	0–2 2–4 4–6 6–8 8+ (ref)			**Walk up to 2.4km – Moderate walkers (vs. non-walker)**	0-2: OR: 0.14 (p=0.000) 2-4: OR: 0.35 (p=0.000) 4-6: OR: 0.51 (p=0.003) 6-8: OR: 0.37 (p=0.001)		
											Walk 2.4km or more – PA recommendation met	(v. non-walker) 0-2: OR: 0.15 (p=0.000) 2-4: OR: 0.26 (p=0.000)		
						Prescence of retail store	self-reported presence or absence of retail stores within a 10-min walk from work	N/A			**Walk up to 2.4km – Moderate walkers**	(v. non-walker) OR: 1.49 (p=0.004)		
											Walk 2.4km or more – PA recommendation met	(v. non-walker) OR: 2.60 (p=0.000) (v. moderate walker) OR: 1.75 (p=0.042)		
						Distance to nearest transit stop	distance to the nearest transit stop	From 450 to 1 km			**Walk up to 2.4km – Moderate walkers**	(v. non-walker) OR: 6.54 (p=0.000)		

										Walk 2.4km or more – PA recommendation met	(v. moderate walker) OR: 0.20 (p=0.004)		
Chanam Lee Anne Vernez Moudo 2006	Walking	438	adults age 18 or older	City of Seattle, Washington, USA	Urban	**Distance to Mix**	integrates access and land use mix	N/A	Increase in walking for transport - physical activity	**Walking for transport**	OR: 2.503 (CI: 1.34, 4.768)	Cross-sectional	Low
						Residential density	Number of residential units per square feet	N/A			OR: 2.443 (CI: 0.999, 5.972)		
Chanam Lee, Jeongjae Yoon Xuemei Zhu 2016	Walking Cycling	178	Children in elementary school	Austin, Texas	Area with rapid growth in residential development	**Walkability**	**Land use-mix**	N/A	Increase walking and cycling for transport - physical activity	**Sedentary-to-active mode shift**	Utilitarian destinations: OR: 0.92 (p value = 0.597) Auto-oriented destinations: OR: 0.16 (p value = <0.001)	Retrospective survey	Very Low
							Traffic safety infrastructure	Prescence en route to school			OR: 0.32 (p value = <0.001)		
							Pedestrian infrastructures	Prescence en route to school			OR: 1.43 (p value = 0.028)		
Yung Liao Pin-Hsuan Huang Chih-Yu Hsiang Jing-Huei et al. 2017	Walking	1032	Older adults age 65 or more	Taiwan	Both metropolitan and non-metropolitan area	**Residential density**	Main type of housing in the participants neighborhood.	Detached single unit / Family unit / Apartment building / condos	Increase in walking for transportation - physical activity	**> 150 min / week of walking for transportation**	OR: 1.87 (CI: 0.97, 3.61)	Cross-sectional	Low
						Access to shops		Perceived			OR: 1.42 (CI: 0.91, 2.21)		

				Access to public transportation	Perceived		OR: 1.39 (CI: 0.89, 2.18)	
				Presence of sidewalks	Perceived		OR: 1.93 (CI: 1.37, 2.72)	
				Access to recreational facilities	Perceived		OR: 1.46 (CI: 0.98, 2.18)	
				Crime safety at night	Perceived		OR: 1.18 (CI: 0.77, 1.79)	
				Traffic safety	Perceived		OR: 0.72 (CI: 0.52, 0.98)	
				Seeing people being active	Perceived		OR: 1.11 (CI: 0.80, 1.55)	
				Aesthetic	Perceived		OR: 1.06 (CI: 0.78, 1.44)	
				Connectivity of street	Perceived		OR: 1.12 (CI: 0.81, 1.56)	
				Presence of destinations	Perceived		OR: 2.39 (CI: 1.60, 3.58)	

Gina S. Lovasi Kathryn M. Neckerman James W. Quinn Christopher C. Weiss Andrew Rundle 2009	Active transportation	13102	adults over 30 years of age	New York, USA	Urban	**Population density**	persons per square kilometer	within 1 km radius buffer	Decrease in Body Mass Index (BMI)	Increase in active transportation - physical activity	**Association with BMI**	Education: Disadvantage: β: 0.10 (CI: -0.16, 0.36) Advantage: β:-0.54 (CI: -0.63, -0.45) Income Disadvantage: β:0.08 (CI: -0.17, 0.33) Advantage: β:-0.56 (CI: -0.68, -0.43)	Cross-sectional	Low
						Land use mix	constructed using a parcel-level dataset (no longer available)	within 1 km radius buffer				Education Advantage: -0.11 (CI: -0.96, 0.73) Disadvantage: -1.42 (CI: -2.07, -0.78) Income Advantage: -1.16 (CI: -1.92, -0.41) Disadvantage: -1.17 (CI: -1.89, -0.45)		

				Public transit use	N/A			Education Disadvantage: β: 0.28 (CI: -1.62, 2.19) Advantage: β:-4.96 (CI: -6.15, -3.78) Income Disadvantage:β: -0.56 (CI: -2.70, 1.59) Advantage: β: -4.86 (CI: -6.06, -3.66	
				Subway access	numbers of subway stops per square kilometer	within 1 km radius buffer		Education Disadvantaged: β: -0.12 (CI: -0.27, 0.04) Advantaged: β: -0.36 (CI: -0.48, -0.24) Income Disadvantaged: β:-0.13 (CI: -0.24, -0.01) Advantaged: **β:**-0.38 (CI: -0.52, -0.24)	

						Bus access	numbers of bus stops per square kilometer	within 1 km radius buffer				Education Disadvantaged: β: -0.02 (CI: -0.01, 0.05) Advantaged: β:-0.07 (CI: -0.08, -0.05) Income: Disadvantaged: β: -0.00 (CI: -0.03, 0.02) Advantaged: β:-0.06 (CI: -0.08, -0.04		
John M. MacDonald, Robert J. Stokes, Deborah A. Cohen, Aaron Kofner, Greg K. Ridgeway 2010	Light rail	498	adults over the age of 18	Charlotte, North Carolina, USA	urban	**Social and physical environment**	Perception of neighborhood social and physical environment within 15 min walk of each participants' home	N/A	Moderate to vigorous physical activity Decrease in BMI and obesity incidence	Increase in active transportation - physical activity	**BMI**	OR: -0.358 (p<0.05)	Cross-sectional Longitudinal Quasi-experimental	Moderate
											Obesity	OR: 0.85 (CI: 0.77, 0..94)		
											Reported physical activity (RPA) - vigorous	OR: 1.11 (CI: 1.01, 1.22)		
						Density of food and alcohol outlets	density of establishments that sell food and alcohol within a half-mile of respondents' household	N/A			**RPA - walking**	OR: 1.25 (CI: 1.04, 1.51)		
											BMI	OR: -0.281 (t=-1.07)		

						Public transit use	how often participants took public transportation (bus or rail)	at least once a week			**BMI**	OR: -1.01 (t=-1.24)		
						LRT use (intervention)	use of the light rail train for commute to work	N/A			**BMI (change in time)**	β: -1.18 (CI: -2.22, -0.13)		
											Obesity (change in time)	OR: 0.19 (CI: 0.04, 0.92)		
											RPA - walking (change in time)	OR: 1.36 (CI: 0.39, 4.73)		
											RPA - vigorous (change in time)	OR: 3.32 (CI: 0.81, 13.63)		
Ma Shwe Zin Nyunt, Faysal Kabir Shuvo, Jia Yen Eng, Keng Bee Yap, Samuel Scherer, et al. 2015	Active transportation (walking and cycling)	402	older adults aged 55 or older	Singapore	Public housing precincts	**Neighborhood Environment Walkability Scale (NEWS - modified)**	**Residential density**	N/A		Increase in active transportation - physical activity	**Transportation physical activity**	β: 1.07 (CI: 0.58, 1.57)	Cross-sectional	Low
							Land use mix-diversity					β: 0.72 (CI: 0.18, 1.25)		
							Street connectivity					β: 0.69 (CI: 0.05, 1.34)		
							Land use mix - access					β: -0.42 (CI: -0.93, 0.10)		
							Pedestrian Infrastructure					β: 0.22 (CI: -0.23, 0.67)		
							Aesthetics					β: 0.17 (CI: 0.12, 0.21)		
							Traffic safety					β: 0.02 (CI: -0.31, 0.35)		

							Safety from crime					β: -0.23 (CI: -0.66, 0.21)		
						GIS Walkability Index (Objective)	Residential lot coverage + 1.5(street density) + land-use mix	within 500 meter radius				β: 1.05 (CI: -1.06, 3.15)		
						GIS Accessability Index (Objective)	walking access to community services and amneties x residential density	within 500 meter radius				β: 4.28 (CI: 2.61, 5.94)		
Neville Owen, Ester Cerin, Eva Leslie, Lorinne duToit, Neil Coffee et al. 2007	Walking	2650	adults age 20 - 65	Adelaide, Australia	Urban	**Walkability Index**	dwelling density, street connectivity, land-use mix, and, net retail area.	1 - 10 (1 indicating low walkability and 10 indicating high walkability)		Increase in walking for transportation - physical activity	**Weekly frequency of walking for transport**	b: 29.1 (p <0.001)	Cross-sectional	Low
Jenna Panter Eva Heine Roger Mackett David Ogilvie 2016	Active transportation (Walking, cycling, running, and public transport) Walking	469	adults 20-71 years	Cambridge, United Kingdom	Urban	**Access to The Cambridgeshrite Guided Busway (intervention)**	distance from each participant's home to the nearest stop or path access point to guided bus.	N/A		Increase in active transportation - physical activity	**Active commuting** **No change** **Increase** **Decrease** **Walking on the commute** **No change** **Increase** **Decrease**	Ref RRR: 1.14 (CI: 0.90, 1.45) RRR: 1.07 (CI: 0.83, 1.37) Ref. RRR: 0.90 (CI: 0.69, 1.18) RRR: 1.13 (CI: 0.83, 1.55)	Quasi-Experimental	Moderate

	Cycling									**<u>Cycling on the commute</u>** **No change** **Increase** **Decrease**	Ref. RRR: 1.34 (CI: 1.03, 1.76) RRR: 1.00 (CI: 0.73, 1.37)		
Camile Perchoux Christopher Enaux Jean-Michel Oppert Mehdi Menai et al. 2017	Active transportation (walking, cycling, transit)	23432	women age 18 and older	Paris, France	Urban	**Perception of the residential environment**	Availability of destinations	Perceived	Decrease in sedentary behavior - physical activity	**Sedentary transportation**	OR: 0.64 (CI: 0.49, 0.82)	Cross-sectional	Low
							Presence of bicycle paths	Perceived			OR: 0.70 (CI: 0.53, 0.91)		
							Pollution	Perceived			OR: 0.77 (CI: 0.59, 1.00)		
							Aesthetics	Perceived			OR: 1.33 (CI: 1.00, 1.78)		
Jerome N. Rachele, Vincent Learnihan, Hannah M. Badland, Suzanne Mavoa, Gavin Turrell, and Billie Giles-Corti 2016	Walking	6901	older adults age 40 - 65 year	Brisbane, Australia	Urban	**Street connectivity**	# of walking catchments within 400 m radial buffer	divided into quintiles	Increase in walking for transport - physical activity	**Walking for transport** **Low (1 - 59 min)** **Moderate (60 - 149 min)** **High (> 150 min)**	Low Lowest: ref Highest: OR: 1.76 (CI: 1.37, 2.28) Moderate: Lowest: ref Highest: OR: 1.40 (CI: 1.10, 1.78) High Lowest: ref Highest: OR: 1.44 (CI: 0.99, 2.12)	Cross-sectional	Low

						Access to public transport stops	Network distance (m) to nearest bus stop	within 400 m of the residence				Low: OR: 1.44 (CI: 1.21, 1.72) Moderate: OR: 1.14 (CI: 0.97, 1.35) High: 1.16 (CI: 0.89, 1.49)		
Erica Reinhard Emilie Courtin Frank J. van Lethen Mauricio Avenado 2018	Bus	18453	Older adults over the age of 60	England	Urban	**Public bus - use (intervention)**	public bus use as a result of free bus travel passes for the eldery	1 - users of public bus 0 - non-users	Decrease in depresive symptom - Mental health	increase in social cohesion, and decrease in social isolation	**Lonliness**	β: −0.794 (CI: −1.528, −0.061)	Quasi-experimental	Moderate
											Social Isolation	β: −0.437 (CI: −0.941, 0.067)		
Chris Rissel Stephen Greaves Li Ming Wen Melanie Crane Chris Standen 2015	Cycling	512	Adults age 18 to 55	Sydney, Australia	High-end urban	**Access to bicycle path**	Percieved access to bicycle path	Percieved		Increase cycling for transporta tion - physical activity	**Use of bicycle path**	OR: 3.58 (CI: 2.01, 6.40)	Quasi-Experimental	Moderate
							distance of participant's residence to the nearest point of the bicycle path	100 m 500 m				OR: 1.04 (CI: 1.02, 1.06) OR: 1.24 (CI: 1.13, 1.37)		
Brian E. Saelens Anne Vernez Moudon Bumjoon Kang et al. 2014	Active transporta tion (Walking and cycling)	693	Adults age 20 and older	King County, Washingto n, USA	Urban	**Public Transit use**	Use of public transportatio n	Users non-users		Increase active transport - physical activity	**Overall physical activity (min/d)**	Transit users: 46.0 (CI: 42.2, 49.8) non-transit users: 37.6 (CI: 34.5, 40.7)	Cross-sectional	Low

Olga L. Sarmiento, Thomas L. Schmid, Diana C. Parra, Adriana Díaz-del-Castillo, Luis Fernando Gómez, Michael Pratt, et al 2010	Active transportation	1285	adults 18 or older	Bogotá, Colombia	Developing country (low - middle income)	**"Ciclovia" participation**	special bike-path in Bógota connected in a circuit	Yes / No (ref)	Increased mental health - Quality of Life	Self-percieved physical and mental health	**WHO - Quality of Life Score (WHO - QOL)**	β: 2.5 (p=0.004)	Cross sectional	Low
											Percieved health status (high v. low)	β: 1.5 (p=0.09)		
						Transport physical activity - biking	Participants transport related habits	Yes / No (ref)			**WHO - QOL score**	β: 2.2 (p=0.037)		
						Land use heterogenity	entropy metric of land-use mix	0.26–0.47 (ref) 0.48–0.62 >0.62			**WHO - QOL score**	0.48-0.62 β: 1.8 (p=0.047) >0.62 β: 1.3 (p=0.189)		
											Percieved health status (high v. low)	0.48-0.62 OR: 1.1 (CI: 0.8, 1.6) >0.62 OR: 1.6 (CI: 1.1, 2.5)		
											"How positive do you feel about the future?" (bad v. positive)	0.48-0.62 OR: 1.4 (CI: 1.0, 2.0) >0.62 OR: 1.4 (CI: 0.9, 2.0)		
						Public transportation	number of public transportation station	0 (ref) 1 or more			**WHO - QOL score**	β: -2.2 (p=0.041)		

Elisabezth Shay Daniel A. Rodriguez Gihyoug Cho Kelly J Cliffton Kelly R. Evenson 2009	Walking	293	adults age 19 - 90	Montgomery County, Maryland, USA	Urban	**Prescence of sidewalks or trail**	within half a mile radius	Low (ref) Medium High	Increase in walking -physical activity	**Weekly walk trips**	Medium IRR: 1.11 (CI: 0.78, 1.59) High IRR: 0.94 (CI: 0.66, 1.34)	Cross-sectional	Low
						Sidewalk condition	determined visually with a descriptive quality assessment rubric				Medium IRR: 1.85 (CI: 1.30, 2.62) High IRR: 1.19 (CI: 0.80, 1.77)		
						Connection	Number of connections with other sidewalks and paths				Medium IRR: 1.08 (CI: 0.77, 1.51) High IRR 0.78 (CI: 0.55, 1.10)		
						Sidewalk width	> 1.22 m				Medium IRR: 1.15 (CI: 0.8, 1.64) High IRR: 0.68 (CI: 0.49, 0.94)		
						Presence of crossing aids	Stop lights, stop signs, pedestrian island, and pedestrian-supportive signage				Medium IRR: 1.12 (CI: 0.79, 1.59) High IRR: 1.48 (CI: 1.03, 2.12)		

						Presence of crosswalk	within half a mile radius					Medium IRR: 1.15 (CI: 0.8, 1.65) High IRR: 1.17 (0.8, 1.72)		
Ken R. Smith, Barbara B. Brown, Ikuho Yamada, Lori Kowaleski-Jones, Cathleen D. Zick, Jessie X. Fan 2008	Walking	453927	adults aged 25 - 64 years	Salt Lake County, Utah, USA	Urban	**Density**	population per square mile	N/A	Decrease in BMI	Increase in active transportation - physical activity	**BMI**	β: -0.001 (p = 0.336)	Cross-sectional	Low
						Street connectivity	# of intersections within 0.25 mile radius	N/A				β: -0.002 (p = 0.092)		
Shiliang Sua, Jianhua Pia, Huan Xiea, Zhongliang Caia, Min Weng 2017	Walking	8117 communities	range of all demographics	Shenzhen, China	Megacity - rapid transition to socio-economic development	**Adjusted Walk Score**	1) principle amenities and utilization frequency (2) a tolerance time approach calculating the walking travel time from community to each amenity (3) three pedestrian characteristic factors (intersection density, block length, and slope)	The final walk score are standardized into the interval between 0 and 100 (high walkability v. Low walkability	Decrease in incident non-communicable diseases	Increase in walking for transport - physical activity	**Incident cardiopathy**	R^2: 0.26 (p<0.01)	Cross-sectional	Low
											Incident hypertension	R^2: 0.14 (p<0.01)		
											Incident liver cancer	R^2: 0.05 (p<0.01)		

Philip J. Troped, Ruth P. Saunders Russell R. Pate,Belinda Reininger, John R. Ureda, and Shirley J. Thompson 2001	Cycling	413	adults age 18 and older	Arlington, Massachusetts, USA	Urban	**Distance to bikeway (perceived)**	estimate of distance in miles from the person's home to the Minuteman Bikeway	N/A	Increase in cycling for transport - physical activity	**Use of the Minuteman Bikeway**	OR: 0.65 (CI: 0.54, 0.79)	Cross-sectional	Low
						Neighborhood environment (perceived)	participants perceived neighborhood environment	Residential (ref) / mix (industrial/commercial)			OR: 0.56 (CI: 0.36, 0.86)		
						busy street barrier (perceived)	whether the participant had to cross a busy street to access the bikeway	Yes (ref) / No			OR: 2.01 (CI: 1.11, 3.63)		
						Distance to bikeway (objective)	GIS distance from participants home to nearest rail trail access	N/A			OR: 0.58 (CI: 0.45, 0.73)		
Philip J. Troped, Ruth P. Saunders, Russell R. Pate, Belinda Reininger, Cheryl L. Addy 2003	Walking Cycling	413	adults 18 or older	Arlington, Massachusetts, USA	high-end suburban	**Street lights**	Perceived presence of sufficient street lights	Yes / no (ref)	Increase in walking and cycling for transportation - physical activity	**Transportation physical activity (walking or cycling / week)**	c: 42.7 (p=0.05)	Cross-sectional	Low
						Enjoyable scenery		Yes / no (ref)			c: 48.94 (p=0.03)		
						Sidewalk presents		Yes / no (ref)			c: 47.75 (p=0.04)		
						Distance to rail trail	GIS distance from participants' homes to an access point on a community rail-trail	N/A			c: -54.65 (p=0.05)		

Gavin Turrell, Michele Haynesb, Lee-Ann Wilson, Billie Giles-Cortiv 2013	Walking	10711	adults age 40 - 65 years	Brisbane, Australia	Urban	**Street connectivity**	No. 4-way intersections within a average 200 dwelling	3 - 4 intersections 5 or more intersections	Increase in walking for transport - physical activity	**Minutes of walking for transport** **>150 min / week**	3-4: OR: 1.83 (CI: 1.29, 2.56) 5+: OR: 2.03 (CI: 1.39, 2.89)	Cross-sectional	Low
						Land use mix	proportion of land area zone as residential, commercial, industrial, recreational, and other	0 to 1			Highly mixed use OR: 1.62 (CI: 1.02, 2.58)		
						Residential density	average block-size in square meters of all residential zoned land	N/A			Most dense OR: 2.72 (CI: 1.85, 3.99)		

β: beta coefficient; CI: Confidence interval; HR: Hazard risk ratio; IRR: Incidence risk ratio ; NO_x: Nitrate oxide OR: Odd ratio; p: p-significance value; R^2: coefficient of multiple determination for multiple regression; VOC: volatile organic compound.

Table S7. Study quality assessment

Reference (Author, Year)	Mode of transport (walking, cycling, car, motorcycle, bus, metro, tram, train, gondola, etc.)	Study period (month/s, years/s)	Exposure response gradient (yes / no)	Magnitude of effect (High [RR>1.5 OR <0.75] / Low [any other])	Imprecision (Yes (sample size was fewer than 200 cases AND the 95% CI included an important effect [When the 95% CI includes no effect OR when RR > 1.25 or RR < 0.75 OR standard deviation > mean]) / No (any other))	Study design: Study design (Expert recommendation, Ecological, Cross-sectional, longitudinal, quasi-experiential, trial, meta-analysis)	Study design: Certainty of the evidence (High, low, very low)	Risk of Bias: Bias due to exposure assessment	Risk of Bias: Bias due to confounding	Risk of Bias: Bias due to selection of participants	Risk of Bias: Bias due to health outcome assessment	Risk of Bias: Bias due to not blinded outcome assessment	Risk of Bias: Total risk of bias	For multiple studies with the same outcome and exposure: Inconsistency (the same direction of the effect [based on a comparison of multiple studies on the same exposure and outcome/determinant, with different results])	For multiple studies with the same outcome and exposure: Quality of the evidence (high, moderate, low, very low)
Rebecca Bentley, Tony Blakely, Anne Kavanagh, Zoe Aitken, Tania King, Paul McElwee, Billie Giles-	Walking	2007 2009 2011 2013	No	Low	No	Longitudinal cohort	High	Low	Low	Low	High	Low	Low		

Corti, Gavin Turrell 2017														
Kim Bongjeong Hyun Hye Sun 2018	Cycling	2013	No	Low	No	Cross-sectional	Low	High	Low	Low	High	Unclear	High	
Christoph Buck Tobias Tkaczicks Yannis Pitsiladis et al. 2014	Walking	September 2007 - February 2008	No	Low	No	Cross-sectional	Low	Low	Low	Low	Low	Unclear	Low	
Barbara B. Brown, Ikuho Yamadab, Ken R. Smith, Cathleen D. Zick, Lori Kowaleski-Jones, Jessie X. Fana 2009	Walking	2008	No	Low	No	Cross-sectional	Low	Low	Low	Low	High	Low	Low	
Barbara B. Brown Carol M. Wemer Calvin P. Tribby Harvey J. Miller Ken R. Smith 2015	Light Rail	May - December 2012 May - November 2013	No	High	No	Quasi-experimental	High	Low	Low	Low	Low	Unclear	Low	

Barbara B. Brown Ken R. Smith Wyatt A. Jensen Doug Tharp 2015	Light Rail	May - December 2015	No	High	Yes	Quasi-experimental	High	Low	Low	Low	Low	Unclear	Low	
Ester Cerin, Eva Leslieb, Lorinne du Toitc, Neville Owenc, Lawrence D. Frank 2007	Walking	2007	No	High	No	Cross-sectional	Low	Low	Low	Low	High	Low	Low	
Lars B. Christiansen, Ester Cerin, Hannah Badland, Jacqueline Kerr, Rachel Davey, Jens Troelsen et al. 2016	Walking	2016	Yes	High	No	Cross-sectional	Low	Low	Low	Low	High	Low	Low	
	Cycling			Low										

Yen-Cheng Chiang, Han-Yu Lei 2016	Walking	April - June 2005	No	N/A	N/A	Expert opinion	Low						High	
Maria Chiu, Mohammad-Reza Rezai, et al. 2016	Walking	2001 - July, 2012	Yes	High	No	Longitudinal cohort	High	Low	Low	Low	Low	Low	Low	
Alex Antonio Florindo Ligia Vizeu Barrozo et al. 2017	Cycling	August 2014 - December 2015	No	High	No	Cross-sectional	Low	Low	Low	Low	High	Low	Low	
Lawrence D. Frank, James F. Sallis, Terry L. Conway, James E. Chapman, Brian E. Saelens, and William Bachman 2006	Active transportation (Walking and cycling)	August - November 1999 May 2002 - December 2003	No	High	No	Cross-sectional	Low	Low	Low	Low	High	Low	Low	

Billie Giles-Corti, Gina Wooda, Terri Pikora, Vincent Learnihan, Max Bulsara, et al. 2010	Walking	July to December 2007	No	High	No	Cross-sectional	Low	Low	Low	Low	High	Low	Low	
Richard Glazier, Maria Criatore et al. 2014	Walking	2003 - 2009	No	Low	No	Cross-sectional	Low	Low	Low	Low	Low	Low	Low	
Anna Goodman, Shannon Sahlqvist, David Ogilvie 2014	Walking	April 2010 - April 2012	No	High	No	Quasi-experimental	High	Low	Low	Low	High	Low	Low	
	Cycling			Low										
Eva Heine Jenna Panter Alice Dalton Andy Jones David Ogilvie 2015	Walking Cycling Bus	2012	No	High	No	Cross-sectional	Low	Low	Low	Low	High	Unclear	High	

Adriano A. F. Hino, Rodrigo S. Reis, Olga L. Sarmiento, Diana C. Parra,and Ross C. Brownson 2013	Walking Cycling	2008	No	High	No	Cross-sectional	Low	Low	Low	Low	High	Low	Low		
Paula Hooper, Matthew Knuimanb, Sarah Foster, Billie Giles-Corti 2015	Walking	2003 - 2006	Yes	Low	No	Longitudinal cohort	High	Low	Low	Low	High	Low	Low		
Wyatt Jensen Barbara B. Brown Ken R. Smith Simon C. Brewer et al. 2017	Active transportation (Walking, cycling or public transportation)	May - November, 2013	No	Low	No	Quasi-experimental	High	Low	Low	Low	Low	Unclear	Low	Yes	Moderate
Jacqueline Kerr, Jennifer A. Edmond et al. 2016	Walking Cycling	2002 - 2011	Yes	Low	No	Cross-sectional	Low	Low	Low	Low	High	Low	Low	Yes	Low

Matthew W. Knuiman, Hayley E. Christian, Mark L. Divitini, Sarah A. Foster, Fiona C. Bull, Hannah M. Badland, Billie Giles-Corti 2013	Walking	2003 - 2012	No	Low	No	Longitudinal cohort	High	Low	Low	Low	High	Low	Low	
Mohammad Javad Koohsari, Takemi Sugiyamaa, Suzanne Mavoab, Karen Villanueva, Hannah Badland, Billie Giles-Corti, Neville Owen 2016	Walking	2003 - 2004	No	Low	No	Cross-sectional	Low	Low	Low	Low	High	Low	Low	

Mohammad Javad Koohsari Andrew T. Kaczynski Tomoya Hanibuchi Ai Shibata et al. 2018	Walking	2011	No	High	No	Cross-sectional	Low	Low	Low	Low	High	Unclear	High	
Kevin J. Krizek, Pamela Jo Johnson 2006	Walking Cycling	2000	No	High	No	Cross-sectional	Low	Low	Low	Low	High	Low	Low	
Ugo Lachapelle , Lawrence D. Frank 2009	Walking	2001 - 2002	No	High	No	Cross-sectional	Low	Low	Low	Low	High	Low	Low	
Chanam Lee Anne Vernez Moudo 2006	Walking	Fall of 2002	No	High	No	Cross-sectional	Low	High	Low	Low	Low	Low	Low	
Chanam Lee, Jeongjae Yoon Xuemei Zhu 2016	Walking Cycling	May, 2011	No	Low	Yes	Retrospective survey	Very low	Low	Low	High	High	Unclear	High	

Yung Liao Pin-Hsuan Huang Chih-Yu Hsiang Jing-Huei et al. 2017	Walking	2016	No	High	No	Cross-sectional	Low	High	Low	Low	High	Low	High	
Gina S. Lovasi Kathryn M. Neckerman James W. Quinn Christopher C. Weiss Andrew Rundle 2009	Active transportation	January 2000 - December 2002	No	High	No	Cross-sectional	Low	High	Low	Low	High	Unclear	High	
John M. MacDonald, Robert J. Stokes, Deborah A. Cohen, Aaron Kofner, Greg K. Ridgeway 2010	Light rail	July 2006 - February 2007 March 2008 - July 2008	No	Low	No	Cross-sectional Longitudinal Quasi-experimental	High	Low	Low	Low	High	Low	Low	

Ma Shwe Zin Nyunt, Faysal Kabir Shuvo, Jia Yen Eng, Keng Bee Yap, Samuel Scherer, et al. 2015	Active transportation (walking and cycling)	2011 - 2012	No	High	No	Cross-sectional	Low	Low	Low	Low	High	High	High	Yes	Low
Neville Owen, Ester Cerin, Eva Leslie, Lorinne duToit, Neil Coffee et al. 2007	Walking	July 2003 - June 2004	No	High	No	Cross-sectional	Low	Low	Low	Low	High	Low	Low		
Jenna Panter Eva Heine Roger Mackett David Ogilvie 2016	Active transportation (Walking, cycling, and public transport)	Data collected: May to Octobre 2009 - 2012 Analysis: 2014	No	Low Low	No	Quasi-Experimental Cohort	High	Low	Low	Low	Low	Low	Low		

Camile Perchoux Christopher Enaux Jean-Michel Oppert Mehdi Menai et al. 2017	Active transportation (walking, cycling, transit)	2013	No	High	No	Cross-sectional	Low	Low	Low	Low	High	Low	Low	
Jerome N. Rachele, Vincent Learnihan, Hannah M. Badland, Suzanne Mavoa, Gavin Turrell, and Billie Giles-Corti 2016	Walking	2007 - 2009 - 2011	Yes	Low	No	Cross-sectional	Low	Low	Low	Low	High	Low	Low	
Erica Reinhard Emilie Courtin Frank J. van Lethen Mauricio Avenado 2018	Bus	2006 - 2014	No	High	No	Quasi-experimental Longitudinal	High	Low	Low	Low	Low	Unclear	Low	

Chris Rissel Stephen Greaves Li Ming Wen Melanie Crane Chris Standen 2015	Cycling	September - October, 2013 - October, 2014	No	High	No	Quasi-Experimental Longitudinal	High	Low	Low	Low	Low	Unclear	Low	
Brian E. Saelens Anne Vernez Moudon Bumjoon Kang et al. 2014	Active transportation (Walking and cycling)	2008 - early July 2009	No	High	No	Cross-sectional	Low	Low	Low	Low	Low	Unclear	Low	

Olga L. Sarmiento, Thomas L. Schmid, Diana C. Parra, Adriana Díaz-del-Castillo, Luis Fernando Gómez, Michael Pratt, et al 2010	Active transportation	2005	No	High	No	Cross sectional	Low	High	Low	Low	High	Unclear	High	
Elisabezth Shay Daniel A. Rodriguez Gihyoug Cho Kelly J Cliffton Kelly R. Evenson 2009	Walking	April 2004 - September 2006	Yes	Low	No	Cross-sectional	Low	Low	Low	Low	Low	Low	Low	

Ken R. Smith, Barbara B. Brown, Ikuho Yamada, Lori Kowaleski-Jones, Cathleen D. Zick, Jessie X. Fan 2008	Walking	2000	No	Low	No	Cross-sectional	Low	Low	Low	Low	High	Low	Low		
Shiliang Sua, Jianhua Pia, Huan Xiea, Zhongliang Caia, Min Weng 2017	Walking	2011	No	High	No	Cross-sectional	Low	Low	High	Low	High	Low	High		
Philip J. Troped, Ruth P. Saunders Russell R. Pate,Belinda Reininger, John R. Ureda, and Shirley J. Thompson 2001	Cycling	Sep-98	No	High	No	Cross-sectional	Low	Low	Low	High	High	Unclear	High	Yes	Low

Philip J. Troped, Ruth P. Saunders, Russell R. Pate, Belinda Reininger, Cheryl L. Addy 2003	Walking Cycling	fall 1998	No	High	No	Cross-sectional	Low	High	Low	High	High	Low	High	
Gavin Turrell, Michele Haynesb, Lee-Ann Wilson, Billie Giles-Cortiv 2013	Walking	May-07	No	High	No	Cross-sectional	Low	Low	Low	Low	High	Low	Low	

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