2015

Workshop Synthesis: Built Environment and Contextual Variables

Kelly Clifton
Portland State University, kclifton@pdx.edu

Pascal Perez
University of Wollongong

Citation Details

Clifton, K., and Perez, P. (2015). Workshop Synthesis: Built Environment and Contextual Variables. Transportation Research Procedia. Volume 11, pages 452–459.

Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 11 (2015) 452 – 459

Transportation Research Procedia

www.elsevier.com/locate/procedia

10th International Conference on Transport Survey Methods

Workshop synthesis: Built environment and contextual variables

Kelly Clifton [a,*] and Pascal Perez [b]

[a]*Portland State University, PO Box 751-CEE, Portland, Oregon, United States*
[b]*SMART Infrastructure Facility, University of Wollongong, Wollongong, NSW, Australia*

Abstract

This two-day workshop focused on the important issue of how to define, convey and understand the built environment context as it relates to transport decisions. The field has grown tremendously over the last few decades, fueled in part by the increasing availability of archived spatial data about the environment and geo-referencing activity and travel patterns. But there are persistent issues particularly with inconsistencies in data format or availability across locations that hamper efforts to advance our understanding across regions. Further, there are new challenges in how we communicate context to survey respondents, particularly in stated preference surveys. Much of the workshop was devoted to these issues and the new opportunities that exist with mixed methods and new innovative approaches for engaging respondents in our surveys.

Peer-review under responsibility of International Steering Committee for Transport Survey Conferences ISCTSC

Keywords:

1. Introduction & Scope

With several decades of contributions, the study of the links between the built environment and various aspects of travel is now an established and mature area of research. While there are questions about the magnitude and specificity of effects, it is generally accepted that there exists an association between the built environment and travel choices. The literature is substantial and there are several comprehensive reviews (Badoe and Miller 2000; Ewing and Cervero 2010; Handy 2006). Despite the significant work in this area, the emergence of new research questions continually places demands for new data and information. Moreover, the growing attention of urban and transport planning to accessibility and walkability criteria encourages methodological cross-overs between transport, quality of life and residential mobility surveys. This workshop focused on how to represent various aspects of the built environment, either real or perceived, and other contextual variables that affect transport related choices (mode, route, location) in a variety of surveys. To support this discussion and provide some specific

Peer-review under responsibility of International Steering Committee for Transport Survey Conferences ISCTSC
doi:10.1016/j.trpro.2015.12.037

research applications, the workshop relied upon four papers and two posters that addressed some aspect of our theme:

- Hurtubia and Donoso (paper): "Measuring perception of qualitative attributes in urban space,"
- Bonet, Greene and Dios Ortuzar (paper): "Valuation of heritage neighbourhood attributes from the perspective of their inhabitants,"
- Beck, Hess and Dumont (paper): "It's a lovely day for a walk: pedestrian route choice with realism,"
- Erath, van Eggermond and Axhausen (paper): "Evaluating novel and traditional survey methods for the construction of a behavioural founded walkability index."
- Simecek (poster): "Human path assignation at maps: discrete choice model of visual attributes of alternatives," and
- Manz, Kagerbauer and Streit (poster): "Weather conditions influencing mode choice – on measuring loyalty and predicting alternatives."

These research papers considered a range of ways to represent context within a number of different methodological approaches and transport outcomes considered. Building upon this background material, the workshop explored various theoretical and methodological aspects, the highlights of which are summarized in the following sections.

2. Background

Although time constraints prevented workshop's participants to exhaustively explore the state-of-practice of representing the built environment in studies of travel behaviour, we found it useful to first provide them with some background information. The development of geographic information systems (GIS) has transformed our ability to include various archived spatial information into our analyses of travel behaviour (Miller and Shaw 2001). There is also an increasing variety of built environment data at a fine-grained spatial scale available (Clifton et al. 2008; Bennenson et al. 2010). As access to these spatially archived data has increased, the methodologies for a consistent and comparable set of built environment measures across locations have been developed and refined (Forsyth 2010).

From these measures of the built environment, many of the most important attributes have been identified and operationalized in statistical or simulation models and used to establish associations with various travel outcomes, such as vehicle miles travelled, automobile trips, transit use and vehicle ownership (Cervero and Kockelman 1997, Transportation Research Board 2009). At the same time, travel surveys have improved their ability to capture non-motorized travel modes, providing the ability to extend the study of these relationships beyond the use of motorized modes (e.g. Forsyth and Krizek 2011; Rodriguez and Joo 2004). Global positioning systems (GPS), associated with mobile technologies, have permitted the incorporation of more detailed disaggregate location information about the traveller and his/her routes, destinations and durations (Shen and Stopher 2014; Abedi et al, 2014; Wolf 2006).

More recently, studies on travel behaviour have found overlapping interests with other disciplines, leading to interdisciplinary collaborations and the interjection of new theories, methods and data. Motivated by a concern over the obesity epidemic in the United States and elsewhere, the health fields were interested in the role of physical activity, including the use of active transportation modes, in contributing to positive health outcomes (Handy et al 2002). This research led to an increasing interest in how the built environment can support or detract from walking and cycling. This interdisciplinary agenda helped shape the types of transportation data collected and emphasized the built and natural environment (Badland et al. 2014, Brownson et al 2009; Ewing et al 2006; Ewing and Handy 2009). For example, travel diaries started including "loop trip" or recreational trips by walking or cycling where the trip itself is the activity. Travel surveys have paid more attention to access and egress modes in order to capture non-motorized activity (Clifton and Muhs 2012, Giles-Corti and Donovan 2002, Giles-Corti et al. 2005).

There is also an intersection with the psychology field, as the role of attitudes and perceptions in shaping behaviour and behavioural change have moved to the forefront (Garling and Golledge 1989). Here, surveys have been adapted to collect information on respondents' subjective assessments of the environment and their attitudes. These constructs have been tested in statistical models along with and in lieu of and along with objective built

environment measures (Adamowicz et al. 1997; Kitamura et al. 1997). These instruments of perceptions tend to be captured with Likert scales measuring the degree of agreement or disagreement with a series of statements and they tend to be used alone or aggregated into an index. In some cases, surveys have focused on satisfaction with livability and how it relates to objective elements of the built environment (Namazi-Rad et al. 2012).

As the field of transport and land use has matured, a new breadth and depth of research questions arise. At the same time, the ability to collect information to inform this research agenda is challenged by these new research questions, technologies available and the changing nature of our built environment. Yet despite the access to improved data, the methods and research designs have not changed very much to respond to these new opportunities. Theories of behaviour and the built environment have expanded to incorporate new fields, but a comprehensive unified theory or set of theories to explain behaviour in the built environment is yet to emerge. Measures of the built environment are often not constructed and tested with an obvious understanding of how they influence travel decisions and how they are perceived and interpreted by the traveller. A clearer theoretical grounding about how the built environment impacts travel decisions is needed (Singleton 2013). Improved data and methods can help to support the development of these theories and their verification.

Related to the appropriate measures of built environment measures are questions about how individuals process and perceive the environment and how they should be characterized in behavioural studies and models (Perez et al. 2014; Stimson and Marans 2011). The built environment has been represented in empirical analysis as discrete, disaggregate variables representing individual elements and as composite measures of the environment, such as indices or factors (e.g. Galster et al. 2001; Walk Score). The former offers insight for planners and designers seeking to create specific built environment policies, such as residential densities or mixed use developments. But these may not adequately capture the ways that individuals perceive and react to their environments. Additionally, they are often correlated with one another making inclusion in statistical models problematic. With the latter, these correlation issues are partially resolved but the appropriate ways to represent the environment remain unsettled.

With increasing availability of disaggregate built environment and behavioural data comes more attention to the spatial scale at which measures are computed (Gehrke and Clifton 2014; Hong et al. 2013). Similar to the above issues of perception is the spatial extent of which various built environment characteristics have an impact on behaviour. Historically, distance buffers, either straight line distance or network distance around a home residence, have been used to capture characteristics in the construct of these variables. As travel data have improved, these variables are computed at other activity locations, besides the home environment (Chatman 2003). But the appropriate scale of these measures to explain transport choices remains poorly understood. Even more complicated are the relevant scale and shape of these measures for issues of route choice (Broach et al. 2012).

Finally, we understand very little about the transferability of these relationships may be across different physical, economic, cultural and social contexts. To do this, comparative studies across urban, regional and international settings are necessary (Zhang et al 2012). The creation of comparable information is complicated by the lack of standards in data collection and archiving. While travel survey methods have greatly improved in this regard (Stopher, P and Stecher, C 2006), archived data on the built environment vary a great deal in terms of availability, form and structure.

This workshop attempted to bring these issues related to the data needs for built environment and travel behaviour studies to the forefront. The next several sections present the highlights of our discussions.

3. Setting the context

The workshop focused on two particular aspects of setting the context for studies of travel behaviour. First is the use of spatial data in analysis of travel survey data. Here, specific measures of the built and natural environment are constructed from data, usually from a public archive although they could be collected as a part of the study using audits, aerial photography or other techniques. The measures are intended to represent the context where the travel decisions are taking place. Examples of this sort include but are not limited to: residential and employment density, transit access, walkability, accessibility, and street configuration. Then once the survey data are augmented with this additional contextual information, multivariate statistical analysis is employed to test their associations with travel outcomes. The challenges in this first case are discussed largely in the next section.

In the second case, the context is needed as a part of the survey design to engage the respondent with the questions or situation posed. This is particularly relevant for stated preference surveys and choice experiments about residential location, vehicle ownership, and travel outcomes. Here, text can be used to describe the character

of a place. However, the use of language has challenges. It is often difficult to adequately convey the salient features of the built environment in ways that respondents can relate to, particularly when the setting is unfamiliar to the respondent. Translating words and urban concepts translate to different languages and cultures can also prove difficult. Grounding the respondent in a common context for these choice surveys is important and the use of imagery can compensate for some of the shortcomings of text descriptions.

Sketches, pictures and video are not new to the survey community. They have often been incorporated into our instruments as the focus of specific queries or as a visual aid to supplement text. Here, the debate is how to incorporate and vary aspects of the environment that are of interest to the study, while carefully controlling for other elements of the context. For this, sketches, often based upon photographs, have long been favoured. However, sketches are criticized for lacking the realism that can engage respondents in the context of the survey. Some argue that photographs and videos provide a better sense of place but can bias respondents based upon elements in the imagery that are difficult to identify and control for. The presence of architectural styles, colours, people, traffic, time of day, types of establishments and rubbish can all impact a respondent's reaction. As the creation and manipulation of imagery becomes easier as 3-dimentional virtual realities and simulations advance and offer the opportunity or respondents to "move" through an environment, stated choice experiments can become more sophisticated. With the use of biometric feedback, we may even monitor emotions and physiological reactions to place.

Another point raised in the workshop the need to broaden the focus beyond the home and work environment and consider the full range of places experienced as a part of daily life. With the increasing availability of built environment data, the barriers to this are low. Further, the context of past experiences is increasingly recognized as important in shaping our current attitudes, motivations, and actions. How to capture the relationship between the context of critical events in our life histories and our current behaviour will be a challenge for research.

4. Measures of the contextual environment using archived spatial data

There is a large accumulation of literature devoted to measuring and operationalizing features of the built environment using archived spatial data (Forsyth 2010, Clifton et al. 2008). These are most commonly used to augment household travel surveys that have geo-referenced the locations of activity and travel. The associations of these objective measures with various travel outcomes are tested using a variety of multivariate statistical techniques. The construct and analysis of this type of contextual data are mature within field of travel behavior and as the following sections will reveal, the majority of the workshop discussion focused largely on other innovative issues. However, there are a few persistent issues that were raised about these data that hamper progress.

Some land use information is still very difficult to obtain – even at the neighbourhood scale. For example, parking supply (and demand) information is not readily available in most cities. Even public supply and cost are not archived, not to mention private parking, including at places of residence and work. Detailed information about sidewalks, crossing aids, bicycle infrastructure, signal timing and other relevant data for nonmotorized modes often only exist when labour intensive audits (in person or from imagery) are conducted.

There is still a need to establish more universal and common understanding of the relationship between the built environment and travel across a broad number of settings. The quality, availability and structure of archived data varies by jurisdiction, sometimes even in the same region, state or province. This dissonance has the most profound impact on our ability to do international comparative studies. To date, there have been few studies that have included international comparisons (e.g. de Abreu e Silva 2009, Ewing and Cervero 2010). While standards are emerging in travel surveys (Stopher and Stecker 2006) allowing for more compatible behavioural data, there is less consistency in the availability and standards in archived built environment data around the world. And while there is a growing interest in comparing the nonphysical aspects of context (discussed below) such as social norms or experiences, controlling for the built environment is important.

There is increasing desire to have more temporally disaggregate built environment data. One rationale for this is to have better ability to match the built environment conditions at the time of travel, as there is often a mismatch in temporal resolution. There is also a lack of multiday data to understand how built environment relates to activity and travel schedules over a longer period (Schönfelder and Axhausen 2010). With an eye towards the emerging activity based models, time based accessibility measures are being introduced to capture the availability of activities over the course of the day (Geurs and Wee 2004). Comparable longitudinal datasets of the built

environment are required in order to better understand the causal mechanisms of behavioural change. The desire to identify the causal relationships between transport choices and characteristics of the built environment requires untangling the persistent issue of self selection (Handy et al. 2005). Discovery methods here beg for more longitudinal studies that include preferences and intention, in addition to built environment and behaviour (Tyler 2011).

Measures of the built environment tend to move together and are highly correlated with one another. For example, dense residential areas tend to also have greater degree of land use mixing, higher levels of transit access, and better sidewalk coverage. This hampers efforts to use multiple measures in statistical studies and thus, data are often reduced or aggregated into indices using a variety of data distillation techniques. This brings about several issues. First, these indices are often developed using location- or region-specific data which then limit their transferability to other places. Second, the use of an index limits the ability to untangle the relative importance of the various individual measures and provide specific policy recommendations to planners.

A more recent interest is how to characterize conditions along a route, rather than merely examining the context around the origins and destinations of trips. For example, the measures of impediments to walking could focus on the average value along the route or the peak value. As it stands, we have limited experience developing appropriate methods to operationalize and test route-level conditions.

There is increasing ability to make use of 3-dimensional data and visualizations for cities (Wu et al. 2010). These data include building height, terrain and other built and natural features of the urban environment. The 3D frameworks allow for better representation of context in studies and public participation efforts. Further, the interactive abilities offer some unique opportunities to "place" study participants in a particular context and allow them to move about in the landscape – as representations of real places or hypothetical virtual realities. Although this capability has been around for more than a decade, the transportation community has not taken full advantage of these data and the possibilities they present.

Including information about the built environment in transport studies has matured to a relatively advanced stage. But, we are slow to consider other environmental conditions, particularly sensory conditions – noise, smells, weather or other sensations. Of these, weather is the most common and meteorological agencies tend to have quite sophisticated, spatially and temporally disaggregate archived data (e.g. the Australian Government's Bureau of Meteorology is a good example). Yet, we really know very little about how to represent the complexity of these conditions in studies of transport choices, the optimal level of representation or how the response to these objective conditions may vary by region.

5. Mixed methods and innovative approaches

As with many areas of travel behavior research, there were calls for greater use of mixed-method approaches in research into the relationship between context and transport outcomes. The complementarity between revealed preference and stated preference surveys has important implications to understand the response to changes in the built environment – increased density and intensity of development, investments in transit and non-motorized infrastructure and services, and even shrinking cities. The desire to understand behavioral change, the role of self-selection, and the relative importantance of transport to residential location decisions would all benefit from a more coordinated revealed-stated preference survey approach.

One advantage of mixed method approaches could be to compare behavioral and psychological results in "real" environments versus representations of those places in surveys. This could benefit the design of surveys with respect to the issues raised in the previous section about how best to use imagery to set the context. Another issue is how to normalize perceptions and establish a common point of reference. Information about perceptions typically relies on Likert scale-type questions with respondents reporting levels of agreement/disagreement or satisfaction/dissatisfaction. When comparing responses to environmental influences across individuals or groups, how can we feel confident in the scale? Again, this is a challenging prospect for survey research but one that will undoubtedly require mixed-methods and innovative approaches.

The workshop participants all recognized a larger role for qualitative inquiry, as the field has moved beyond acceptance of these approaches and now embrace their ability to inform our understanding of behavior. Whether used alone or as a precursor or follow up to more quantitative approaches, they offer explanations for the

motivations for behavior – perceptions, beliefs, experiences and emotions. Rather than justify the role of qualitative methods in defining context and its role, the workshop focused on the relatively lack of training and qualifications to engage in these methods among transport researchers. Either more education on how to collect and analyze information via these methods is needed or transport researchers need to collaborate with those from fields with more experience. Too often, these methods are not given the attention in the transport community to ensure rigor and validity.

The workshop discussion also discussed the relatively little new information coming from built environment – travel behavior research, despite there being no shortage of new policy questions. One suggestion was the need for researchers to branch out from "legacy methods," including travel diary surveys even with the assistance of global positioning systems and smart phone technologies. Among the new innovations suggested were the use of gaming, direct observation techniques, rapid ethnographies, vignettes, and virtual and augmented reality. These new opportunities may better convey context to respondents and gage its importance in decision making. But at the moment, most transport researchers are unfamiliar with these approaches and how they can be useful.

6. Theory building

A key deficit in understanding the role of the built environment is the lack of a comprehensive, unified theory of behavior to guide us in our study design and data collection effort. As transport research is an interdisciplinary endeavor, the field draws a lot from others. In its early days, time and costs were the primary factors of interest, as transport studies drew largely from economics and rational choice theory. As the field has matured, the disciplines of geography and planning have introduced the interest in activities, constraints, and the built environment. A more recent influence comes from the psychology and health fields, where the theory of planned behavior has punctuated to incorporate the subjective reactions to the objective measures of the built environment, including attitudes, perceptions, motivations and spatial cognition.

Although travel behavior research has been very open to the inclusion of perspectives from other disciplines, it tends to be done in an ad hoc way. Variables are added to model specifications or data are mined without a clear idea of how all of these elements explain travel outcomes from a theoretical perspective. The role of the built environment in influencing our transport decisions is complex and works through multiple pathways. More attention needs to be given to theory building, in addition to our policy-driven research. This lack of a comprehensive theoretical framework to guide our work may be partly responsible for some the stagnation of progress.

7. Conclusions

The workshop concluded with a great deal of optimism about this research and the methods available to establish context and understand its influence on travel. Data are increasingly open source or available to researchers; however, there is a great deal of variation in the types, resolution and format of information around the globe. Researchers are open to exploring new techniques and improving those long established methods. As the transport system is asked to achieve other public goals besides utilitarian transport, such as livability, health, quality of life and fun, the need to understand these relationships will be increased. Further, as people become more connected with each other and with their built environment, there will be new opportunities to passively and actively observe these interactions.

Acknowledgements

The authors would like to thank the workshop participants for a lively and engaging discussion: Kay Axhausen (CH), Caroline Bayart (FR), Martin Berger (AT), Akli Berri (FR), Lidia Bonet (CL), Geoffrey Clifton (AU), Andrew Collins (AU), Ricardo Daziano (US), Alex Erath (CH), Ana Patricia Herrera Medina (CO), Ricardo Hurtubia (CL), Peter Jones (UK), Nodoka Kasahara (JP), Francoise Potier (FR), and Christopher Standen (AU).

Appendix A. Papers presented during the workshop

Measuring perception of qualitative attributes in urban space. Author: Ricardo Hurtubia.
Valuation of heritage neighbourhood attributes from the perspective of their inhabitants. Authors: Lidia Bonet-Juan de Dios Ortuzar.
It's a lovely day for a walk: pedestrian route choice with realism. Authors: Matthew Beck, Stephane Hess and Jeffrey Dumont.
Evaluating novel and traditional survey methods for the construction of a behavioral founded walkability index. Authors: Alex Erath, Michael van Eggermond and Kay W. Axhausen.

Appendix B. Posters associated with the workshop

Human path assignation at maps: discrete choice model of visual attributes of alternatives. Author: Michael Simecek.
Weather conditions influencing mode choice – on measuring loyalty and predicting alternatives. Authors: Wilko Manz, Martin Kagerbauer and Tatjana Streit.

References

Abedi N., Bhaskar A. and Chung E. 2014. Tracking spatio-temporal movement of human in terms of space utilization using Media-Access-Control address data. *Applied Geogr*aphy, 51: 72-81.

De Abreu e Silva, J. and Goulias, K. 2009. Structural Equations Model of Land Use Patterns, Location Choice, and Travel Behavior: Seattle, Washington, Compared with Lisbon, Portugal, *Transportation Research Record: Journal of the Transportation Research Board*, 2135: 106-113.

Adamowicz, W., Swait, J., Boxall, P., Louviere, J. and Williams, M. 1997. Perceptions versusobjective measures of environmental quality in combined revealed and stated preference models of environmental valuation, *Journal of environmental economics and management* 32(1): 6584.

Badland H., Mavoa S., Villanueva, K., Roberts R., Davern M. and Giles-Corti B. 2014. The development of policy-relevant transport indicators to monitor health behaviours and outcomes. *Journal of Transport & Health*, in press, DOI: 10.1016/j.jth.2014.07.005.

Badoe, DA and Miller, EJ. 2000. Transportation–land-use interaction: empirical findings in North America, and their implications for modeling. *Transportation Research Part D: Transport and Environment*, 5(4): 235-263.

Benenson I., Martens K. and Rofé Y. 2010. Measuring the Gap Between Car and Transit Accessibility. *Transportation Research Record: Journal of the Transportation Research Board*, 2144 (1): 28-35.

Broach, J; Dill, J. and Gliebe, J. 2012. Where do cyclists ride? A route choice model developed with revealed preference GPS data, *Transportation Research Part A: Policy and Practice*, Volume 46, Issue 10, Pages 1730–1740

Brownson, R., C. Hoehner, K. Day, A. Forsyth, and J. Sallis. 2009. Measuring the built environment for physical activity: State of the science. *American Journal of Preventive Medicine*, Vol. 36, No. 4S, pp. S99-S123.e12.

Cervero, R and Kockelman, K. 1997. Travel demand and the 3Ds: density, diversity, and design. *Transportation Research Part D: Transport and Environment* 2 (3), 199-219.

Chatman, D. 2003. How workplace land use affects personal commercial travel and commute mode choice. *Transportation Research Record: Journal of the Transportation Research Board*, 1831: 193-201.

Clifton, KJ; Ewing, R; Knaap, GJ and Song, Y. 2008. Quantitative analysis of urban form: a multidisciplinary review, *Journal of Urbanism: International Research on Placemaking and Urban Sustainability*, 1(1): 17-45.

Clifton, Kelly J. and Muhs, Christopher. 2012. Capturing and Representing Multimodal Trips in Travel Surveys: A Review of the Practice," *Transportation Research Record: Journal of the Transportation Research Board*, No. 2285, pp. 74-83.

Ewing, & Cervero. 2010. Travel and the Built Environment: A Meta-Analysis. *Journal of the American Planning Association*, 76(3), 265-294.

Ewing, & Handy. 2009. Measuring the Unmeasurable: Urban Design Qualities Related to Walkability. *Journal of Urban Design*, 14(1), 65-84.

Ewing, R., Handy, S., Brownson, R. C., Clemente, O., & Winston, E. 2006. Identifying and measuring urban design qualities related to walkability. *Journal of Physical Activity & Health*, 3, S223-S240.

Forsyth, A (ed). 2010. NEAT-GIS (Neighborhood Environment for Active Transport) Protocols, an updated version of Environment and Physical Activity: GIS Protocols; version 5.0. Available online at: http://designforhealth.net/resources/other/gis-protocols/

Forsyth, A and Krizek, K. 2001. Urban design: Is there a distinctive view from the bicycle?, *Journal of Urban Design* 16(4):531-549.

Galster, G; Hanson, R; Ratcliffe, M; Wolman, H; Coleman, S; and Freihage, J. 2001. Wrestling Sprawl to the Ground: Defining and Measuring an Elusive Concept, *Housing Policy Debate*, Vol. 12, no. 4, p. 685.

Gärling, T and Golledge, RG.1989. Environmental Perception and Cognition, in *Advances in Environment, Behavior, and Design, Volume 2*, Springer US, pp 203-236

Gehrke, SR and Clifton, KJ. 2014. Operationalizing Land Use at Varying Geographic Scales and its Connection to Mode Choice: Evidence from Portland, Oregon, *Transportation Research Record: Journal of the Transportation Research Board*, Transportation Research Board of the National Academies, Washington, D.C., Issue 2453, 2014, pp 128–136.

Geurs, KT and van Wee, B. 2004. Accessibility evaluation of land-use and transport strategies: review and research directions, *Journal of Transport Geography* 12, p:127–140

Giles-Corti B. and Donovan R.J. 2002. The relative influence of individual, social and physical environment determinants of physical activity. *Social Science & Medicine*, 54 (12): 1793-1812.

Giles-Corti B., Broomhall M.H., Knuiman M., Collins C., Douglas K., Ng K., Lange A. and Donovan R.J. 2005. Increasing walking: how important is distance to, attractiveness, and size of public open space? *American Journal of Preventive Medicine*, 28 (2): 169-176.

Handy. 2006. Critical assessment of the literature on the relationships among transportation, land use, and physical activity. prepared for the Transportation Research Board and Institute of Medicine Committee on Physical Activity, Health, Transportation, and Land Use, Washington, DC, January.

Handy, SL; Boarnet, MG; Ewing, R and Killingsworth, RE. 2002. How the built environment affects physical activity: views from urban planning, *American Journal of Preventive Medicine* 23 (2):64-73.

Handy, S; Cao, X; and Mokhtarian, P. 2005. Correlation or causality between the built environment and travel behavior? Evidence from Northern California*, Transportation Research Part* D 10: p. 427–444.

Hong, J., Q. Shen, and L. Zhang. 2013. How do built-environment factors affect travel behavior? A spatial analysis at different geographic scales. *Transportatio*n, pp. 1-22.

Kitamura, R; Laidet, L; and Mokhtarian, P. 1997. A micro-analysis of land use and travel in five neighborhoods in the San Francisco Bay Area, *Transportation* 24: 125–158.

Marans R.W. and Stimson R.(Eds). 2011. *Investigating Quality of Urban Life – Theory, Methods and Empirical Research*. Springer, The Netherlands, 456p.

Miller, HJ and Shaw, S. 2001. *Geographic Information Systems for Transportation: Principles and Applications*, New York: Oxford University Press.

Namazi-Rad M.R., Perez P., Berryman M. and Lamy F. 2012. An experimental determination of perceived liveability in Sydney. In: Proceedings of 8th International Conference on Social Science Methodology (RC33, Sydney, July 2012). ACSPRI Conferences, pp. 1-13.

Perez P., Huynh N., Lam Cao V., Wickramasuriya R. and Berryman M. 2014. TransMob: An Agent Based Simulation of Transport Demand and Residential Mobility in South East Sydney. In: Proceedings of the 10th Social Simulation Conference (ESSA, Barcelona, Sept 2014). ESSA, UAB, Barcelona, Spain, paper #144. Available online: http://fawlty.uab.cat/SSC2014/SSC2014_SESSIONS_ESSA.html

Rodriguez, D. and J. Joo. 2004. The relationship between non-motorized mode choice and the local physical environment. *Transportation Research Part D*, Vol. 9, pp. 151-173.

Schönfelder, S. and K.W. Axhausen (2010) *Urban Rhythms and Travel Behaviour: Spatial and Temporal Phenomena of Daily Travel*, Ashgate, Farnham.

Shen, L and Stopher, P. 2014. Review of GPS Travel Survey and GPS Data-Processing, *Transport Rev*iews; 34(3):316-334.

Singleton, PA. 2013. A Theory of Travel Decision-Making with Applications for Modeling Active Travel Demand, masters thesis, Portland State University, Portland, OR. Available at: http://pdxscholar.library.pdx.edu/cgi/viewcontent.cgi?article=2493&context=open_access_etds

Stopher, P and Stecker, C. 2006. *Transport Survey Standards and Futures, in Travel survey methods, quality and future directions* (Stopher and Stecher, Eds), London: Emerald, pp 531-544.

Transportation Research Board. 2009. Driving and the Built Environment The Effects of Compact Development on Motorized Travel, Energy Use, and CO2 Emissions, Special Report 298, Transportation Research Board of the National Academies, Washington, D.C.

Tyler N. 2011. Capabilities and Accessibility: A model for progress. *Journal of Accessibility and Design for All*, 1 (1): 2013-7087.

Wolf, J. 2006. The application of new technologies in travel surveys, in *Travel survey methods, quality and future directions* (Stopher and Stecher, Eds), London: Emerald, pp 531-544.

Wu, H., He, Z. and Gong, J. 2010. A virtual globe-based 3D visualization and interactive framework for public participation in urban planning processes, *Computers, Environment and Urban Systems*, 34(4):291–298.

Zhang, L, Hong, JH, Nasri, A and Shen, Q. 2012. How built environment affects travel behavior: A comparative analysis of the connections between land use and vehicle miles traveled in US cities, *Journal of Transport and Land Use*, Volume: 5, Issue Number: 3, pp: 40-53.