Transport Reviews

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/ttrv20

Measuring transport-associated urban inequalities: Where are we and where do we go from here?

Esra Suel, Claude Lynch, Maria Wood, Tom Murat, Gerard Casey & Adam Dennett

To cite this article: Esra Suel, Claude Lynch, Maria Wood, Tom Murat, Gerard Casey & Adam Dennett (18 Aug 2024): Measuring transport-associated urban inequalities: Where are we and where do we go from here?, Transport Reviews, DOI: 10.1080/01441647.2024.2389800

To link to this article: https://doi.org/10.1080/01441647.2024.2389800

TRANSPORT REVIEWS
https://doi.org/10.1080/01441647.2024.2389800

Routledge
Taylor & Francis Group

OPEN ACCESS Check for updates

Measuring transport-associated urban inequalities: Where are we and where do we go from here?

Esra Suel, Claude Lynch, Maria Wood, Tom Murat, Gerard Casey and Adam Dennett

Centre for Advanced Spatial Analysis, University College London, London, UK

ABSTRACT

Reducing urban inequalities is at the forefront of the global sustainable development agenda, as well as national and local policies. While existing measures of inequality are mostly focused on income and wealth, it is widely recognised that non-monetary disparities such as in health, education, and housing play a crucial role in creating and reinforcing inequalities. Transport plays a central role in mitigating inequalities by enhancing access to employment, education, and essential services. It is also directly and indirectly related to disparities in housing, neighbourhoods, and health. Policymakers increasingly recognize the potential of transport policies in addressing inequalities; however, the effects of interventions need to be understood beyond the transport sector only and should consider wider impacts. In this review, we concentrate on three interlinked sectors – housing, land-use, and transportation – where local governments possess some capacity to influence the processes by which inequalities are created and exacerbated. Currently, empirical research on inequalities within these domains is fragmented. Models and datasets used for scenario testing, planning, and intervention evaluation are often disjointed, sector-focused, and rarely consider distributional effects. Our aim is to critically review the literature across different disciplines and perspectives and propose future interdisciplinary directions towards better measurement and modelling of transport-associated inequalities.

ARTICLE HISTORY
Received 19 May 2024
Accepted 2 August 2024

KEYWORDS
Transport inequalities; housing inequalities; neighbourhood disparities; multiple deprivation

1. Introduction

Since the 1970s, income and wealth inequality have raised in most countries worldwide (Piketty & Saez, 2014). Cities play a pivotal role as arenas for the concentration of these inequalities, as well as sites of innovation in fomenting solutions to them, given that they are home to 55% of the global population – a figure projected to increase to 68% by 2050 (UN, 2022). Despite the fact that urban dwellers, on average, enjoy higher incomes, greater access to opportunities for social mobility, and better health compared to their rural counterparts (Bloom et al., 2008; Dye, 2008; Young, 2013), urban inequalities

CONTACT Esra Suel e.suel@ucl.ac.uk 90 Tottenham Court Road, London W1T 4TJ, UK
Supplemental data for this article can be accessed online at https://doi.org/10.1080/01441647.2024.2389800

persist – often surpassing disparities found elsewhere (OECD, 2016). Within-city disparities are on the rise, with 75% of global cities experiencing higher levels of income inequality compared to two decades ago (UN Habitat, 2016b). The gap between the rich and the poor widened not only in cities of low- and middle-income countries, but also high-income countries (OECD, 2016). Reducing inequalities matters not just on a moral level but has been shown to matter for everyone – for improving overall health and wellbeing, social resilience, educational outcomes and enabling social mobility, and reducing violence (Dorling, 2014, 2019; Wilkinson & Pickett, 2009). Urban equity is a policy priority in many cities around the globe and at the forefront of the global sustainable development agenda, including Sustainable Development Goals and initiatives like Habitat III, C40 Cities, United Cities and Local Governments, and WHO Healthy Cities. However, we are still far from universal solutions.

While income and wealth inequality shapes other forms of disparities, it is non-monetary disparities that further contribute to and exacerbate inequalities. Cities are not only divided by income or wealth, but also by allocations of urban resources such as space and place, which shapes access to housing, employment, education, healthcare, services, and opportunities. Wealthier residents tend to benefit more from urban advantages (e.g. easier access to jobs and services, better services, higher quality spaces) and suffer less from disadvantages (e.g. higher levels of pollution, congestion, lack of access to greenspace) relative to their less affluent neighbours (Tonkiss, 2020). This is evident, for example, from huge variations in life expectancy between neighbourhoods in the same city that are only a few kilometres apart in the UK (Bennett et al., 2015; Bennett et al., 2018; Yu et al., 2021). Improvements in non-monetary dimensions, in turn, have the potential to improve daily lives and wellbeing, and also help reduce the magnitude of inequalities in income and wealth (Couture et al., 2019). Inequalities of space and access, while less frequently at the fore of the discussion, can play a crucial role in mediating and ameliorating the negative effects of uneven wealth distribution.

It is impossible to think of space and access in urban areas without considering the role that transport and transportation infrastructure play. Access to essential services and opportunities, such as employment, education, healthcare, and recreational activities, are intricately linked to the availability, efficiency, and affordability of transport. Individuals with limited means may face challenges affording transportation costs or be forced to substitute financial costs for time, potentially restricting their access to job opportunities, and further exacerbating their challenges. Those with greater financial means have more agency in selecting better-connected residential locations, with the more financially disadvantaged facing a reduced range of residential options, further pushing up their transport costs. These ideas have been well articulated before in terms of spatial mismatch and entrapment theory (Titheridge et al., 2014), which describe how social disadvantage and transport disadvantage often intersect.

The relationship between housing and transport adds another layer of complexity, as affordable housing tends to be situated in areas with limited neighbourhood amenities and restricted access to public transportation (Saberi et al., 2017; Welch, 2013). These spatial dynamics impact the mobility and opportunities available to residents, contributing to disparities between those who can afford to live in high-quality homes in well-connected areas and those who cannot. Well-connected areas with good transportation links tend to attract more resources, businesses, and amenities, with implications for land value and affordability. This relationship can be observed where, for example, new railway lines such as Crossrail (since re-named the Elizabeth Line) in London, UK, led to noticeable house-price inflation in areas close to proposed stations along the line (Comber & Arribas-Bel, 2017).

Inequalities in health are also reinforced due to transportation decisions and attributes, including travel times, access to health care, and opportunities for active travel. Specific communities are disproportionately affected by the negative effects of pollution and congestion linked to increased mobility needs and transportation infrastructure. Those without reliable transport may face barriers to participating in social activities, contributing to social disparities and social exclusion. Such isolation may be exacerbated for vulnerable groups, such as elderly individuals and people with disabilities. The creation of new transport infrastructure in and through areas inhabited by specific communities, while often helping to reduce inequalities through increasing accessibility for marginalised groups (Breau et al., 2023), can also actively create and reinforce inequalities where the infrastructure is not targeted at these communities, such as the creation of US Highways which split communities along racial lines (Church et al., 2000; DiMento & Ellis, 2012; Geurs & van Eck, 2001; Van Wee & Geurs, 2011).

Transport, therefore, is an integral part of efforts towards achieving more equitable cities. However, measuring and tracking transport-related inequalities is challenging. It requires frameworks that consider multiple dimensions simultaneously to capture the complex relationship between transport and other factors. Figure 1 illustrates the conceptual framework guiding our review, outlining the interconnected dimensions within three key areas: housing, neighbourhoods, and transport. These dimensions contribute to inequalities across multiple urban domains (in red) such as health, education, and social mobility. Drivers of change (in blue) within cities can either mitigate or exacerbate

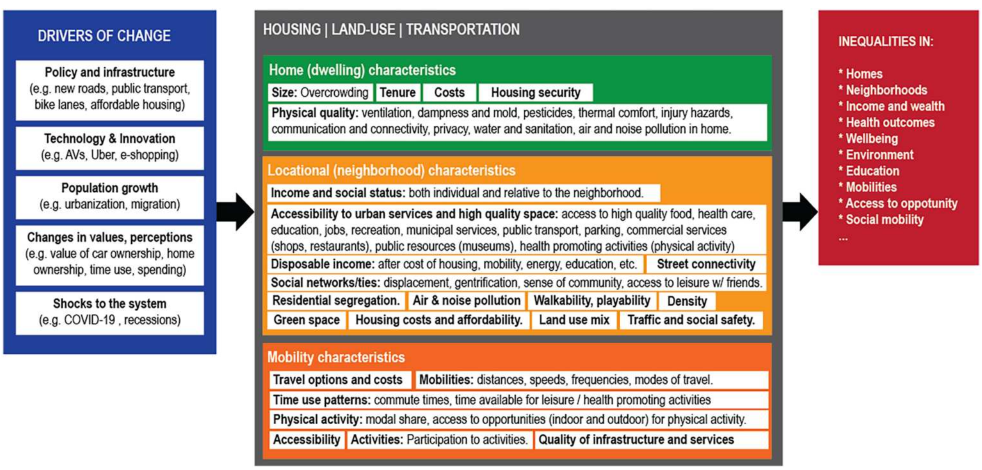

Figure 1. Conceptual framework for our review. It lays out the various dimensions within each of the interlinked areas under consideration: housing (depicted in green), neighbourhoods (depicted in yellow), and mobility (depicted in orange). The figure also represents the diverse range of drivers of change in cities (depicted in blue) that influence the reduction or exacerbation of inequalities across various urban domains (depicted in red).

these inequalities such as technological advancements, policy interventions, population growth, infrastructure investments, system shocks, and shifts in behaviour.

In this review, our first objective is to critically review empirical research on transport disparities. We focus on two main areas: disparities in accessibility levels and observed variations in individual mobility among different socioeconomic groups (Banister, 2018). Second, we review the literature on housing and health disparities from the perspective of their links to transport decisions, critically evaluating their potential contribution to the development of multidimensional metrics. Third, we review existing relevant datasets and identify data gaps that must be addressed to support the development of improved multidimensional measures for transport-related inequalities. Finally, we review modelling and forecasting frameworks utilised to assess the effects of transport investments and interventions, focusing on the extent to which inequality impacts are considered.

Our goal is to propose a new research agenda aimed at measurement, tracking, and modelling approaches capable of capturing interlinkages and complexities between transportation and other non-monetary dimensions of urban inequality. While local government and planning agencies may not have the tools and capacity to directly influence income and wealth inequalities, they do possess more power over the transport, land-use, and housing sectors and the processes through which inequalities in these domains are created and intensified (United Cities and Local Governments, 2012). This, in turn, has the potential to help address inequalities in wealth, income, and health.

2. Measurement of inequalities using measures of transport accessibility

The primary focus of transport inequalities research is on the measurement of levels of accessibility and its distribution over space and across different population groups (C. Bhat et al., 2000; Bills & Walker, 2017; Carleton & Porter, 2018; Di Ciommo & Shiftan, 2017; Geurs & van Eck, 2001; Hickman et al., 2019; LaMondia et al., 2010; Litman, 1997; Lucas et al., 2016; Lucas et al., 2019; Martens, 2012; Nahmias-Biran et al., 2017; Neutens et al., 2010; Pereira et al., 2017; Pritchard et al., 2019; Talen & Anselin, 1998; Van Wee & Geurs, 2011). While it is widely accepted that transport systems can help reduce inequalities by enhancing physical accessibility, defining and measuring "accessibility" is challenging (Gould, 1969). From a theoretical perspective, accessibility involves four main components (Geurs & Van Wee, 2004): land-use (locations of activities and their attributes – e.g. residential and commercial), transport (with travel time, cost, comfort and effort characteristics), temporal constraints and dynamics (availability of activities at different times of day, temporal constraints of individuals), and individual or collective needs, preferences, abilities, and opportunities. These are also captured in our conceptual framework as part of "locational (neighbourhood) characteristics' and "mobility characteristics' in Figure 1.

Empirical measures of accessibility, which are also used in health research (Litman, 1997), often do not capture all these components jointly due to data constraints and the respective siloed nature of their use cases. As a result, multiple accessibility metrics are developed separately (Geurs & van Eck, 2001; Geurs & Van Wee, 2004; Van Wee & Geurs, 2011). *Infrastructure-based metrics* focus on access to the transport system as measured by metrics such as the distance to public transport stops and incorporate attributes of the transport system including travel times, travel costs, connectivity of the network, off-peak and peak service levels, reliability, speed (Linneker & Spence, 1992). *Location-based* metrics focus on available opportunities that can be accessed (e.g. jobs, food stores, hospitals, schools, restaurants) within a time or distance threshold (Geurs & van Eck, 2001; Geurs & Van Wee, 2004; S. L. Handy & Niemeier, 1997; Hansen, 1959; Wilson, 1971), yet rarely incorporate individual needs or quality of available opportunities. *Person-based* metrics add in the focus on individual accessibility subject to individual spatio-temporal constraints and schedules incorporating ideas from time–space geography (Ilägcrstrand, 1970; Kwan, 1998; Lucas et al., 2019; H. J. Miller, 1991). *Utility-based* measures introduce an additional focus on the benefits individuals (with varying characteristics and preferences) might gain from access to spatially distributed opportunities. These measures quantify benefits in monetary terms using discrete choice methods (M. Ben-Akiva & Lerman, 1979; M. E. Ben-Akiva & Lerman, 1985; Bills & Walker, 2017; Dixit & Sivakumar, 2020; Niemeier, 1997; Sweet, 1997) and are sometimes used for evaluating proposed policy and investments (e.g. cost–benefit analyses), but are rarely used to track changes over time to evaluate effects of previous interventions (El-Geneidy & Levinson, 2007).

Utilising these conceptions of accessibility to assess transport inequalities primarily emphasises the *potential for travel*, often disregarding realised or *observed mobility patterns*. While it is possible to incorporate observed original departures or destination arrivals in location-based metrics of accessibility, data is rarely available (Rodrigue, 2020). This is a significant shortcoming, as they can overlook factors that have substantial impacts on lived mobility-related disparities and active utilisation due to constraints on things like time, employment, resources, income, and other social or cultural factors that may limit participation. Such dynamics are not captured by accessibility measures as they exclude individual utilisation of transport infrastructure.

3. Measurement of inequalities using observed mobility patterns

An alternative approach to studying transport inequalities focuses on observed mobility patterns. Urban populations have become more mobile on average over time with the increasing availability, affordability, and efficiency of transport (Banister, 2018). Daily travel distances for all modes, including air travel, and car ownership levels have increased over the past decades. Variations in observed mobility can be studied and measured through attributes capturing transport resources (e.g. car ownership, annual public transit tickets), travel behaviour (e.g. trip frequencies, travel distances, speed, and time) and related risks (e.g. injuries).

Research has shown that certain vulnerable groups, such as those with low income, the elderly, and children, tend to travel less but are disproportionately affected by externalities resulting from increased aggregate mobility, leading to higher risks of traffic-related injuries and elevated exposure to air and noise pollution. Contrary to intuition, the wealthy benefit more from public spending on transport in high-income cities, as they tend to travel longer distances and predominantly use cars and trains, compared to the less affluent who travel less and mostly rely on buses (Banister, 2018; Sustainable Development Commission, 2011). These findings suggest that transport infrastructure investments hold the potential to worsen existing inequalities in cities.

The primary limitation of analysing observed mobility trends, however, lies in its reliance on observed travel, lacking the ability to capture latent demand – travel demand that remains unsatisfied due to constraints on time, budgets, availability, and information (e.g. low-income populations being priced out from their preferred modes or activities) (Bills et al., 2012; Bills & Walker, 2017). Additionally, travel is a derived demand; it is typically not an end objective but a means to satisfying demand for other activities such as work, shopping, leisure, etc. (Axhausen & Gärling, 1992; Bhat & Koppelman, 1999). Reductions in mobility, therefore, do not necessarily indicate worsening effects, they may result from people's increased ability to participate in desired activities with less travel facilitated by, for instance, technological innovation (Mokhtarian, 2002; Pattabhiraman, 2012) or improved accessibility through better land-use policies (Banister, 1999; S. Handy et al., 2005). In fact, such reductions are desirable, as a continued increase in aggregate mobility is not sustainable (Greene & Wegener, 1997). There is a need to measure activity participation separately from mobility to understand if their association is changing over time, potentially decoupling unsustainable mobility from activity participation.

4. Addressing housing trade-offs in transport disparities research

A significant gap in existing measures used to study transport disparities is the lack of consideration for the trade-offs people are forced to make between their residential location and neighbourhoods, housing quality and expenses, and the costs and time allocated to travel (Grube-Cavers & Patterson, 2015; Revington, 2015). Figure 1 lays out the resulting characteristics of individuals resulting from these trade-offs captured within home (dwelling) characteristics, locational (neighbourhood) characteristics, and mobility characteristics. The choice of housing and transportation behaviour are closely linked. Housing location decisions are influenced by preferences for specific transportation modes and desired travel times for various purposes such as commuting, shopping, and other activities. Conversely, the availability of jobs, urban services, and transportation modes near one's residential location will have an impact on mobility behaviours. The extent to which these trade-offs result in equity concerns and exacerbate inequalities is of interest, yet challenging to measure. Overlooking this, however, has implications for designing transport interventions. For example, interventions aimed at reducing inequalities in transport accessibility may focus on improving accessibility in areas with poor access levels. Improved accessibility of such areas, in turn, will enhance neighbourhood attractiveness, leading to increases in housing prices and potentially displacing the resident population due to gentrification dynamics (Yee & Dennett, 2022). Observed improvements in accessibility would not fully capture these dynamics and the extent of displacement. On the other hand, merely quantifying variations in observed mobility would fail to differentiate between induced travel, such as individuals travelling longer distances due to high housing costs near job locations, and higher rates of travel among groups choosing to reside in suburbs despite being able to afford central homes or traveling for other purposes while also being close to jobs and urban amenities. There is a need for research and development of measurement tools to allow us to explore if and how trade-offs between housing and transport disproportionately affect specific population segments, such as those on low-incomes and the elderly.

Existing research on housing inequalities has predominantly been conducted in separate disciplines often isolated from transport literature. Housing inequalities arise from the high cost of housing, supply limitations, differences in the security of tenure and the physical and locational (neighbourhood) attributes of homes (UN Habitat, 2016a). The increase in housing prices relative to income (also relative to other goods) over the past 50 years (Albouy et al., 2016) has intensified ownership disparities, particularly affecting lower-income households and younger populations globally, with specific examples found across Europe and the United States (Andrews & Sánchez, 2011; Arundel & Doling, 2017; Gyourko et al., 2013; Hochstenbach, 2018; Lennartz et al., 2016; Moretti, 2013; Van Nieuwerburgh & Weill, 2010; Wind et al., 2017). Housing tenure contributes to inequalities by its impact on disposable income (owning a home frequently resulting in lower monthly outgoings than renting), wealth accumulation (the value of property increasing at much higher rates than wage increases), housing security (where lax regulation can leave tenants, particularly in the private rental sector, liable to "no-fault" evictions) and quality (with few incentives for landlords to maintain the quality of their accommodation) (Dustmann et al., 2022; Murie & Forrest, 1980; Whitehead, 2007). The quality of owner-occupied residences tends to be higher as they tend to be better maintained compared to rental homes (Filandri & Olagnero, 2014; Halket & di Custoza, 2015; Souza, 2018; Sternlieb, 1966; Sweeney, 1974; Taggart, 1970). Recent evidence suggests that socially rented accommodation in the UK, is more energy efficient and thus cheaper to run than housing in the owner-occupied or private rental sector (Buyuklieva et al., 2024). Observed increases in housing prices in cities are attributed to predominantly increases in land value associated with supply shortages rather than improvements to dwelling characteristics and quality (Aladangady et al., 2017; Forrest & Murie, 1989; Hamnett, 1992; Wind & Hedman, 2018). Changes in land value are influenced by changes in neighbourhood attractiveness including transport investments. This trend reinforces persistent patterns of socio-economic segregation (Arundel & Hochstenbach, 2020; Bischoff et al., 2014; Bischoff & Reardon, 2014; Musterd et al., 2017; Sampson, 2012; Sampson & Sharkey, 2008). This is alongside the financialization of the sector, which has shifted housing into an asset class to be bought, sold and profited from internationally, and a means to prop up ailing national economies, rather than a local human right to shelter (Dorling, 2014).

Transportation plays a crucial role in these dynamics, as improved transport accessibility can either exacerbate housing costs in certain neighbourhoods (Comber & Arribas-Bel, 2017) or mitigate them by enabling access to areas with more affordable housing options and higher-quality homes. Current metrics used in quantifying transport inequalities do not capture the relationship between housing and transport trade-offs. This highlights a gap in the literature and the need for research to develop measurement frameworks that can simultaneously consider attributes relating to transport, neighbourhoods, housing quality and affordability for a more comprehensive picture of transport-related urban inequalities and how they intersect.

5. Linking transport inequalities to health disparities

One of the extensively researched non-monetary dimensions of urban disparities is health inequalities. It is widely acknowledged that income and wealth inequality play a significant role in shaping health disparities. There is also consensus that addressing disparities in space and access can help mitigate the negative effects of uneven wealth distribution on health inequality. It is therefore a policy objective for many cities around the globe to prioritize enhancements in housing and neighbourhood environments to tackle health inequalities. Transportation infrastructure and service improvement is seen as a facilitator to help tackle health inequalities through its impacts on housing quality and affordability, as well as neighbourhood accessibility and environment.

Housing, including dwelling characteristics, costs (Mueller & Tighe, 2007; Tighe, 2010) and location (Cummins et al., 2007; R. Davidson et al., 2008; Duncan & Kawachi, 2018; A. V. D. Roux, 2016), is a fundamental determinant of health, influencing various health outcomes, including infectious and chronic diseases, injuries, and mental health (Ezzati et al., 2018; Krieger & Higgins, 2002; World Health Organization, 2018). The physical quality of homes – such as size, dampness, heating systems, energy efficiency, ventilation, insulation, sanitation, illumination, and structural deficiencies – contributes to health disparities by impacting exposure to air and noise pollution, overcrowding, thermal comfort, injury risk, and exposure to harmful substances, pollutants, pests, and allergens (Bornehag et al., 2001; Braubach, 2007; Dunn & Hayes, 2000; Lejeune et al., 2016; Spengler & Sexton, 1983). Studies on neighbourhood-level environmental and social characteristics have explored their connections to health disparities, exposome, through residential segregation, access to educational opportunities, exposure to environmental hazards, and crime (Bischoff & Reardon, 2014; Burke, 1993; Firebaugh & Acciai, 2016; Grimes, 1993; Malleson et al., 2010; Wild, 2005). Research indicates that exposure to the built and natural environment, including buildings, street networks, road infrastructure, vegetation, green spaces, pollution, and food environments, influences physical activity, sleep, cardiovascular health, mortality, obesity, mental health outcomes, and injury risk (Fong et al., 2018; Richardson et al., 2013). Social neighbourhood environments, such as economic resources, residential segregation, crime rates, social disorder, and collective efficacy, are also correlated with levels of obesity, physical activity, mortality, mental health outcomes, and pregnancy outcomes (Arcaya et al., 2016).

Transportation infrastructure influences several of these dimensions. It directly impacts housing costs and various locational attributes. It also indirectly influences housing quality, as individuals are often forced to make trade-offs which can result in residing in substandard housing conditions to gain increased access to jobs and services. More direct links between transport and health disparities have also been studied focusing on transport effects on air and noise pollution levels (Brauer, 2006; Clark & Stansfeld, 2007), physical activity (De Nazelle et al., 2011; N. Mueller et al., 2015; Prince et al., 2022; Ravensbergen et al., 2023), road safety (Bhalla et al., 2014), commute times (Christian, 2012; Milner et al., 2017; Petrov et al., 2018), and access to food and healthcare.

Research on the impact of housing and neighbourhood environments on urban health offers a promising framework for examining various aspects of the urban environment that are potentially modifiable through transport interventions and assessing their broader impacts on urban inequalities. However, two main research gaps need highlighting for the purposes of this review. First, only a small fraction of studies consider multiple housing and neighbourhood exposures jointly, primarily due to data availability issues. This limits our ability to disentangle confounding effects and analyse the independent, additive, or multiplicative impacts of co-exposures (Arcaya et al., 2016; Nieuwenhuijsen et al., 2019; Oakes et al., 2015; Rugel & Brauer, 2020). There is a need for comprehensive datasets and multidimensional measures encompassing housing, neighbourhoods, and transport that can be used jointly and consistently tracked over time (A.-V. D. Roux, 2001; Macintyre et al., 2002; Meijer et al., 2012; A.-V. D. Roux, 2007). Second, much of the existing research on neighbourhoods and health remains cross-sectional, limiting our ability to establish causality and evaluate policy interventions. Only a few longitudinal studies, natural experiments, and randomised experiments offer insights into questions regarding how to effect urban change (Arcaya et al., 2016; Frank et al., 2007; Halonen et al., 2015; Halonen et al., 2016; Hirsch et al., 2014; Jokela, 2014a, 2014b; Katz et al., 2001; Oakes et al., 2015; Sharkey & Sampson, 2010). This limits our capacity to forecast the potential effects of transport interventions.

4. Data gaps

Most people are forced to make some trade-offs when choosing where to live, work, shop, socialize and how to travel. Their resulting disadvantages and advantages (e.g. short vs. long commute, small flat vs. house with garden, high vs low rent, high vs. low pollution) will be a function of their constraints and preferences. We would expect everyone to be relatively disadvantaged in some dimensions depicted in Figure 1. Even the rich living in a city like London who enjoy high-quality homes and high access (R. J. Lee et al., 2017) to urban services, for instance, are exposed to high levels of air and noise pollution (Fecht et al., 2015). In a sprawling city like Los Angeles, even the most advantaged suffer from long travel times (Massunaga & Peltz, 2020). Traditional measures focused on specific sectors fall short of capturing the complexity of city life and individual experiences. The challenge lies in defining metrics and compiling datasets capable of capturing the complexity of outcomes resulting from these trade-offs. Ideally, we would want to measure and track individual-level information on housing (e.g. costs, quality, overcrowding), neighbourhoods (e.g. accessibility to opportunities, green spaces, pollution, walkability, segregation), and mobility (e.g. commute times, travel costs, available modes) as summarised in Figure 1. Temporal availability is also key for longitudinal tracking, to allow for the evaluation of policy effectiveness and interventions, as well as studying whether specific demographic groups are disproportionately disadvantaged by the various drivers of change (e.g. technology, population growth, changes in values and preferences, shocks to the system like pandemics).

Area-level indices that measure multidimensional deprivation are available in some countries, especially in the developed part of the world, including the UK, Canada, and New Zealand (Crampton et al., 2020; Pampalon et al., 2009; Smith et al., 2015). They provide area estimates of factors such as housing affordability and quality, life expectancy, access to green space, and commute times. These metrics use information collected from geographical information systems and sensors (e.g. location of parks, transport stations, air pollution), individuals living in these areas (e.g. life expectancy, housing costs) through surveys (e.g. expenditure surveys), and administrative datasets (e.g. hospital records, tax records). They provide area-level estimates for various characteristics of interest captured in Figure 1 such as housing quality, costs, and neighbourhood accessibility. They are useful for mapping, visualising, and analysing disparities across regions in countries and neighbourhoods in cities, particularly when available at a small-area level.

Area-level data, however, can conceal individual variations within the analysed statistical unit, posing a risk for ecological fallacy. Individuals residing in a neighbourhood with high levels of housing quality on average may still experience deprivation at the individual level. A notable example was the Grenfell Tower in London, situated in an affluent neighbourhood yet housing residents in deprived conditions. Improvements in a neighbourhood may not necessarily reflect overall progress for residents of that neighbourhood, as people migrate in and out of neighbourhoods and some may be priced out or displaced. Improved public transport accessibility might not directly benefit original residents, as such investments may lead to pricing out of disadvantaged groups from these neighbourhoods. As a result, observed improvements in area-level measures of transport accessibility for previously underserved areas may not translate into better conditions for the communities residing there. Instead, they might even face worsening circumstances if they are priced out or displaced.

To address these issues with area-level data, one would need to capture individual-level variations by using individual-level data. However, collecting individual-level data at scale over long periods, especially across multiple dimensions of interest, is much more difficult and fraught with challenges relating to the confidentiality of people within the data. As a result, such data are rarely available, despite increasing interest in capturing multiple domains (Tiznado-Aitken & Farber, 2024). Deprivation measures based on individual-level data are rarely available. Even when they are, such as in the US and UK (Dhongde & Haveman, 2017; Glassman, 2019), they often rely on single data sources like the census with trade-offs made between richness across some dimensions of interest, whether space, time or attributes and not all at once. The problem is that richness across all dimensions is often not practically possible, or ethically desirable where too much personal information about respondents could be revealed. Census data frequently privilege spatial detail and attribute breadth over temporal regularity and attribute depth. Detailed information across attribute depth and temporal regularity is frequently collected through separate survey instruments (e.g. household travel surveys, housing surveys). The main shortcoming is that these lack individual-level information on the multiple dimensions of interest.

One promising research direction is the development of approaches that can utilize disparate individual and area-level data sources, enabling the creation of population-level measures of urban metrics that can capture multiple interconnected dimensions and individual variations over time. Small-area estimation methods have been successfully applied in epidemiology and public health (Elliott et al., 1992; Elliott & Wartenberg, 2004; Openshaw, 1984; Piel et al., 2020; Robinson, 2009; Wakefield, 2008) yet are rarely used to study transport-related inequalities. The main idea is to conduct spatial analyses of individual or aggregate data at the neighbourhood scale (e.g. lowest census geography of a few streets or blocks). The assumption is that populations within these small areas will be relatively homogenous compared to larger areas, allowing to study of relationships between metrics of interest. Methods to combine individual-level data with area level data are employed to tackle some of the challenges posed by the ecological fallacy in ecological studies (Wakefield, 2008), and to overcome the spatial/temporal/attribute breadth and depth trade-offs described above through generating what are effectively multi-dimensionally rich synthetic populations. In the context of our review, small-area estimation approaches will allow researchers to systematically study how non-monetary resources are distributed among different socioeconomic groups. For instance, area-level research has shown disparities in the distribution of green space among racial and economic groups in the US (Casey et al., 2017; Klompmaker et al., 2023). In London, the UK's largest city, public transport accessibility varies unequally across income groups, with lower income groups having significantly lower access to public transportation (Nie & Suel, 2024). Other area-studies have revealed unequal exposure to air and noise pollution among racial and economic groups in numerous cities globally (Hajat et al., 2015). Data linkage becomes crucial to make the most of increasingly available datasets that capture various characteristics of homes, neighbourhoods, and mobility from a range of sources from more traditional surveys to administrative data, from satellite and street-imagery to mobile phones. Advances in methods, including Bayesian approaches (Lindgren & Rue, 2015) and deep learning (Suel et al., 2021), increasingly allow linkage and analysis of large volumes of available data from disparate sources. Table S1 in supplementary materials provides information on distinct datasets and individual-level variables commonly found in European and North American cities along with the types of data of interest for studying transport-related urban inequalities.

5. Modelling and evaluating distributional effects of interventions

Designing interventions that effectively achieve multi-sector objectives (e.g. reducing travel times, meeting housing demand, reduce air and noise pollution) while addressing inequalities poses a significant research and policy challenge (Ezzati et al., 2018; Giles-Corti et al., 2016; Sallis et al., 2016). Actions taken by the city (such as implementing affordable housing policies or investing in transport infrastructure) or by individuals (such as relocating further from the city centre to reduce housing costs) can yield multiple positive or negative impacts on inequalities, as well as unintended consequences such as displacement. Modelling frameworks that can consider dynamics over time and interactions between urban sectors are desirable. Planning Support Systems (PSS), which refer to computerised tools designed to support planners in their daily tasks and decision making, have been put forward as promising to address these limitations since the late 1980s (Geertman & Stillwell, 2004; Harris & Batty, 1993; Vonk et al., 2005). Integrated urban models aim to establish comprehensive frameworks and tools for modelling and predicting the impacts of policies and technologies (Buytaert et al., 2012; Iacono et al., 2008; E. J. Miller, 2018). Spatial interaction models, urban micro-simulation models and agent-based models find application in land-use and transport planning, housing and real estate markets, crime, and education (Arhami et al., 2013; Axhausen et al., 2016; Axhausen & Gärling, 1992; Beevers et al., 2013; Buytaert et al., 2012; Chapin, 1968; Heppenstall et al., 2011; Iacono et al., 2008; Malleson et al., 2010; Rasouli & Timmermans, 2014).

Spatial interaction models (SIMs) are widely used in simulating aggregate flows between spatial zones and supporting decision-making across various domains, including transport, retail, housing, land-use, and public health (Haynes & Fotheringham, 1985). Originally inspired by principles from physics, SIMs model the flow of people, goods, or information between origin and destination zones in relation to their gravitational forces, primarily influenced by characteristics of these geographic zones and inversely related to their spatial separation (Batty & Mackie, 1972; Fotheringham & O'Kelly, 1989). In transportation, they are often used for predicting the impact of new developments and inference for gaining insights into the driving factors behind observed flows of individuals (Batten & Boyce, 1987; Fotheringham & O'Kelly, 1989). State-of-the-art SIMs have evolved to incorporate social science theory into their core structures and have embraced increasingly advanced representations of origins, destinations, and their separation, factoring in aspects like geographic, financial, cultural, economic, and social influences (Rowe et al., 2022). The proliferation of GIS and the availability of extensive spatial datasets and big data sources have enabled SIMs to more effectively capture disaggregated patterns, local variations and interdependencies more effectively (Siła-Nowicka & Fotheringham, 2019). Despite the progress made, several challenges persist in the field of SIMs as summarised by the recent review by Rowe et. al. (Rowe et al., 2022). They rarely consider the distributional effects of interventions to evaluate how different socio-economic groups will be impacted by proposed infrastructures, interventions, and policies. While their aggregate nature does pose challenges to study inequalities across individuals, the small-area methods proposed above are promising.

Aggregate modelling methods like SIMs, have been criticised for treating geographical components as homogeneous entities and tendencies to overpredict demand (Batty, 2011; Flyvbjerg et al., 2005). This has led to bottom-up modelling approaches operating at the level of the individual. These include cellular automata, microsimulation, and agent-based models (ABMs) (Heppenstall et al., 2011). ABMs are considered state-of-art and increasingly applied in transport, facilitated by the availability of software tools like MATSim (W Axhausen et al., 2016). ABMs incorporate individual-level behaviour and can simulate complex situations and dynamics where agents interact with each other and the urban environment at fine spatial and temporal resolution (Chapin, 1968; Rasouli & Timmermans, 2014). Aligned with sectoral priorities in transport, these models are primarily employed to assess mean or aggregate outcomes, measuring sector-specific performances, such as aggregate travel time savings and jobs available within a distance threshold averaged over the city. ABMs can model and predict behaviour at the individual agent level where agents have socio-economic attributes, and therefore provide a framework to study distributional effects of interventions across different population groups, yet existing literature remains limited (Bills et al., 2012; Bills & Walker, 2017; Castiglione et al., 2006; De Palma et al., 2007; Dixit & Sivakumar, 2020; Nahmias-Biran & Shiftan, 2016). In recent years there has been a trend for these state-of-the-art simulation techniques (making use of diverse synthetic populations) to move from academia into practice. Activity-based models (often implemented as an agent-based model) have been widely used in the US starting with the seminal CT-RAMP model and there are now 10 major cities in the US who use iterations of similar approaches (W. Davidson et al., 2010; Vovsha et al., 2004; Vovsha & Bradley, 2006). Similar but distinct methodological approaches have been developed in Europe, with notable examples in Switzerland (Scherr et al., 2020), Germany (Moeckel et al., 2003) and France (Hörl & Balac, 2021). Their development is often a joint endeavour across industry and academia, reflecting the underlying research still to be done on the behavioural drivers of transport behaviour. A key focus of these models in recent developments is understanding the behavioural component of choice, the influence of evolving population dynamics and support for deeper equity and distributional impacts.

We identify three main limitations that need to be addressed when using existing urban modelling frameworks to assess inequalities. First, the accuracy of simulation results is highly reliant on the accuracy of underlying behavioural assumptions. Existing models consider socio-economic variables such as income, education, and employment, and how they have implications for sector-specific behaviour – e.g. in transport behaviour, and housing decisions separately. They rarely consider more complex behaviours and variables to capture interactions between multiple sectors and dimensions in Figure 1 (e.g. trade-offs between time and budget constraints, the impact of housing and job security on behaviour, the influence of factors such as race, ethnicity, and immigration status on choice sets). There is a need to enhance existing frameworks to incorporate these dimensions for predictions. Second, uncertainty in predictions is rarely quantified. One of the initial motivations behind PSS was to replace top-down and black-box models that were used to make city planning decisions, with more transparent support tools (D. B. Lee, 1973; D. B. Lee, 1994). However, the increasing complexity of these models contradicts this motivation, as it becomes challenging to quantify uncertainties within the many sub-parts of these models. They also become more difficult to interpret, making it difficult to track and understand the implications of the assumptions underlying each of these sub-models either because of the modelling complexity or because of closed-source software practices. There is a need to better quantify uncertainties associated with model scenario testing and forecasts. There are also challenges with the ability of local regional and state governments to technically manage such models, with often a deep reliance on professional (third-party consulting) services and a limited in-house ability to own, manage, update and use these models, with the risks that deferring such important tasks to third-parties brings (Mazzucato & Collington, 2023). Third, while models are utilised in planning, they have not been effectively employed to track and evaluate the performance of an implemented policy. There is a need for tools that allow the continuous evaluation of policies and their effects, enabling adjustments to be made while they are being implemented. Such capability is also crucial from an accountability perspective, providing citizens with tools to hold modellers and policy-makers accountable for interventions.

6. Future directions and research needs

In this paper we critically review research concerning transport-related urban inequalities from disparate disciplines, focusing not only on transport inequalities but also on housing affordability and quality, neighbourhood characteristics, locational attributes, and links to health disparities. While academic research tends to be discipline-specific and rarely links these inter-related issues together, individuals living their lives *must* consider these linkages. They do so implicitly when making trade-offs in deciding where to live; considering the attributes of their dwellings and neighbourhoods at the same time as assessing their mobility options. The resulting disparities cannot be adequately understood and addressed if we only focus on transportation inequalities. Considering the multidimensional nature of transport-related inequalities, we propose two main research directions for future research based on gaps identified:

(1) *Measurement and tracking of multidimensional inequalities relating to transport through new data collection or bespoke data-linkage and estimation methods*. The initial goal here should be identifying a set of relevant metrics from an equity

standpoint and quantifying disparities across these dimensions. It is crucial to expand measurement and tracking capabilities beyond transportation alone, recognising its interconnectedness with housing and neighbourhood characteristics. We propose the collection of multiple housing, neighbourhood, and transportation metrics from individuals – including information on housing (e.g. costs, quality, overcrowding), neighbourhoods (e.g. accessibility to opportunities, green spaces, pollution, walkability, segregation), and mobility (e.g. commute times, travel costs, available modes) as summarised in Figure 1. Collected data should have a temporal dimension to allow studying change and inequality dynamics over time. Where these data might not be routinely collected or accessible, the successful application of small-area estimation methods in epidemiology and environmental health (such as more deterministic microsimulation methods or alternative probabilistic Bayesian methods) offers a promising framework for synthesising data from diverse sources – ranging from surveys to GIS-derived area-level measures – generating new dataset which enable the study of associations across different dimensions while minimising the risk of ecological fallacy. Ongoing assessment is crucial to evaluate the effectiveness of cities in their common ambition to reduce disparities while simultaneously addressing other pressing challenges, such as attaining net-zero emissions and enhancing the health and well-being of their residents.

(2) *Development of modelling and scenario testing capabilities that can consider distributional effects of interventions*. Urban modelling methods like spatial interaction models and agent-based models have been successfully applied to scenario testing and evaluation of transport interventions. The evaluation metrics, however, often focus on aggregate outcomes rather than differences between groups. For instance, assessments often would use overall travel time savings without considering how these benefits are distributed among different demographic segments or which groups derive the greatest advantage from investments. It's crucial to measure these impacts to understand if transport changes might worsen existing inequalities in society. A second direction of future research should therefore focus on bridging this gap by integrating inequality evaluation metrics into existing modelling frameworks. This would enrich forecasting capabilities by adding in consideration of distributional impacts and facilitate their use to evaluate inequality implications of planned transport interventions and policy.

In the title of this article, we pose the question "where are we and where do we go from here?" and in reviewing the current state of transport-related inequalities research and identifying these two clear deficiencies in data and measurement and in models and scenarios which need to pay more attention to inequalities and distributional effects and outcomes, both provide a clear signpost to the direction we should head, something which presents big opportunities for serious impact to be made beyond the traditional narrow focus of traffic and transportation as transportation modelling sits at the centre of urban and regional decision-making and socio-economic progress.

Disclosure statement

No potential conflict of interest was reported by the author(s).

References

Aladangady, A., Albouy, D., & Zabek, M. (2017). *Housing inequality*. NBER Working Paper Series, 21916.

Albouy, D., Ehrlich, G., & Liu, Y. (2016). *Housing demand, cost-of-living inequality, and the affordability crisis*. NBER Working Paper Series, 22816.

Andrews, D., & Sánchez, A. C. (2011). The evolution of homeownership rates in selected OECD countries: Demographic and public policy influences. *OECD Journal: Economic Studies*, *2011*(1), 1–37. doi:10.1787/eco_studies-2011-5kg0vswqpmg2

Arcaya, M. C., Tucker-Seeley, R. D., Kim, R., Schnake-Mahl, A., So, M., & Subramanian, S. (2016). Research on neighborhood effects on health in the United States: A systematic review of study characteristics. *Social Science & Medicine*, *168*, 16–29. doi:10.1016/j.socscimed.2016.08.047

Arhami, M., Kamali, N., & Rajabi, M. M. (2013). Predicting hourly air pollutant levels using artificial neural networks coupled with uncertainty analysis by Monte Carlo simulations. *Environmental Science and Pollution Research*, *20*(7), 4777–4789. doi:10.1007/s11356-012-1451-6

Arundel, R., & Doling, J. (2017). The end of mass homeownership? Changes in labour markets and housing tenure opportunities across Europe. *Journal of Housing and the Built Environment*, *32*(4), 649–672. doi:10.1007/s10901-017-9551-8

Arundel, R., & Hochstenbach, C. (2020). Divided access and the spatial polarization of housing wealth. *Urban Geography*, *41*(4), 497–523. doi:10.1080/02723638.2019.1681722

Axhausen, K. W., & Gärling, T. (1992). Activity-based approaches to travel analysis: Conceptual frameworks, models, and research problems. *Transport Reviews*, *12*(4), 323–341. doi:10.1080/01441649208716826

Axhausen, K. W., Horni, A., & & Nagel, K. (2016). *The multi-agent transport simulation MATSim*. Ubiquity Press.

Banister, D. (1999). Planning more to travel less: Land use and transport. *The Town Planning Review*, *70*(3), 313–338.

Banister, D. (2018). *Inequality in transport*. Alexandrine Press.

Batten, D. F., & Boyce, D. E. (1987). Spatial interaction, transportation, and interregional commodity flow models. In P. Nijkamp (Ed.), *Handbook of regional and urban economics* (vol. 1, pp. 357–406). Elsevier.

Batty, M. (2011). A generic framework for computational spatial modelling. In A. Heppenstall, A. T. Crooks, L. M. See, & M. Batty (Eds.), *Agent-based models of geographical systems* (pp. 19–50). Springer.

Batty, M., & Mackie, S. (1972). The calibration of gravity, entropy, and related models of spatial interaction. *Environment and Planning A: Economy and Space*, *4*(2), 205–233. doi:10.1068/a040205

Beevers, S. D., Kitwiroon, N., Williams, M. L., Kelly, F. J., Ross Anderson, H., & Carslaw, D. C. (2013). Air pollution dispersion models for human exposure predictions in London. *Journal of Exposure Science & Environmental Epidemiology*, *23*(6), 647–653. doi:10.1038/jes.2013.6

Ben-Akiva, M., & Lerman, S. R. (1979). Disaggregate travel and mobility-choice models and measures of accessibility. In D. Hensher & P. Stopher (Eds.), *Behavioural travel modelling* (pp. 654–679). Routledge.

Ben-Akiva, M. E., & Lerman, S. R. (1985). *Discrete choice analysis: Theory and application to travel demand* (vol. 9). MIT Press.

Bennett, J. E., Li, G., Foreman, K., Best, N., Kontis, V., Pearson, C., Hambly, P., & Ezzati, M. (2015). The future of life expectancy and life expectancy inequalities in England and Wales: Bayesian spatiotemporal forecasting. *The Lancet*, *386*(9989), 163–170. doi:10.1016/S0140-6736(15)60296-3

Bennett, J. E., Pearson-Stuttard, J., Kontis, V., Capewell, S., Wolfe, I., & Ezzati, M. (2018). Contributions of diseases and injuries to widening life expectancy inequalities in England from 2001 to 2016: A population-based analysis of vital registration data. *The Lancet Public Health*, *3*(12), e586–e597. doi:10.1016/S2468-2667(18)30214-7

Bhalla, K., Brauer, M., Burnett, R., Cohen, A. I., Freedman, G., Leach-Kemon, K., … Shotten, M. S. (2014). *Transport for health: The global burden of disease from motorized road transport*. World Bank Group. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/984261468327002120/transport-for-health-the-global-burden-of-disease-from-motorized-road-transport.

Bhat, C., Handy, S., Kockelman, K., Mahmassani, H., Chen, Q., & Weston, L. (2000). *Urban accessibility index: literature review*. Center of Transportation Research, University of Texas at Austin, Springfield.
Bhat, C. R., & Koppelman, F. S. (1999). *Activity-based modeling of travel demand (handbook of transportation science (pp. 35-61)*. Springer.
Bills, T. S., Sall, E. A., & Walker, J. L. (2012). Activity-Based travel models and transportation equity analysis. *Transportation Research Record: Journal of the Transportation Research Board*, *2320*(1), 18–27. doi:10.3141/2320-03
Bills, T. S., & Walker, J. L. (2017). Looking beyond the mean for equity analysis: Examining distributional impacts of transportation improvements. *Transport Policy*, *54*, 61–69. doi:10.1016/j.tranpol.2016.08.003
Bischoff, K., & Reardon, S. F. (2014). Residential Segregation by Income, 1970–2009. In *Diversity and disparities: America enters a new century* (vol. 43). Russell Sage Foundation.
Bischoff, K., Reardon, S. F., & Logan, J. (2014). Diversity and disparities: America enters a new century. The Russell Sage Foundation, 1970–2009.
Bloom, D. E., Canning, D., & Fink, G. (2008). Urbanization and the wealth of nations. *Science*, *319*(5864), 772–775. doi:10.1126/science.1153057
Bornehag, C.-G., Blomquist, G., Gyntelberg, F., Järvholm, B., Malmberg, P., Nordvall, L., Nielsen, A., Pershagen, G., & Sundell, J. (2001). Dampness in buildings and health. *Indoor air*, *11*(2), 72–86. doi:10.1034/j.1600-0668.2001.110202.x
Braubach, M. (2007). Residential conditions and their impact on residential environment satisfaction and health: Results of the WHO large analysis and review of European housing and health status (LARES) study. *International Journal of Environment and Pollution*, *30*(3/4), 384–403. doi:10.1504/IJEP.2007.014817.
Brauer, M. (2006). Health effects of transport-related air pollution. *Canadian Journal of Public Health*, *97*(5), 418–419.
Breau, S., Wylie, M., Manaugh, K., & Carr, S. (2023). Inclusive growth, public transit infrastructure investments and neighbourhood trajectories of inequality in Montreal. *Environment and Planning A: Economy and Space*, *55*(8), 2009–2030. doi:10.1177/0308518X231162091
Burke, L. M. (1993). *Environmental equity in Los Angeles* (pp. 93–96). National Center for Geographic Information and Analysis.
Buytaert, W., Baez, S., Bustamante, M., & Dewulf, A. (2012). *Web-based environmental simulation: Bridging the gap between scientific modeling and decision-making*. ACS Publications.
Buyuklieva, B., Oléron-Evans, T., Bailey, N., & Dennett, A. (2024). Variations in domestic energy efficiency by property, neighbourhood and local authority type: Where are the largest challenges for the net-zero transition of the UK's residential stock? *Frontiers in Sustainability*, *5*, 1329034. doi:10.3389/frsus.2024.1329034
Carleton, P. R., & Porter, J. D. (2018). A comparative analysis of the challenges in measuring transit equity: Definitions, interpretations, and limitations. *Journal of Transport Geography*, *72*, 64–75. doi:10.1016/j.jtrangeo.2018.08.012
Casey, J. A., James, P., Cushing, L., Jesdale, B. M., & Morello-Frosch, R. (2017). Race, ethnicity, income concentration and 10-year change in urban greenness in the United States. *International Journal of Environmental Research and Public Health*, *14*(12), 1546. doi:10.3390/ijerph14121546
Castiglione, J., Hiatt, R., Chang, T., & Charlton, B. (2006). Application of travel demand microsimulation model for equity analysis. *Transportation Research Record: Journal of the Transportation Research Board*, *1977*(1), 35–42. doi:10.1177/0361198106197700105
Chapin Jr, S. F. (1968). Activity systems and urban structure: A working schema. *Journal of the American Institute of Planners*, *34*(1), 11–18. doi:10.1080/01944366808977214
Christian, T. J. (2012). Trade-offs between commuting time and health-related activities. *Journal of Urban Health*, *89*(5), 746–757. doi:10.1007/s11524-012-9678-6
Church, A., Frost, M., & Sullivan, K. (2000). Transport and social exclusion in London. *Transport Policy*, *7*(3), 195–205. doi:10.1016/S0967-070X(00)00024-X
Clark, C., & Stansfeld, S. A. (2007). The effect of transportation noise on health and cognitive development: A review of recent evidence. *International Journal of Comparative Psychology*, *20*(2), 2. doi:10.46867/IJCP.2007.20.02.10

Comber, S., & Arribas-Bel, D. (2017). “Waiting on the train”: The anticipatory (causal) effects of cross-rail in ealing. *Journal of Transport Geography*, *64*, 13–22. doi:10.1016/j.jtrangeo.2017.08.004

Couture, V., Gaubert, C., Handbury, J., & Hurst, E. (2019). *Income growth and the distributional effects of urban spatial sorting*. NBER.26142.

Crampton, P., Salmond, C., & Atkinson, J. (2020). A comparison of the NZDep and New Zealand IMD indexes of socioeconomic deprivation. *Kōtuitui: New Zealand Journal of Social Sciences Online*, *15* (1), 154–169. doi:10.1080/1177083X.2019.1676798

Cummins, S., Curtis, S., Diez-Roux, A. V., & Macintyre, S. (2007). Understanding and representing ‘place’ in health research: A relational approach. *Social Science & Medicine*, *65*(9), 1825–1838. doi:10.1016/j.socscimed.2007.05.036

Davidson, R., Mitchell, R., & Hunt, K. (2008). Location, location, location: The role of experience of disadvantage in lay perceptions of area inequalities in health. *Health & Place*, *14*(2), 167–181. doi:10.1016/j.healthplace.2007.05.008

Davidson, W., Vovsha, P., Freedman, J., & Donnelly, R. (2010). CT-RAMP family of activity-based models. Proceedings of the 33rd Australasian transport research forum (ATRF).

De Nazelle, A., Nieuwenhuijsen, M. J., Antó, J. M., Brauer, M., Briggs, D., Braun-Fahrlander, C., Cavill, N., Cooper, A. R., Desqueyroux, H., & Fruin, S. (2011). Improving health through policies that promote active travel: A review of evidence to support integrated health impact assessment. *Environment International*, *37*(4), 766–777. doi:10.1016/j.envint.2011.02.003

De Palma, A., Motamedi, K., Picard, N., & Waddell, P. (2007). Accessibility and environmental quality: inequality in the Paris housing market. *European Transport*, *36*, 47–74.

Dhongde, S., & Haveman, R. (2017). Multi-Dimensional deprivation in the U.S. *Social Indicators Research*, *133*(2), 477–500. doi:10.1007/s11205-016-1379-1

Di Ciommo, F., & Shiftan, Y. (2017). Transport equity analysis. *Transport Reviews*, 37(2), 139–151.

DiMento, J. F., & Ellis, C. (2012). *Changing lanes: Visions and histories of urban freeways*. MIT Press.

Dixit, M., & Sivakumar, A. (2020). Capturing the impact of individual characteristics on transport accessibility and equity analysis. *Transportation Research Part D: Transport and Environment*, *87*, 102473. doi:10.1016/j.trd.2020.102473

Dorling, D. (2014). *All that is solid: How the great housing disaster defines our times, and what we can do about it*. Penguin UK.

Dorling, D. (2019). *Inequality and the 1%*. Verso Books.

Duncan, D. T., & Kawachi, I. (2018). *Neighborhoods and health*. Oxford University Press.

Dunn, J. R., & Hayes, M. V. (2000). Social inequality, population health, and housing: A study of two Vancouver neighborhoods. *Social Science & Medicine*, *51*(4), 563–587. doi:10.1016/S0277-9536(99)00496-7

Dustmann, C., Fitzenberger, B., & Zimmermann, M. (2022). Housing expenditure and income inequality. *The Economic Journal*, *132*(645), 1709–1736. doi:10.1093/ej/ueab097

Dye, C. (2008). Health and urban living. *Science*, *319*(5864), 766–769. doi:10.1126/science.1150198

El-Geneidy, A., & Levinson, D. (2007). Mapping accessibility over time. *Journal of Maps*, *3*(1), 76–87. doi:10.1080/jom.2007.9710829

Elliott, P., & Wartenberg, D. (2004). Spatial epidemiology: Current approaches and future challenges. *Environmental Health Perspectives*, *112*(9), 998–1006. doi:10.1289/ehp.6735

Elliott, P., Westlake, A. J., Hills, M., Kleinschmidt, I., Rodrigues, L., McGale, P., Marshall, K., & Rose, G. (1992). The small area health statistics unit: A national facility for investigating health around point sources of environmental pollution in the United Kingdom. *Journal of Epidemiology & Community Health*, *46*(4), 345–349. doi:10.1136/jech.46.4.345

Ezzati, M., Webster, C. J., Doyle, Y. G., Rashid, S., Owusu, G., & Leung, G. M. (2018). Cities for global health. *BMJ*, *363*, 1–7.

Fecht, D., Fischer, P., Fortunato, L., Hoek, G., De Hoogh, K., Marra, M., Kruize, H., Vienneau, D., Beelen, R., & Hansell, A. (2015). Associations between air pollution and socioeconomic characteristics, ethnicity and age profile of neighbourhoods in England and The Netherlands. *Environmental Pollution*, *198*, 201–210. doi:10.1016/j.envpol.2014.12.014

Filandri, M., & Olagnero, M. (2014). Housing inequality and social class in Europe. *Housing Studies*, *29*(7), 977–993. doi:10.1080/02673037.2014.925096

Firebaugh, G., & Acciai, F. (2016). For blacks in America, the gap in neighborhood poverty has declined faster than segregation. *Proceedings of the National Academy of Sciences*, *113*(47), 13372–13377. doi:10.1073/pnas.1607220113

Flyvbjerg, B., Skamris Holm, M. K., & Buhl, S. L. (2005). How (in) accurate are demand forecasts in public works projects? *Journal of the American Planning Association*, *71*(2), 131–146. doi:10.1080/01944360508976688

Fong, K. C., Hart, J. E., & James, P. (2018). A review of epidemiologic studies on greenness and health: Updated literature through 2017. *Current Environmental Health Reports*, *5*(1), 77–87. doi:10.1007/s40572-018-0179-y

Forrest, R., & Murie, A. (1989). Differential accumulation: Wealth, inheritance and housing policy reconsidered. *Policy & Politics*, *17*(1), 25–39. doi:10.1332/030557389783219460

Fotheringham, A. S., & O'Kelly, M. E. (1989). *Spatial interaction models: Formulations and applications* (Vol. 1). Kluwer Academic Publishers.

Frank, L. D., Saelens, B. E., Powell, K. E., & Chapman, J. E. (2007). Stepping towards causation: Do built environments or neighborhood and travel preferences explain physical activity, driving, and obesity? *Social Science & Medicine*, *65*(9), 1898–1914. doi:10.1016/j.socscimed.2007.05.053

Geertman, S., & Stillwell, J. (2004). Planning support systems: An inventory of current practice. *Computers, Environment and Urban Systems*, *28*(4), 291–310. doi:10.1016/S0198-9715(03)00024-3

Geurs, K. T., & Ritsema van Eck, J. R. (2001). *Accessibility measures: Review and applications: Evaluation of accessibility impacts of land-use transport scenarios, and related social and economic impacts*. RIVM report 408505 006 Rijksinstituut voor Volksgezondheid en Milieu.

Geurs, K. T., & Van Wee, B. (2004). Accessibility evaluation of land-use and transport strategies: Review and research directions. *Journal of Transport Geography*, *12*(2), 127–140. doi:10.1016/j.jtrangeo.2003.10.005

Giles-Corti, B., Vernez-Moudon, A., Reis, R., Turrell, G., Dannenberg, A. L., Badland, H., Foster, S., Lowe, M., Sallis, J. F., & Stevenson, M. (2016). City planning and population health: A global challenge. *The Lancet*, *388*(10062), 2912–2924. doi:10.1016/S0140-6736(16)30066-6

Glassman, B. (2019). *Multidimensional deprivation in the United States, 2017*. US Department of Commerce, Economics and Statistics Administration, US Census Bureau. https://www.census.gov/content/dam/Census/library/publications/2019/demo/acs-40.pdf.

Gould, P. R. (1969). Spatial diffusion, resource paper No. 4.

Greene, D. L., & Wegener, M. (1997). Sustainable transport. *Journal of Transport Geography*, *5*(3), 177–190. doi:10.1016/S0966-6923(97)00013-6

Grimes, S. (1993). Residential segregation in Australian cities: A literature review. *International Migration Review*, *27*(1), 103–120. doi:10.1177/019791839302700105

Grube-Cavers, A., & Patterson, Z. (2015). Urban rapid rail transit and gentrification in Canadian urban centres: A survival analysis approach. *Urban Studies*, *52*(1), 178–194. doi:10.1177/0042098014524287

Gyourko, J., Mayer, C., & Sinai, T. (2013). Superstar cities. *American Economic Journal: Economic Policy*, *5*(4), 167–199. doi:10.1257/pol.5.4.167

Hägerstrand, T. (1970). *What About People in Regional Science* (24, pp. 7–21). Regional Science Association.

Hajat, A., Hsia, C., & O'Neill, M. S. (2015). Socioeconomic disparities and air pollution exposure: A global review. *Current Environmental Health Reports*, *2*(4), 440–450. doi:10.1007/s40572-015-0069-5

Halket, J., & di Custoza, M. P. M. (2015). Homeownership and the scarcity of rentals. *Journal of Monetary Economics*, *76*, 107–123. doi:10.1016/j.jmoneco.2015.08.003

Halonen, J. I., Pulakka, A., Stenholm, S., Pentti, J., Kawachi, I., Kivimäki, M., … Vahtera, J. (2016). Change in neighborhood disadvantage and change in smoking behaviors in adults: a longitudinal, within-individual study. *Epidemiology*, 27(6), 803–809.

Halonen, J. I., Stenholm, S., Kivimäki, M., Pentti, J., Subramanian, S., Kawachi, I., & Vahtera, J. (2015). Is change in availability of sports facilities associated with change in physical activity? A prospective cohort study. *Preventive Medicine*, *73*, 10–14. doi:10.1016/j.ypmed.2015.01.012

Hamnett, C. (1992). The geography of housing wealth and inheritance in Britain. *The Geographical Journal*, *158*(3), 307–321.

Handy, S., Cao, X., & Mokhtarian, P. (2005). Correlation or causality between the built environment and travel behavior? Evidence from northern California *Transportation Research Part D: Transport and Environment*, *10*(6), 427–444. doi:10.1016/j.trd.2005.05.002

Handy, S. L., & Niemeier, D. A. (1997). Measuring accessibility: An exploration of issues and alternatives. *Environment and Planning A: Economy and Space*, *29*(7), 1175–1194. doi:10.1068/a291175

Hansen, W. G. (1959). How accessibility shapes land use. *Journal of the American Institute of Planners*, *25*(2), 73–76. doi:10.1080/01944365908978307

Harris, B., & Batty, M. (1993). Locational models. *Geographic Information and Planning Support Systems. Journal of Planning Education and Research*, *12*(3), 184–198.

Haynes, K. E., & Fotheringham, A. S. (1985). G. I. Thrall (Ed.), *Gravity and spatial interaction models*. Regional Research Institute, West Virginia University.

Heppenstall, A. J., Crooks, A. T., See, L. M., & Batty, M. (2011). *Agent-based models of geographical systems*. Springer Science & Business Media.

Hickman, R., Lira, B. M., Givoni, M., & Geurs, K. (2019). *A companion to transport, space and equity*. Edward Elgar Publishing.

Hirsch, J. A., Diez Roux, A. V., Moore, K. A., Evenson, K. R., & Rodriguez, D. A. (2014). Change in walking and body mass index following residential relocation: The multi-ethnic study of atherosclerosis. *American Journal of Public Health*, *104*(3), e49–e56. doi:10.2105/AJPH.2013.301773

Hochstenbach, C. (2018). Spatializing the intergenerational transmission of inequalities: Parental wealth, residential segregation, and urban inequality. *Environment and Planning A: Economy and Space*, *50*(3), 689–708. doi:10.1177/0308518X17749831

Hörl, S., & Balac, M. (2021). Synthetic population and travel demand for Paris and Île-de-France based on open and publicly available data. *Transportation Research Part C: Emerging Technologies*, *130*, 103291. doi:10.1016/j.trc.2021.103291

Iacono, M., Levinson, D., & El-Geneidy, A. (2008). Models of transportation and land use change: A guide to the territory. *Journal of Planning Literature*, *22*(4), 323–340. doi:10.1177/0885412207314010

Jokela, M. (2014a). Are neighborhood health associations causal? A 10-year prospective cohort study with repeated measurements. *American Journal of Epidemiology*, 180(8), 776–784.

Jokela, M. (2014b). Jokela responds to "repeated measures and effect identification". *American Journal of Epidemiology*, *180*(8), 788–789. doi:10.1093/aje/kwu232

Katz, L. F., Kling, J. R., & Liebman, J. B. (2001). Moving to opportunity in Boston: Early results of a randomized mobility experiment. *The Quarterly Journal of Economics*, *116*(2), 607–654. doi:10.1162/00335530151144113

Klompmaker, J. O., Hart, J. E., Bailey, C. R., Browning, M. H., Casey, J. A., Hanley, J. R., Minson, C. T., Ogletree, S. S., Rigolon, A., & Laden, F. (2023). Racial, ethnic, and socioeconomic disparities in multiple measures of blue and green spaces in the United States. *Environmental Health Perspectives*, *131*(1), 17007. doi:10.1289/EHP11164

Krieger, J., & Higgins, D. L. (2002). Housing and health: Time again for public health action. *American Journal of Public Health*, *92*(5), 758–768. doi:10.2105/AJPH.92.5.758

Kwan, M. P. (1998). Space-time and integral measures of individual accessibility: A comparative analysis using a point-based framework. *Geographical Analysis*, *30*(3), 191–216. doi:10.1111/j.1538-4632.1998.tb00396.x

LaMondia, J. J., Blackmar, C. E., & Bhat, C. R. (2010). *Comparing transit accessibility measures: a case study of access to healthcare facilities*. Transport Research Board 2011 Annual Meeting. Washington, DC.

Lee, D. B. (1973). Requiem for large-scale models. *Journal of the American Institute of Planners*, *39*(3), 163–178. doi:10.1080/01944367308977851

Lee, D. B. (1994). Retrospective on large-scale urban models. *Journal of the American Planning Association*, *60*(1), 35–40. doi:10.1080/01944369408975549

Lee, R. J., Sener, I. N., & Jones, S. N. (2017). Understanding the role of equity in active transportation planning in the United States. *Transport Reviews*, *37*(2), 211–226. doi:10.1080/01441647.2016.1239660

Lejeune, Z., Xhignesse, G., Kryvobokov, M., & Teller, J. (2016). Housing quality as environmental inequality: The case of wallonia, Belgium. *Journal of Housing and the Built Environment*, *31*(3), 495–512. doi:10.1007/s10901-015-9470-5

Lennartz, C., Arundel, R., & Ronald, R. (2016). Younger adults and homeownership in Europe through the global financial crisis. *Population, Space and Place*, *22*(8), 823–835. doi:10.1002/psp.1961

Lindgren, F., & Rue, H. (2015). Bayesian spatial modelling with R-INLA. *Journal of Statistical Software*, *63*(19), 19. doi:10.18637/jss.v063.i19

Linneker, B., & Spence, N. (1992). An accessibility analysis of the impact of the M25 London orbital motorway on Britain. *Regional Studies*, *26*(1), 31–47. doi:10.1080/00343409212331346761

Litman, T. (1997). *Evaluating transportation equity*. Victoria Transport Policy Institute Victoria.

Lucas, K., Martens, K., Di Ciommo, F., & Dupont-Kieffer, A. (2019). *Measuring transport equity*. Elsevier.

Lucas, K., Van Wee, B., & Maat, K. (2016). A method to evaluate equitable accessibility: Combining ethical theories and accessibility-based approaches. *Transportation*, *43*(3), 473–490. doi:10.1007/s11116-015-9585-2

Macintyre, S., Ellaway, A., & Cummins, S. (2002). Place effects on health: How can we conceptualise, operationalise and measure them? *Social Science & Medicine*, *55*(1), 125–139. doi:10.1016/S0277-9536(01)00214-3

Malleson, N., Heppenstall, A., & See, L. (2010). Crime reduction through simulation: An agent-based model of burglary. *Computers, Environment and Urban Systems*, *34*(3), 236–250. doi:10.1016/j.compenvurbsys.2009.10.005

Martens, K. (2012). Justice in transport as justice in accessibility: Applying Walzer's 'spheres of justice'to the transport sector. *Transportation*, *39*(6), 1035–1053. doi:10.1007/s11116-012-9388-7

Massunaga, S., & Peltz, J. F. (2020). Skipping L.A. traffic in a helicopter: 'Not a poor man's way of transportation.' Los Angeles Times. https://www.latimes.com/business/story/2020-01-30/kobe-bryant-chartered-helicopter-industry

Mazzucato, M., & Collington, R. (2023). *The big con: How the consulting industry weakens our businesses, infantilizes our governments, and warps our economies*. Penguin.

Meijer, M., Röhl, J., Bloomfield, K., & Grittner, U. (2012). Do neighborhoods affect individual mortality? A systematic review and meta-analysis of multilevel studies. *Social Science & Medicine*, *74*(8), 1204–1212. doi:10.1016/j.socscimed.2011.11.034

Miller, H. J. (1991). Modelling accessibility using space-time prism concepts within geographical information systems. *International Journal of Geographical Information Systems*, *5*(3), 287–301. doi:10.1080/02693799108927856

Miller, E. J. (2018). Integrated urban modeling. *Journal of Transport and Land Use*, *11*(1), 387–399.

Milner, A., Badland, H., Kavanagh, A., & LaMontagne, A. D. (2017). Time spent commuting to work and mental health: Evidence from 13 waves of an Australian cohort study. *American Journal of Epidemiology*, *186*(6), 659–667. doi:10.1093/aje/kww243

Moeckel, R., Spiekermann, K., & Wegener, M. (2003). Creating a synthetic population. (Ed.) Proceedings of the 8th international conference on computers in urban planning and urban management (CUPUM).

Mokhtarian, P. L. (2002). Telecommunications and travel: The case for complementarity. *Journal of Industrial Ecology*, *6*(2), 43–57. doi:10.1162/108819802763471771

Moretti, E. (2013). Real wage inequality. *American Economic Journal: Applied Economics*, *5*(1), 65–103. doi:10.1257/app.5.1.65

Mueller, N., Rojas-Rueda, D., Cole-Hunter, T., De Nazelle, A., Dons, E., Gerike, R., Götschi, T., Panis, L. I., Kahlmeier, S., & Nieuwenhuijsen, M. (2015). Health impact assessment of active transportation: A systematic review. *Preventive Medicine*, *76*, 103–114. doi:10.1016/j.ypmed.2015.04.010

Mueller, E. J., & Tighe, J. R. (2007). Making the case for affordable housing: Connecting housing with health and education outcomes. *Journal of Planning Literature*, *21*(4), 371–385. doi:10.1177/0885412207299653

Murie, A., & Forrest, R. (1980). Wealth, inheritance and housing policy. *Policy & Politics*, *8*(1), 1–19. doi:10.1332/030557380782719258

Musterd, S., Marcińczak, S., Van Ham, M., & Tammaru, T. (2017). Socioeconomic segregation in European capital cities. Increasing separation between poor and rich. *Urban Geography*, *38*(7), 1062–1083. doi:10.1080/02723638.2016.1228371

Nahmias-Biran, B.-h., Martens, K., & Shiftan, Y. (2017). Integrating equity in transportation project assessment: A philosophical exploration and its practical implications. *Transport Reviews*, *37*(2), 192–210. doi:10.1080/01441647.2017.1276604

Nahmias-Biran, B.-h., & Shiftan, Y. (2016). Towards a more equitable distribution of resources: Using activity-based models and subjective well-being measures in transport project evaluation. *Transportation Research Part A: Policy and Practice*, *94*, 672–684. doi:10.1016/j.tra.2016.10.010

Neutens, T., Schwanen, T., Witlox, F., & De Maeyer, P. (2010). Equity of urban service delivery: A comparison of different accessibility measures. *Environment and Planning A: Economy and Space*, *42*(7), 1613–1635. doi:10.1068/a4230

Nie, Y., & Suel, E. (2024). Disparities in Public Transport Accessibility in London from 2011 to 2021. Working Paper.

Niemeier, D. A. (1997). Accessibility: An evaluation using consumer welfare. *Transportation*, *24*(4), 377–396. doi:10.1023/A:1004914803019

Nieuwenhuijsen, M. J., Agier, L., Basagaña, X., Urquiza, J., Tamayo-Uria, I., Giorgis-Allemand, L., Robinson, O., Siroux, V., Maitre, L., & de Castro, M. (2019). Influence of the urban exposome on birth weight. *Environmental Health Perspectives*, *127*(4), 47007. doi:10.1289/EHP3971

Oakes, J. M., Andrade, K. E., Biyoow, I. M., & Cowan, L. T. (2015). Twenty years of neighborhood effect research: An assessment. *Current Epidemiology Reports*, *2*(1), 80–87. doi:10.1007/s40471-015-0035-7

OECD. (2016). Making cities work for all: data and actions for inclusive growth.

Openshaw, S. (1984). The modifiable areal unit problem. In D. G. Janelle, B. Warf, & K. Hansen (Eds.), *Concepts and techniques in modern geography*. Springer Science & Business Media.

Pampalon, R., Hamel, D., Gamache, P., & Raymond, G. (2009). A deprivation index for health planning in Canada. *Chronic Diseases in Canada*, *29*(4), 178–191. doi:10.24095/hpcdp.29.4.05

Pattabhiraman, V. R. (2012). *A needs-based approach to activity generation for travel demand analysis*. Massachusetts Institute of Technology.

Pereira, R. H., Schwanen, T., & Banister, D. (2017). Distributive justice and equity in transportation. *Transport Reviews*, *37*(2), 170–191. doi:10.1080/01441647.2016.1257660

Petrov, M. E., Weng, J., Reid, K. J., Wang, R., Ramos, A. R., Wallace, D. M., Alcantara, C., Cai, J., Perreira, K., & Giacinto, R. A. E. (2018). Commuting and sleep: Results from the hispanic community health study/study of latinos sueño ancillary study. *American Journal of Preventive Medicine*, *54*(3), e49–e57. doi:10.1016/j.amepre.2017.11.006

Piel, F. B., Fecht, D., Hodgson, S., Blangiardo, M., Toledano, M., Hansell, A., & Elliott, P. (2020). Small-area methods for investigation of environment and health. *International Journal of Epidemiology*, *49*(2), 686–699. doi:10.1093/ije/dyaa006

Piketty, T., & Saez, E. (2014). Inequality in the long run. *Science*, *344*(6186), 838–843. doi:10.1126/science.1251936

Prince, S. A., Lancione, S., Lang, J. J., Amankwah, N., de Groh, M., Garcia, A. J., Merucci, K., & Geneau, R. (2022). Are people who use active modes of transportation more physically active? *An Overview of Reviews Across the Life Course. Transport Reviews*, *42*(5), 645–671.

Pritchard, J. P., Tomasiello, D., Giannotti, M., & Geurs, K. (2019). An international comparison of equity in accessibility to jobs: London, São Paulo and the randstad. *Findings*. doi:10.32866/7412.

Rasouli, S., & Timmermans, H. (2014). Activity-based models of travel demand: Promises, progress and prospects. *International Journal of Urban Sciences*, *18*(1), 31–60. doi:10.1080/12265934.2013.835118

Ravensbergen, L., Wasfi, R., Van Liefferinge, M., Ehrlich, I., Prince, S. A., Butler, G., Kestens, Y., & El-Geneidy, A. (2023). Associations between light rail transit and physical activity: A systematic review. *Transport Reviews*, *43*(2), 234–263. doi:10.1080/01441647.2022.2099999

Revington, N. (2015). Gentrification, transit, and land use: Moving beyond neoclassical theory. *Geography Compass*, *9*(3), 152–163. doi:10.1111/gec3.12203

Richardson, D. B., Volkow, N. D., Kwan, M.-P., Kaplan, R. M., Goodchild, M. F., & Croyle, R. T. (2013). Spatial turn in health research. *science*, *339*(6126), 1390–1392. doi:10.1126/science.1232257

Robinson, W. S. (2009). Ecological correlations and the behavior of individuals*. *International Journal of Epidemiology*, *38*(2), 337–341. doi:10.1093/ije/dyn357

Rodrigue, J.-P. (2020). *The geography of transport systems*. Routledge.

Roux, A. V. D. (2001). Investigating neighborhood and area effects on health. *American Journal of Public Health*, *91*(11), 1783–1789. doi:10.2105/AJPH.91.11.1783

Roux, A.-V. D. (2007). Neighborhoods and health: Where are we and were do we go from here? *Revue D'epidemiologie et de Sante Publique*, *55*(1), 13–21. doi:10.1016/j.respe.2006.12.003

Roux, A. V. D. (2016). Neighborhoods and health: What do we know? What should we do? *American Journal of Public Health*, *106*(3), 430–431. doi:10.2105/AJPH.2016.303064.

Rowe, F., Lovelace, R., & Dennett, A.. (2022). . In Levi John Wolf, Richard Harris, & Alison Heppenstall (Eds.), (pp. 177–196). Edward Elgar Publishing.

Rugel, E. J., & Brauer, M. (2020). Quiet, clean, green, and active: A navigation guide systematic review of the impacts of spatially correlated urban exposures on a range of physical health outcomes. *Environmental Research*, *185*, 109388. doi:10.1016/j.envres.2020.109388

Saberi, M., Wu, H., Amoh-Gyimah, R., Smith, J., & Arunachalam, D. (2017). Measuring housing and transportation affordability: A case study of Melbourne, Australia. *Journal of Transport Geography*, *65*, 134–146. doi:10.1016/j.jtrangeo.2017.10.007

Sallis, J. F., Bull, F., Burdett, R., Frank, L. D., Griffiths, P., Giles-Corti, B., & Stevenson, M. (2016). Use of science to guide city planning policy and practice: How to achieve healthy and sustainable future cities. *The Lancet*, *388*(10062), 2936–2947. doi:10.1016/S0140-6736(16)30068-X

Sampson, R. J. (2012). *Great American city: Chicago and the enduring neighborhood effect*. University of Chicago Press.

Sampson, R. J., & Sharkey, P. (2008). Neighborhood selection and the social reproduction of concentrated racial inequality. *Demography*, *45*(1), 1–29. doi:10.1353/dem.2008.0012

Scherr, W., Manser, P., Joshi, C., Frischknecht, N., & Métrailler, D. (2020). Towards agent-based travel demand simulation across all mobility choices–the role of balancing preferences and constraints. *European Journal of Transport and Infrastructure Research*, *20*(4), 152–172. doi:10.18757/ejtir.2020.20.4.4463

Sharkey, P., & Sampson, R. J. (2010). Destination effects: Residential mobility and trajectories of adolescent violence in a stratified metropolis. *Criminology*, *48*(3), 639–681. doi:10.1111/j.1745-9125.2010.00198.x

Siła-Nowicka, K., & Fotheringham, A. S. (2019). Calibrating spatial interaction models from GPS tracking data: An example of retail behaviour. *Computers, Environment and Urban Systems*, *74*, 136–150. doi:10.1016/j.compenvurbsys.2018.10.005

Smith, T., Noble, M., Noble, S., Wright, G., McLennan, D., & Plunkett, E. (2015). *The English indices of deprivation 2015*. Department for Communities and Local Government.

Souza, M. (2018). Why are rented dwellings less energy-efficient? Evidence from a representative sample of the US housing stock. *Energy Policy*, *118*, 149–159. doi:10.1016/j.enpol.2018.03.013

Spengler, J. D., & Sexton, K. (1983). Indoor air pollution: A public health perspective. *Science*, *221*(4605), 9–17. doi:10.1126/science.6857273

Sternlieb, G. (1966). *The tenement landlord*. Rutgers University Press.

Suel, E., Bhatt, S., Brauer, M., Flaxman, S., & Ezzati, M. (2021). Multimodal deep learning from satellite and street-level imagery for measuring income, overcrowding, and environmental deprivation in urban areas. *Remote Sensing of Environment*, *257*, 112339. https://www.sciencedirect.com/science/article/pii/S0034425721000572

Sustainable Development Commission. (2011). Fairness in a car-dependent society.

Sweeney, J. L. (1974). Housing unit maintenance and the mode of tenure. *Journal of Economic Theory*, *8*(2), 111–138. doi:10.1016/0022-0531(74)90009-X

Sweet, R. J. (1997). An aggregate measure of travel utility. *Transportation Research Part B: Methodological*, *31*(5), 403–416. doi:10.1016/S0191-2615(97)00004-0

Taggart, R. (1970). *Low-income housing: A critique of federal aid*. The Johns Hopkins University Press.

Talen, E., & Anselin, L. (1998). Assessing spatial equity: An evaluation of measures of accessibility to public playgrounds. *Environment and Planning A: Economy and Space*, *30*(4), 595–613. doi:10.1068/a300595

Tighe, J. R. (2010). Public opinion and affordable housing: A review of the literature. *Journal of Planning Literature*, *25*(1), 3–17. doi:10.1177/0885412210379974
Titheridge, H., Mackett, R. L., Christie, N., Oviedo Hernández, D., & Ye, R. (2014). Transport and poverty: a review of the evidence.
Tiznado-Aitken, I., & Farber, S. (2024). The Scarborough Survey: An interdisciplinary hybrid instrument to explore suburban challenges in Canada.
Tonkiss, F. (2020). City government and urban inequalities. *City*, *24*(1-2), 286–301. doi:10.1080/13604813.2020.1739931
UN. (2022). World Population Prospects 2022. https://population.un.org/wpp/
UN Habitat. (2016a). Only 13% of world's cities have affordable housing–according to new research.
UN Habitat. (2016b). Urbanization and Development: Emerging Futures.
United Cities and Local Governments. (2012). Who can address urban inequality? The often forgotten roles of local government.
Van Nieuwerburgh, S., & Weill, P.-O. (2010). Why has house price dispersion gone up? *Review of Economic Studies*, *77*(4), 1567–1606. doi:10.1111/j.1467-937X.2010.00611.x
Van Wee, B., & Geurs, K. (2011). Discussing equity and social exclusion in accessibility evaluations. *European Journal of Transport and Infrastructure Research*, *11*(4), 350–367.
Vonk, G., Geertman, S., & Schot, P. (2005). Bottlenecks blocking widespread usage of planning support systems. *Environment and Planning A: Economy and Space*, *37*(5), 909–924. doi:10.1068/a3712
Vovsha, P., & Bradley, M. (2006). Advanced activity-based models in context of planning decisions. *Transportation Research Record: Journal of the Transportation Research Board*, *1981*(1), 34–41. doi:10.1177/0361198106198100106
Vovsha, P., Petersen, E., & Donnelly, R. (2004). Impact of intrahousehold interactions on individual daily activity-travel patterns. *Transportation Research Record: Journal of the Transportation Research Board*, *1898*(1), 87–97. doi:10.3141/1898-11
Wakefield, J. (2008). Ecologic studies revisited. *Annual Review of Public Health*, *29*(1), 75–90. doi:10.1146/annurev.publhealth.29.020907.090821
Welch, T. F. (2013). Equity in transport: The distribution of transit access and connectivity among affordable housing units. *Transport Policy*, *30*, 283–293. doi:10.1016/j.tranpol.2013.09.020
Whitehead, C. M. (2007). Planning policies and affordable housing: England as a successful case study? *Housing Studies*, *22*(1), 25–44. doi:10.1080/02673030601024580
Wild, C. P. (2005). Complementing the genome with an "exposome": the outstanding challenge of environmental exposure measurement in molecular epidemiology. *Cancer Epidemiology, Biomarkers & Prevention*, *14*(8), 1847–1850. doi:10.1158/1055-9965.EPI-05-0456
Wilkinson, R. G., & Pickett, K. E. (2009). Income inequality and social dysfunction. *Annual Review of Sociology*, *35*(1), 493–511. doi:10.1146/annurev-soc-070308-115926
Wilson, A. G. (1971). A family of spatial interaction models, and associated developments. *Environment and Planning A: Economy and Space*, *3*(1), 1–32. doi:10.1068/a030001
Wind, B., & Hedman, L. (2018). The uneven distribution of capital gains in times of socio-spatial inequality: Evidence from Swedish housing pathways between 1995 and 2010. *Urban Studies*, *55*(12), 2721–2742. doi:10.1177/0042098017730520
Wind, B., Lersch, P., & Dewilde, C. (2017). The distribution of housing wealth in 16 European countries: Accounting for institutional differences. *Journal of Housing and the Built Environment*, *32*(4), 625–647. doi:10.1007/s10901-016-9540-3
World Health Organization. (2018). WHO housing and health guidelines.
Yee, J., & Dennett, A. (2022). Stratifying and predicting patterns of neighbourhood change and gentrification: An urban analytics approach. *Transactions of the Institute of British Geographers*, *47*(3), 770–790. doi:10.1111/tran.12522
Young, A. (2013). Inequality, the urban-rural Gap, and migration*. *The Quarterly Journal of Economics*, *128*(4), 1727–1785. doi:10.1093/qje/qjt025
Yu, J., Dwyer-Lindgren, L., Bennett, J., Ezzati, M., Gustafson, P., Tran, M., & Brauer, M. (2021). A spatiotemporal analysis of inequalities in life expectancy and 20 causes of mortality in sub-neighbourhoods of metro Vancouver, British Columbia, Canada, 1990–2016. *Health & Place*, *72*, 102692. doi:10.1016/j.healthplace.2021.102692