Health implications of transport: evidence of effects of transport on social interactions[i]

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Abstract

Some links between transport and health are widely known, such as active travel, physical (in)activity, air pollution and injuries. Others are not as apparent and are much less studied, for example social interactions. This article reviews the evidence that transport impacts on social interactions, and that social interactions impact on health. It is an updated version of part of chapter 5 from *Health on the Move 2*.

There is growing evidence that aspects of transport influence social exclusion, social capital, social cohesion and social networks. Numerous studies have identified associations between these aspects of social interaction and morbidity and mortality. Community severance – where transport infrastructure or the speed or volume of traffic act as a physical or psychological barrier– impacts on individuals' travel, social networks, and the accessibility of goods, services and facilities, and has scope to influence health through a number of routes. With the development of more

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comprehensive measures, such as of community severance, it is likely that there will be stronger evidence that transport influences health through these pathways.

Keywords
Transport, social exclusion, social capital, social cohesion, social networks, community severance, health

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1. Introduction

The effects of transport on health are complex and numerous and bring consequences for transport planners and those for whom they plan (for a broad summary, see Cohen et al, 2014). While some of these effects have been widely studied (for example active travel, physical (in)activity, air pollution, and injuries), others are less apparent. Hence many working in the field may not realise that transport also impacts on health through its effects on people's social interactions, which are important for health in a number of ways. This article explains some of the links between transport, social interactions and health. The article does not cover the effects of transport on stress; this is covered elsewhere (see *Health on the Move 2* (HotM2) chapter 5 (Mindell et al, 2011)).

This article is a revised and updated version of part of a book chapter (chapter 5) from HotM2 (Watkins & Mindell, 2011). This overview of the literature introduces the ways that transport impacts on social interactions and that social interactions are related to health. It is intended to illustrate the state of the evidence, but is not an exhaustive review.

1.1 Definitions

In this article we refer to the social circumstances of interest broadly as 'social interactions'. By this, we refer to social exclusion, social capital, social cohesion, and social networks collectively. There are, of course, other aspects of social interaction that are important, but the purpose of this paper is to explore those most relevant to both transport and health.

We use the term *social exclusion* to describe "the process by which people are prevented from participating in the economic, political and social life of the community because of reduced accessibility to opportunities, services and social networks, due in whole or part to insufficient mobility in a society and environment built around the assumption of high mobility" (Kenyon at al 2002: 210), i.e. social exclusion describes structural processes that can result in *social isolation* (see section 2.1, below).We acknowledge there is overlap between some elements of the concepts of social exclusion, social isolation, social capital, social networks and social networks (see, for example Levitas, 2006), but in this paper we treat them as discrete in order to aid interpretation of previous studies.

Putnam has been influential developing the concept of *social capital*, which he refers to as the value of social networks, and the inclinations that arise from these networks to do things for each other (Putnam 2000). Social capital is described by Currie and Stanley in their 2008 review as "the advantage individuals and communities can gain from social participation, mutual assistance and trust" (Currie & Stanley 2008). This is linked to - although distinct from - *social cohesion*, which is described as comprising both the structural forms of social networks, and the quality of social relationships (Marmot 2005), in this case with respect to the neighbourhood or community. Similar to social cohesion is the term 'sense of community', sometimes used in the transport literature.

The term *social network* is used to describe the quantity or quality of social contacts a person has. Social networks are important for many reasons. Social capital and social cohesion both require social contacts in order to develop (and social isolation occurs in the absence of social contacts), so social networks could be thought of as a prerequisite for these to occur. Social networks also enable social support to be provided; this is the provision of emotional, tangible (material), informational support, or belonging (Wills 1985).

Comment [JSM1]: And/or
Social exclusion results in diminished social contacts
Though people may be 'excluded' from work, paid for leisure activities, transport, healthcare but still have plenty of local social contacts, surely, so overlapping Venn diagrams but not totally synonymous?

2. Access to transport

2.1 Access and social exclusion

Lack of access to transport or withdrawal of public transport services, can diminish social networks, and subsequently levels of social support, while adequate, reliable and affordable transport networks can be beneficial (Nicholl et al 1987). Whether transport is accessible depends not only on the provision of public transport services and physical proximity to them but also the cost, provision of information, and other aspects such as safety and crime. If these are poor, individuals can be considered to be at transport disadvantage, and may face social exclusion following reduced accessibility to opportunities, services and social networks (Kenyon at al 2002: p210). This is likely to exacerbate existing socio-economic inequalities. The relationship between transport disadvantage and social exclusion was recognised by the UK Government's Social Exclusion Unit in 2003 (Social Exclusion Unit, 2003) and remains on the transport research agenda (see for example Lucas 2012). In a recent study in Canada, Julien and colleagues found the relationship between

accessibility of services and amenities was conducive to social participation, and social participation itself was linked to frequency of transport use (but not walking frequency) (Julien et al 2014).

Empirical work exploring the links between access, social exclusion and wellbeing has found that increased trip making indirectly increases personal well-being thorough reducing social exclusion (Stanley et al 2011). Social isolation is a related phenomenon and can be brought about by social exclusion. Social isolation was shown to impact on health in a large study of 16,849 participants. In that study, it was found that social isolation was a predictor of mortality, with an effect size as great as that of smoking, and greater than that of having high blood pressure (Pantell et al 2013).

2.2 Access and social capital

In addition to social exclusion, it has been suggested that access to transport can affect social capital. Currie and Stanley's 2008 review suggested that 'co-presence' on public transport (face-to-face contact while travelling together) may contribute to social capital, but that car dependence and driving alone may have a negative impact on social capital. Therefore while increasing car use could potentially reduce social exclusion (disregarding the impact of the social gradient in car ownership), the negative consequences of this for social capital mean that the social environment would likely benefit most from provision of a public transport network that is comprehensive, efficient, cheap, and safe.

Both neighbourhood and individual aspects of social capital were associated with self-rated health in a large recent Dutch study (n=53,269) (Mohnen et al 2014). A 2014 review of social capital and health considered social capital to incorporate social participation, civic participation, social network, social support, trust, norm of reciprocity and sense of community (Choi et al 2014). The authors comment that the heterogeneity of measurement of social capital makes meta-analysis of these studies challenging. The review of 14 studies found some limited evidence that social participation and civic participation aspects of social capital were associated with some beneficial effects for all-cause mortality and cardiovascular mortality in the extreme comparison groups (Choi et al 2014). However, the authors did not find evidence for other dimensions of social capital as effective predictors of mortality,

cardiovascular disease or cancer. A 2005 review found strong evidence of an inverse relationship between individual level social capital and mental health (De Silva et al 2005).

3. Built environment

3.1 Walkability and social capital

There is growing evidence that aspects of the built environment such as the layout of the street network can influence social interactions. This occurs in a number of ways. Firstly, neighbourhood walkability – often measured by intersection density, land use mix, and/or population density – is thought to be beneficial for social relationships because walkable neighbourhoods promote walking, which in turn creates opportunities for social interaction. For example, Leyden's study in Ireland found that walkability of neighbourhoods was related to knowing neighbours and aspects of social capital including knowing neighbours, feeling connected to the community and trust (Leyden 2003). Rogers and colleagues surveyed participants about perceived walkability and found that more walkable neighbourhoods in two US cities had higher levels of trust and community aspects of social capital (as described by Putnam) (Rogers et al 2013). As discussed in the previous section, social capital may have a beneficial impact on all cause and cardiovascular mortality (Choi et al 2014), and mental health (De Silva et al 2005).

3.2 Walkability and social cohesion

Zhu and colleague's study (2014) of 449 adults moving to a walkable neighbourhood in the USA found that social interactions and neighbourhood cohesion increased significantly. Increases in both walking and totally physical activity were also observed. Du Toit and colleagues' study in Australia (2007) found a weak association between walkability and sense of community but no association with three other sociability constructs studied (local social interaction, social cohesion and informal social control). French and colleagues' more recent study (2014) - also in Australia - found perceived street connectivity, infrastructure for walking and cycling and neighbourhood aesthetics all to be associated with a sense of community, indicative of social cohesion as described in other studies. It should be noted, however, that sense of community is also influenced by other aspects of the built

environment that are less related to transport, such as housing types (Talen 1999, Kim 2007).

In the health literature, poor or limited social cohesion has been found to be associated with poorer self-reported health (Marmot 2005). A review in 2012 of neighbourhood characteristics and mortality found an association between social cohesion and all-cause mortality in the three included studies, although the authors caution that the measurement tools varied considerably between studies (Meijer et al 2012).

3.3 Public and green space

Transport planning and street design can promote social interaction by providing places for people to gather and by reducing the dominance of cars, as in a Home Zone, or the Dutch woonerf[ii] (Appleyard 2006). Biddulph observed pedestrians in traffic calmed and Home Zone streets and found increased time spent in streets and more social interaction in the Home Zone, as well as more time spent playing by children (Biddulph 2012). The benefits of Home Zones are linked to the idea of speed and volume of traffic having a negative impact on social interaction discussed in the following section. In addition, public and green spaces also enable social interaction and contribute to social cohesion by providing a venue for chance encounters and creating a sense of place (Talen 1999). Such spaces often facilitate active travel (Faculty of Public Health, 2010), which means public and green spaces may impact on health through multiple mechanisms (social interaction and physical activity).

Contact with safe green spaces can also improve mental well-being, increase physical activity, reduce inequalities, and increase social interactions (Faculty of Public Health, 2010). A recent evidence review by the UCL Institute of Health Equity found that access to green space was associated with a range of better health outcomes

[ii]What is now known as a Home Zone originated in the late 1960s in the Dutch city of Delft and was originally known as woonerf. Local residents who were upset about traffic in their neighbourhood replaced their brick streets with traffic-slowing serpentine paths. Slower traffic (around 10mph in a Home Zone or walking pace in the woonerf) was combined with additional features (such as flowerbeds, play areas, fences and trees) to create a sense of place which encouraged neighbours to socialise and provided a safe space for children to play (Appleyard 2006, Ministerie van Verkeer en Waterstaat 2006).

and less income-related inequality. Specifically, there is an association between access to green spaces and health in general, physical activity, mental health and well-being (PHE and UCL Institute of Health Equity, 2014). A further study found green space was associated with reduced health inequalities as measured by all-cause mortality and circulatory disease, suggesting that environments that promote good health might play a role in reducing socio-economic health inequalities (Mitchell and Popham, 2008).

Part of the mechanism by which green space influences health appears to be via enabling physical activity. A review of the physical and mental health benefits of green or public open spaces (terms used synonymously in that review) found that while there was strong evidence of the health benefits of physical activity, the evidence linking green space availability with physical activity levels was weaker (Lee and Maheswaran 2011). The review also found a lack of robust evidence of the link between green spaces and mental health and well-being. However, some studies reported associations between green space and a variety of psychological, emotional and mental health benefits, including quality of life (Lee and Maheswaran 2011). Green spaces may benefit mental and emotional health partly by improving social capital, by providing a place for people to make social connections (Lee and Maheswaran 2011). These reviewers suggest that the relationship between green space and health is likely to be complex and moderated by many individual factors such as age, gender, ethnicity and disability, and environmental factors such as safety, accessibility, and the condition and features of the green space.

4. Traffic volume and speed

4.1 Traffic and social networks

Traffic volume and speed can diminish neighbours' social interaction, leading to smaller social networks. This was first identified in Appleyard and Lintell's work in San Francisco (Appleyard & Lintell, 1972). Appleyard and Lintell looked at the residents of three streets in San Francisco who were similar apart from the traffic levels on their streets: one was light, one moderate, and one heavy. On average, residents on the light street had 3.0 friends and 6.3 acquaintances on their street; those on the moderate street had 1.3 friends and 4.1 acquaintances; and those on the heavy street had 0.9 friends and 3.1 acquaintances (Appleyard, 1981). This was

recently repeated on three streets in Bristol, UK, and the findings were remarkably similar. On average, residents of the light street had 5.4 friends and 6.1 acquaintances; on the medium street this was 2.5 friends and 3.7 acquaintances; and on the heavy street 1.2 friends and 2.8 acquaintances (Hart & Parkhurst, 2011).

A causal relationship between social networks and morbidity has been demonstrated by a number of previous studies. For example, a study of pregnancy outcomes among wives of US soldiers in the 1970s found that the strength of social support networks influenced the rate of pregnancy complications (Nuckolls et al, 1972). Weak social networks were also associated with serious mental illness among survivors of the Granville Train Disaster in Australia (Boman, 1979), and the Alameda County Study found that strength of social networks was associated with a four-fold difference in subsequent all-cause mortality, even among participants who were healthy at baseline (Berkman & Syme, 1979). More recently, a 2007 study of the role of social networks in obesity found that an individual's chance of becoming obese increased by 57% (95%CI 6 to 123) if he or she had a friend who became obese within a given time period (Christakis 2007). In a study of environmental characteristics and mental health, Leslie and Cerin concluded that social networks (as a characteristic of neighbourhood satisfaction) was an independent predictor of mental health, as measured by the SF-12 tool (Leslie & Cerin 2008).

In 2010 a systematic review and meta-analysis of social relationships (of which social networks were one aspect) and mortality risk found a 50% increase in the odds of survival among those with stronger social relationships across 148 studies – an effect of similar magnitude to the benefits of stopping smoking (Holt-Lunstad et al 2010). In this review, across the studies which measured social networks (rather than social support) there was a 57% increase in the odds of survival among those with stronger social networks.

4.2 Community severance

Community severance (also known as the 'barrier effect') is where the speed or volume of traffic or other transport infrastructure inhibits access to goods, services and people. A 2007 review of community severance noted that the effects were broader than merely division of people from services, and included psychological effects of traffic and effects on quality of life and social cohesion, as well as

implications for accessibility planning, mobility, and social exclusion (Bradbury et al, 2007). Pedestrian crossings may not allow for older pedestrians to cross the road in the allotted time (Asher et al 2012; TRL 2014), which may also contribute to severance.

Mindell and Karlsen's 2012 review of the literature up to 2010 identified what was known about the effects of community severance on health, and found that community severance has impacts on travel, social networks, and the liveability of streets. Updating this literature review in Feb 2015, SB identified a small number of newer studies, corroborating the effect of the neighbourhood environment on walking for transport (Van Cauwenberg et al, 2014; Jia et al, 2014); of traffic on travel behaviour (Ogilvie et al, 2010; Tsunoda et al, 2012); and that transport problems can cause psychological distress (Taylor et al 2012).

The difficulty of crossing the road may separate housing from, and diminish access to, health promoting facilities, such as schools, parks, recreation facilities, shops and health services (Rajé 2004; Smith & Gurney 1992). Community severance has also therefore been linked with social exclusion (Bradbury et al 2007; Rajé 2004). Major roads form boundaries delimiting neighbourhoods. This effect increases with the age of the road, as new generations limit themselves – or are limited – to considering only the area on their side of the road as part of their neighbourhood (Grigg & Ford 1983). There is also an effect on carers: those living on almost traffic-free streets have more social contacts locally and know more adults willing to help look after their children than those living on streets with more traffic (Hüttenmoser 1995). Construction of bypasses is known to reduce the barrier effect of traffic in the bypassed communities (Egan et al 2003).

As there are many ways in which community severance may impact on social interactions and health, new approaches are needed to measure health outcomes, health-related behaviours, and environmental factors, which may be affected by community severance, or changes in these that are attributable to severance. It is difficult to measure the effects of community severance on travel and mobility, and even more so for effects on social interactions or on health. It is also at present not possible to evaluate the effectiveness of interventions to reduce community severance, or to conduct an economic appraisal of the value of interventions. *Street Mobility and Network Accessibility* (www.ucl.ac.uk/street-mobility) is a three-year

(2014-2016) research project at UCL which aims to develop a toolkit (in the form of a questionnaire, modelled community severance index, monetised appraisal technique, and other guidance) to measure community severance at individual and area levels, such that the effects of community severance on mobility, health and wellbeing can be assessed.

5. Conclusions

Transport has impacts on social interactions that are wide-ranging and not always obvious. This article, an updated and abridged version of chapter five from HotM2, has reviewed the literature that transport may affect social interactions through access to transport, aspects of the built environment, and through the effects of traffic on community severance. Access to transport is important to prevent social exclusion and to build social capital. Walkable environments can promote social capital and social cohesion. Traffic and severance have important consequences for social networks. With established measures, the evidence base is very likely to grow. The evidence that these different aspects of social interactions affect health has also been summarised.

It is possible that the findings of some of the studies we have reviewed are due to reverse causality: e.g. people who are physically active choose to live in areas where there are green spaces or other opportunities for physical activity, or people who are more sociable choose an area with better infrastructure for social interactions, rather than the environment influencing individual behaviour. This was seen in Lovejoy and Handy's qualitative study (2011) of Mexican immigrants in California, where social networks provided access to transport. Future research studies investigating the relationship between transport, social interactions and health and using a longitudinal design will enable stronger evidence to be obtained.

The impact that transport has on social interactions is complex; it can be positive or negative; and may operate in combination, as well as in competing ways. For example, living near reliable and frequent bus links could facilitate access to friends and relatives, which may reduce the risk of social exclusion (health promoting). However, this may also entail living near a busy trunk road causing community severance, which may result in knowing fewer neighbours and having a smaller social network (detrimental to health). These effects will also vary across the life

course, as well as in different groups, depending on demographic and socio-economic characteristics, lifestyles, geography, and transport preferences. Therefore these effects should not be considered in isolation, rather, they should be considered more broadly in terms of wider determinants of health.

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References

Appleyard B & Cox L (2006). At home in the zone: creating livable streets in the US. *Planning* 2006 Oct, 30-35.

Appleyard D, Lintell M (1972). The environmental quality of city streets: The residents' viewpoint. *American Institute of Planners Journal*. 38:84-101.

Appleyard D (1981). *Livable streets.* University of California Press, Berkeley.

Asher L, Aresu M, Falaschetti E, Mindell J (2012). Most older pedestrians are unable to cross the road in time: a cross-sectional study. *Age Ageing* 41:690–4.

Berkman L, Syme SL (1979). Social networks, host resistance, and mortality: A nine-year follow-up study of Alameda County residents. *American Journal of Epidemiology*. 109:186-204.

Biddulph, M (2012). Street design and street use: comparing traffic calmed and home zone streets. *Journal of Urban Design*, 17(2), 213-232.

Boman B (1979). Behavioural observations on the Granville train disaster and the significance of stress for Psychiatry. *Social Science and Medicine*. 13A:463-71.

Bradbury A, Tomlinson P, Millington A (2007). *Understanding the evolution of community severance and its consequences on mobility and social cohesion over the past century.* Association for European Transport.

Choi M, Mesa-Frias M, Nüesch E, Hargreaves J, Prieto-Merino D, Bowling A, & Casas, JP (2014). Social capital, mortality, cardiovascular events and cancer: a systematic review of prospective studies. *International journal of epidemiology*, 43(6), 1895-1920.

Christakis NA & Fowler JJ (2007). The Spread of Obesity in a Large Social Network over 32 years. *New England Journal of Medicine* 357(4) 370-79.

Cohen JM, Boniface S, Watkins SJ (2014). Health implications of transport planning, development and operations. *J. Transp. Health* 1:63–72.

Currie G & Stanley J (2008). Investigating links between social capital and public transport. *Transport Reviews*, 28(4), 529-547.

De Silva MJ, McKenzie K, Harpham T, & Huttly SR (2005). Social capital and mental illness: a systematic review. *Journal of epidemiology and community health,* 59(8), 619-627.

Du Toit L, Cerin E, Leslie E, & Owen N (2007). Does walking in the neighbourhood enhance local sociability?. *Urban Studies*, 44(9), 1677-1695.

Egan M, Petticrew M, Ogilvie D, Hamilton V (2003). New roads and human health: a systematic review. *American Journal of Public Health,* 93:1463-71.

Faculty of Public Health (2010). *Great Outdoors: How Our Natural Health Service Uses Green Space To Improve Wellbeing. An Action Report. Faculty of Public Health & Natural England,* 2010. http://www.fph.org.uk/uploads/r_great_outdoors.pdf. (last accessed 18/02/2015).

French S, Wood L, Foster SA, Giles-Corti B, Frank L, & Learnihan V (2014). Sense of community and its association with the neighborhood built environment. *Environment and Behavior*, 46(6), 677-697.

Grigg AO, Ford WG (1983). *Review of some effects of major roads on urban communities. TRRL Supplementary Report 778.* London: Department of the Environment, Department of Transport, 1983

Hart J, Parkhurst G (2011). Driven to excess: Impacts of motor vehicles on the quality of life of residents of three streets in Bristol UK. *World Transp. Policy Pract,* 17:12–30.

Holt-Lunstad J, Smith TB, Layton JB (2010). Social relationships and mortality risk: a meta-analytic review. *PLoS Med*, 7:e1000316.

Hüttenmoser M (1995). Children and their living surroundings: empirical investigations into the significance of living surroundings for the everyday life and development of children. *Children's Environments*, 12:403-13.

Jia Y, Usagawa T, Fu H (2014) The Association between Walking and Perceived Environment in Chinese Community Residents: A Cross-Sectional Study. PLoS ONE 9(2): e90078.

Julien D, Richard L, Gauvin L, Fournier M, Kestens Y, Shatenstein B, Daniel M, Mercille G & Payette H (2014). Transit use and walking as potential mediators of the association between accessibility to services and amenities and social participation among urban-dwelling older adults: Insights from the VoisiNuAge study. *Journal of Transport & Health*, 03/10/2014 (epub ahead of print).

Kenyon S, Lyons G, & Rafferty J (2002). Transport and social exclusion: investigating the possibility of promoting inclusion through virtual mobility. *Journal of Transport Geography*, 2002, 10(3), 207-219.

Kim, J (2007). Perceiving and valuing sense of community in a New Urbanist development: A case study of Kentlands. *Journal of Urban Design*, 12(2), 203-230.

Lee ACK, & Maheswaran R (2011). The health benefits of urban green spaces: a review of the evidence. *Journal of Public Health,* 33(2), 212-222.

Leslie E & Cerin E (2008). Are perceptions of the local environment related to neighbourhood satisfaction and mental health in adults? *Preventative Medicine* 47: 273-278.

Levitas R (2006). Chapter 5. The concept and measurement of social exclusion. In: Pantazis C, Gordon D & Levitas R (eds.) Poverty and Social Exclusion in Britain, Bristol, The Policy Press.

Leyden KM (2003). Social Capital and the built environment: the importance of walkable neighbourhoods. *American Journal of Public Health*, 93(9): 1546-1551.

Lovejoy, K., & Handy, S. (2011). Social networks as a source of private-vehicle transportation: The practice of getting rides and borrowing vehicles among Mexican

immigrants in California. Transportation research part A: policy and practice, 45(4), 248-257.

Lucas K (2012). Transport and social exclusion: Where are we now? *Transport Policy*, 20, 105-113.

Marmot, M. (2005). The social environment and health. *Clinical Medicine*, 5(3), 244-248.

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.

Mindell JS, Cohen JM, Watkins SJ (eds.) (2011). *Health on the Move 2.Policies for health-promoting transport.* Stockport: Transport and Health Study Group, 2011. www.transportandhealth.org.uk

Mindell JS, Karlsen S (2012). Community severance and health: what do we actually know? *J. Urban Health*, 89:232–246.

Ministerie van Verkeer en Waterstaat (2006) *Road Traffic Signs and Regulations in the Netherlands.* http://www.rijksoverheid.nl/ministeries/ienm#ref-verkeerenwaterstaat (Accessed 25/02/2015)

Mitchell R, Popham F (2008). Effect of exposure to natural environment on health inequalities: an observational population study. *Lancet,* 372:1655-60.

Mohnen, S. M., Völker, B., Flap, H., Subramanian, S. V., & Groenewegen, P. P. (2014). The Influence of Social Capital on Individual Health: Is it the Neighbourhood or the Network?. Social Indicators Research, 1-20.

Nicholl JP, Freeman MR, Williams BT (1987). Effects of subsidising bus travel on the occurrence of road traffic casualties. *J Epidemiol Community Health,* 41:50-54.

Nuckolls KB, Cassell J, Kaplan BW (1972). Psychosocial Assets, Life Crisis and the Prognosis of Pregnancy. *American Journal of Epidemiology*, 95:431-41.

Ogilvie D, Mitchell R, Mutrie N, Petticrew M, Platt S (2010). Shoe leather epidemiology: active travel and transport infrastructure in the urban landscape. *Int. J. Behav. Nutr. Phys. Act.* 7:43.

Pantell, M., Rehkopf, D., Jutte, D., Syme, S. L., Balmes, J., & Adler, N. (2013). Social isolation: a predictor of mortality comparable to traditional clinical risk factors. *American Journal of Public Health,* 103(11), 2056-2062.

PHE and UCL Institute of Health Equity (2014). *Local action on health inequalities: Improving access to green spaces.* UCL Institute of Health Equity and Public Health England.

Putnam RD (2000). *Bowling Alone: The Collapse and Revival of American Community*, Simon and Schuster, New York.

Rajé F (2004). Engineering social exclusion? Poor transport links and severance. *Municipal Engineer,* 157:267-73.

Rogers SH, Gardner KH, & Carlson CH (2013). Social Capital and Walkability as Social Aspects of Sustainability. *Sustainability*, 5(8), 3473-3483.

Smith JD, Gurney A (1992). *Community effects of traffic congestion: A review of the London Assessment Study Data.* Crowthorne, Berks.: Transport Research Laboratory.

Social Exclusion Unit (2003). *Making the Connections: Transport and Social Exclusion Interim findings from the Social Exclusion Unit*, available from http://mtcwatch.com/pdfiles/3819-CO.pdf (last accessed 05.02.2015)

Stanley JK, Hensher DA, Stanley JR, & Vella-Brodrick D (2011). Mobility, social exclusion and well-being: Exploring the links. *Transportation research part A: policy and practice*, 45(8), 789-801.

Talen, E (1999). Sense of community and neighbourhood form: An assessment of the social doctrine of new urbanism. *Urban Studies*, 36(8), 1361-1379.

Taylor AW, Chittleborough C, Gill TK, Winefield H, Baum F, Hiller JE, Goldney R, Tucker G, Hugo G (2012). Relationship of social factors including trust, control over life decisions, problems with transport and safety, to psychological distress in the community. *Soc. Psychiatry Psychiatr. Epidemiol*, 47:465–73.

Tsunoda, K, Tsuji, T, Kitano, N, Mitsuishi, Y, Yoon, J-Y, Yoon, J, Okura, T (2012). Associations of physical activity with neighborhood environments and transportation modes in older Japanese adults. *Preventive Medicine*, 55:113–118.

TRL (2014). *A Review of Pedestrian Walking Speeds and Time Needed to Cross the Road.* London: Living Streets.

Van Cauwenberg J, De Donder L, Clarys P, De Bourdeaudhuij I, Buffel T, De Witte N, Dury S, Verté D & Deforche B (2104). Relationships between the Perceived Neighborhood Social Environment and Walking for Transportation among Older Adults. *Social Science & Medicine* 104: 23–30.

Watkins SJ, Mindell JS (2011). 'Stress, social support, and community severance'. Chapter 5 in Mindell JS, Cohen JM, Watkins SJ (Eds) *Health on the Move 2. Policies for health-promoting transport*. Stockport: Transport and Health Study Group.

Wills TA (1985). Supportive functions of interpersonal relationships. In Cohen S & Syme L (eds.) *Social support and health*. Orlando, FL: Academic Press. pp. 61–82.

Zhu, X., Yu, C. Y., Lee, C., Lu, Z., & Mann, G. (2014). A retrospective study on changes in residents' physical activities, social interactions, and neighborhood cohesion after moving to a walkable community. Preventive medicine, 69, S93-S97.