5.1 The Built Environment and Getting People Active

5.1.1 The Benefits of Getting People Active

There is a well established link between the composition of the built environment and our ability to be physically active (Booth et al. 2000). The gradual removal of physical activity from daily life has set in train a raft of negative health related consequences. The rapid increase in non communicable disease such as coronary heart disease and diabetes, currently experienced in both developed and developing countries, is of major concern (Booth et al. 2001).

Contemporary recognition of the relationship between physical activity and health benefits has grown concurrently with increasing mortality from non communicable chronic diseases and sedentary lifestyles. The research of Morris and Crawford in the 1950s explored the observations that sedentary workers suffered more heart disease than those in active jobs. They compared bus conductors with bus drivers and government clerks with postmen to arrive at this conclusion (Morris and Crawford 1958 p. 5111). Their study of the incidence of myocardial fibrosis (evidence of early coronary heart disease) in 3,800 corpses enabled confirmation of the hypothesis that ‘men in physically active jobs have a lower incidence of coronary (ischaemic) heart disease in middle age than men in physically inactive jobs’ (Morris and Crawford 1958 p. 5111). This early study importantly recognised that an absence of movement in daily life is unhealthy.

Beyond health specific benefits, it appears that physical activity is also linked to overall community well-being (Wood et al. 2010) through the encouragement of social interaction and community engagement (Echeverría et al. 2008). Moreover, there are economic and environmental benefits to physical activity that go beyond an individual’s health (Bauman et al. 2008; Shoup and Ewing 2010).

Of course, since 1958, the role of physical activity as a modifiable risk factor of disease has been well researched and is now firmly established. The remainder of this section explores the way the built environment can encourage physical activity within an increasingly sedentary society.

5.1.2 How Can the Built Environment Get People Active?

The built environment can be modified to facilitate or constrain physical activity. It can be structured in ways that increase opportunities for, and reduce barriers to physical activity.

Characteristics of the built environment influence physical activity. These characteristics differ depending on population groups (e.g. children, youth, the elderly, socially and economically disadvantaged, differently abled), for varying purposes of physical activity (e.g. transportation, exercise), and in diverse contexts (e.g. inner suburban, outer suburban, regional, rural). The form of the built environment, such as residential and commercial density, land use mix, connectivity and accessibility, also influences the way we move and what we do within that environment. In particular, the built environment can shape travel behaviour, including the quantity of walking, cycling, public transport and car travel, as well as the amount of leisure time that is available for other healthy pursuits. The built environment can also facilitate opportunities for recreational physical activity, by providing well maintained and useful open spaces, in addition to safe and amenable streets for non-utilitarian walking and cycling.

5.1.3 Key Studies

There has been a lot of research on the links between the built environment and physical activity. This section provides an overview of current research outcomes to support the associations between the built environment and physical activity. Using the search methodology outlined in Section 4, 769 articles were identified as reviewing relevant research or directly examining the relationship between the built environment and physical activity. Given the huge number of papers in this area and the work to date, a review of existing reviews was employed as the principal method to examine this body of literature. A total of 55 review papers published between 2000 and 2010 summarising the relationship between the built environment and physical activity were subsequently identified within the 1,300 articles. Four 'grey' reviews of the literature were added based on the knowledge of the authors and recommendations from the steering group. Finally, references from 2010 were also assessed to ensure that the latest research not incorporated in existing reviews was captured. It should be noted that a number of reviews met the search criteria yet obviously aimed to relate to a very general audience. These reviews were not included. It was considered that they would add nothing more to our study.

To further narrow the focus of the Review and avoid duplication, if a review identified by the search criteria was reviewed in the same context, more recently, the older review was excluded. For example, Gebel et al. 2005 review the built environment implications for physical activity from nine reviews, including Lee and Moudon (2004). Gebel et al. (2005) therefore replaces Lee and Moudon (2004) and the eight other prior reviews already covered for the purposes of this Literature Review. An exception to this is the landmark study conducted by the US based Transportation Research Board (2005).

Using this process of elimination, 37 studies were ultimately reviewed, with the following studies included in the Annotated Bibliography in Appendix 3.

Bauman and Bull 2007
Black and Macinko 2008
Brownson et al. 2006
Burke et al. 2008
Cao et al. 2009
Cavill et al. 2008
Davison et al. 2008
Dunton et al. 2009
Ewing and Cervero 2010
Ewing and Dumbaugh 2009
Faulkner et al. 2009
Feng et al. 2010
Ferreira et al. 2007
Frost et al. 2010
Galvez et al. 2010
Gebel et al. 2005
Gebel et al. 2007
Handy et al. 2009
Heinen et al. 2010
Kaczynskl and Henderson 2008
Kahn et al. 2002
Leck 2006
Mead et al. 2006
Ogilvie et al. 2007
Pucher et al. 2010
Radbone and Hamnett 2003
Renalds et al. 2010
Saelens and Handy 2008
Sallis and Glanz 2009
Sallis et al. 2009
Shoup and Ewing 2010
Wendel-Vos et al. 2007

While these reviews vary in quality and approach, common themes were identified to explore the elements of the built environment that can get people active.

5.1.4 Major Themes in This Domain

Articulating the Evidence

Evidence from multilevel and quasi-experimental evaluations of environmental changes is now beginning to surface to clarify the comprehensive body of published cross sectional research. Increasingly, the idea that neighbourhoods can be designed and modified to support physical activity is justified as a public health issue. Nevertheless, it remains difficult to define exactly what it is about the built environment that gets people active and what form this environment might take in an Australian context.

The following section draws the literature together under common themes. Our starting point is a discussion about the application of ecological theories of health promotion and behaviour change to the way people are physically active within their built environment. Concluding that a 'policy mix' is required, the Review goes on to illuminate built environment attributes of mixed uses, distances and density, and the way the literature treats these attributes, including their impact on physical activity. The Review then turns to the built environment's role in facilitating recreational physical activity. It concludes with evidence on the way built environments can support every day movement as part of how people engage with the environments where they live and work.

The Policy Mix Required

Key Message: Research on encouraging physical activity generally follows socio-ecological models of behaviour and concludes that a mix of social, economic, political and built environment policies is required to positively influence levels of physical activity.

Popular barriers to physical activity are multi-dimensional and complex, crossing spatial, temporal and discipline boundaries.

Radbone and Hamnett (2003) review a number of survey based studies on why people do not walk. They conclude that time needed, danger from motor vehicles, fears about personal security, inclement weather, poor health, quality and amenity of pedestrian facilities, distance, having dependents or baggage, and perceptions of a 'lack of glamour' associated with walking compared with other travel modes are the most often identified barriers. In a review of bicycle commuting, Heinen et al. (2010) emphasise that time, safety, perceptions of social norms, and the impracticality of distance are among the most important barriers to cycling uptake. Bauman et al. (2008) cite a survey of 2,403 cyclists conducted by Garrard et al. (2006) to identify confidence, motivation, skills, beliefs, attitudes, time, opportunity, and perceptions of enjoyment, as the primary barriers to cycling. The main inference from this analysis of barriers to physical activity is that some are attitudinal, while others relate to the built environment and to the biophysical environment. Some are highly influenced by political decision making, others by economic conditions and social norms.

This complexity suggests that traditional biological and psychological models of behaviour focused on the individual will not provoke the kind of behavioural change required to increase physical activity (Brownson et al. 2005; Sallis and Glanz 2009; Pouliou and Elliott 2010). Instead, the most effective interventions will operate at multiple levels. They will be tailored to place (Mitra et al. 2010) and the people living in that place, respecting that individuals of different ages (Carver et al. 2010a; Frank et al. 2010), socio-economic and cultural backgrounds (Dahmann et al. 2010; Franzini et al. 2010; Turrell et al. 2010) and genders (Bonham and Koth 2010; Michael et al. 2010) will respond to interventions differently. Furthermore, while environmental change can be low cost, high reach, and provide supportive environments for later targeted interventions (Brownson et al. 2006), educational programs, policy change and economic incentives must also be employed (Gebel et al. 2005; Rodríguez 2009). The socio-ecological model of behaviour change is based on the idea that comprehensive approaches to change physical activity levels need to consider interventions at multiple levels – the individual, social and environmental. The latter component, environmental influences on physical activity, is the subject of this section of the Review.

The requirement for a mix of adjustments is evident from the research on single focus 'one off' interventions. In a meta analysis of built environment/transport research to 2009, Ewing and Cervero (2010) found walking and cycling behaviour to be generally 'inelastic' with respect to changes in the built environment. This infers that mode uptake for walking and cycling is generally not responsive to the small scale built environment modifications assessed in their review (Ewing and Cervero 2010). This is supported by Krizek et al. (2009) who assessed over 300 articles on cycling and walking. They stress that 'only via an integrated range of environmental features...pricing policies (and) education programs will substantive changes result' (Krizek et al. 2009 p.5). Despite their inference of inelasticity of travel behaviour, Ewing and Cervero (2010) still conclude that the combined effect of built environment variables on physical activity could be quite large. However, this is an effect that does not readily reveal itself through meta-analysis of small scale individual modifications.

Sample Policy

'The NSW BikePlan features encouragement actions to make cycling as easy and accessible as walking or driving a short distance by:

- developing an internet portal to cycling information, including interactive bike mapping on the Transport Info 131500 website...
- rolling out cycling skills and awareness training for adults, with a priority focus on Parramatta, Liverpool and Penrith...
- preparing teacher resources on student bike-riding skills...'

The NSW Bike Plan 2010 p. 5.

Sample Evidence

'...separate [cycling] facilities are only part of the solution. [Cycle friendly] cities reinforce the safety, convenience, and attractiveness of cycling with extensive bike parking, integration with public transport, comprehensive traffic education and training of both cyclists and motorists, and a wide range of promotional events intended to generate enthusiasm ... At the same time, car use is made expensive, less convenient, and less necessary through a host of taxes and restrictions on car ownership, use, and parking. And land use policies foster relatively compact, mixed-use developments that generate more bikeable, shorter trips.'

Pucher and Buehler 2007 p. 53.

Accessibility and the Importance of Distance

Key Message: Research consistently shows that keeping necessary trip distances short through mixed use and compact development will help to make active transport a viable option.

Accessibility is generally measured as the distance between origin and destination and, in the majority of the literature, distance is significantly correlated with active transport. Longer distances discourage all mobility, particularly those involving physical activity. Essentially, shorter distance represents increased convenience and therefore reduced cost to the individual through time and effort required to use physically active transport modes.

Both perceived and actual distance between destinations are significantly and positively correlated with physical activity (Transportation Research Board 2005; Bauman and Bull 2007). The importance of distance is strongly emphasised in the review of commuting by cycle undertaken by Heinen et al. (2010). They cite at least 11 studies which conclude that an increase in trip distance results in cycling having a much lower share in mode choice. The same conclusion is confirmed by the Australian 'Journey to Work' census data. This indicates that cycle commuters tend to live closer to their work than other types of commuters (Rissel and Garrard 2006). Distance is also a regularly cited variable that encourages utilitarian walking. Wen et al. (2010) conclude that the inconvenience of distance is a major barrier to walking to work. Bauman and Bull (2007) cite proximity and walkable distance as more often associated with both utilitarian and recreational walking.

Sprawl is a proxy for contemporary suburban form, characterised by low density and homogeneity of land use, which invariably results in increased distances between uses. Automobile dependency has enabled the development of low density, single use suburbs and it logically follows that poor accessibility by active transport is often used as an indicator of urban sprawl. There have been numerous studies seeking to clarify the apparent link between urban sprawl, decreased physical activity and increased obesity (Ewing et al. 2003; Ewing 2005;

Frumkin 2005; Brown et al. 2008; Garden and Jalaludin 2009; Trubka et al. 2010). As an example, Feng et al. (2010) review 22 studies which overwhelmingly indicate significant associations between sprawl and physical activity. In the context of adolescents using active travel options to get to school, Dunton et al. (2010) cite sprawl as being associated with less utilitarian physical activity and higher obesity outcomes. Generally, research in this area concludes that it is the poor accessibility and increased distances between land uses characteristic of 'sprawl', rather than sprawl as a tangible concept, that discourages physical activity. This is particularly so in relation to utilitarian physical activity.

If accessibility and distance are key determinants of physical activity, the question remains - how far are people willing to walk and cycle? Krizek et al. (2009) indicate a strong market for cycling trips less than two and a half kilometres. Keijer and Rietveld (2000), Rietveld (2000) and Martens (2004) suggest that the bicycle is most often used for distances up to three and a half kilometres. More recent studies have shown people are willing to cycle up to ten kilometres to access high frequency public transport services (as reviewed by Pucher et al. 2010). The standard distance for walking is cited anecdotally as 400 metres (Krizek et al. 2009). However, similar to cycling, various studies have shown that people will walk greater distances for utilitarian purposes to access, for example, public transport or other services (Besser and Dannenberg 2005). Burke and Brown (2007) present detailed information on the distances people walk for transport purposes in Brisbane. They use the South East Queensland Travel Survey which provides information on the weekday travel of 10,931 respondents. Burke and Brown report that the median distances people walk from home to all other places, using the walk mode only, is just under one and a half kilometres (1.45). In essence, their research suggests that the more desirable the destination, the further people are willing to walk or cycle to access it. Nevertheless, this is constrained, with the limit being defined by context and time.

Time, and the recognition that distance is a surrogate for time, is often excluded from the literature. Time is a cost of active transport both in real terms and because it represents the amount of effort required (Saarloos et al. 2009). Lack of time is a major reason why people do not engage in healthy behaviours (Tranter 2010). It is easy to conceive that a ten minute cycle across the flats of Amsterdam would get the average commuter cyclist a greater distance than a ten minute ride across the ridges of Sydney's northern beaches or a steep coastal town. Unfortunately, incorporating time into the complex models used to predict walkability and cyclability is far more difficult and contextually dependent than incorporating more objective measures of distance. Despite this, future studies need to recognise the proxy-based relationship between time and distance when determining propensity for active transport to access destinations.

Sample Policy

'Locate food stores, shops and local facilities (such as post boxes and public telephones) within close walking distance to dwellings and businesses. The concept of 'close walking distance' will vary according to people's different fitness levels but usually ranges between 400 to 800 metres...'

National Heart Foundation of Australia (Victorian Division) 2004 p.13.

Sample Evidence

'The most consistent set of conclusions (on the built environment correlates of walking) relates to proximity to potential destinations. Five reviews found sufficient evidence to conclude that accessibility based on distance to destinations is associated with more walking... Three reviews concluded that mixed land use is also associated with more walking. Because mixed land use means destinations are within closer proximity, this finding is consistent with the findings for accessibility.'

Saelens and Handy 2008 pS557.

The Surrogate of Density

Key Message: While higher density areas generally display environments conducive to physical activity, the research suggests that increasing the residential density of the built environment alone will not necessarily encourage increased physical activity. The intuitive notion that higher density may encourage physical activity is now being substituted in the research by the concept that density, mixed use and micro-design elements *in some combination* are most likely to influence levels of physical activity.

It makes sense that higher densities will essentially lead to shorter distances between origins and destinations and, as established above, shorter distances encourage active transport. Land-use concepts, such as new urban designs, link higher density levels with increased shares of non-motorised travel (Leck 2006; Saelens and Handy 2008; Walton et al. 2008; Rodríguez 2009). This suggests that in denser urban areas, distances between locations are shorter, and consequently can be bridged more easily on foot or by bicycle. This assumption is, to an extent, supported by the research.

Using 17 primary studies, Leck's 2006 meta-analysis assessed the significance of five urban form variables – residential density, employment density, land use mix, sidewalk ratio, and grid percentage – together with seven travel variables – vehicle miles travelled, vehicle hours travelled, vehicle trips, non-work vehicle trips, and probability of commuting by automobile, transit, or by walking. The analysis found residential density is the most important built environment element that influences travel choices. Residential density was positively statistically significantly correlated with the probability of commuting to work by active transport modes. Leck also found employment density to exert a strong influence on travel behaviour. In their report on 'Getting Australia Moving' Bauman et al. (2008) refer to Handy (2004) and review others as evidence of the ills of low density land use and its connection to car-dependent societies. Radbone and Hamnett (2003) cite an unpublished study by Holtzclaw (1994) which concluded that a doubling of density produces 25 to 30 percent less driving per household when all of the conditions generally accompanying density are present. These conditions include better public transport, more local shopping, and a pedestrian-friendly environment. After citing various studies on density and vehicle miles travelled (VMT), Ewing also confirms Holtzclaw's recommendation that 'doubling urban density results in a 25-30 percent reduction in VMT, or a slightly smaller reduction when the effects of other variables are controlled' (Ewing, 1997, as cited by Radbone and Hamnett 2003 p. 3). Heinen et al. (2010) reviewed Pucher and Buehler (2006), Guo et al. (2007), Parkin et al. (2008) and Zahran et al. (2008) to conclude that higher densities lead to a higher cycling share. Litman (2007) concludes that higher densities are related to lower levels of car ownership and car use which in turn has positive effects on walking and cycling environments. Similarly, Witlox and Tindemans (2004) found that inhabitants of higher density city centres choose the bicycle as a mode of transport more often than residents in the suburbs. Further, the landmark review of the US Transportation Research Board (2005), the 'TRB Report', concludes that there are links between higher density, at both origin and destination, and decreased automobile use and increased walking and public transport use. Finally, Bauman and Bull (2007) rate population density as significantly associated with physical activity.

The research generally shows, therefore, that aggregate physical activity levels, particularly active transport share, will increase with density. However, the question remains, how much density is enough to encourage active transport options? The idea of 'proper city densities' (Jacobs 1961 p. 221) has been the subject of debate in planning theory and practice for quite some time, although its relationship with physical activity is a more recent topic of discussion and theorisation. Both Radbone and Hamnett (2003) and the TRB Report (2005) cite a US study by Dunphy and Fisher (1994) which indicates that the total number of trips does decline (slightly) with density, while there is an increase in trips by public transport, walking, cycling and taxi. This study showed trip share by walking and cycling increased markedly above densities of 7,500 people per square mile. By comparison, the average population density in Sydney was 1,347 people per square mile in the 2001 census.

This suggests that density would have to more than triple before reaching the point at which mode shares would alter. Conversely, more recent evidence reviewed by Feng et al. (2010) suggests that walking begins to increase at densities between 1,000 and 3,999 people per square mile. A population density of 3,000 people per square mile was found to be required to decrease distances travelled by car. These conflicting propositions of 'proper' densities to encourage walking and cycling infer that the relationship between density and active travel is one of correlation rather than cause. As articulated by Feng et al. (2010), it is possible that the variable of density is simply a 'surrogate for an unobserved... latent construct' (Feng et al. 2010 p. 185).

The literature often cites density as a proxy for other variables (TRB Report 2005). This leads many of the reviews to conclude that density is less significant than other built form variables, often accompanying density, in influencing travel behaviour. A higher density neighbourhood will typically have less parking, a greater variety of land use, more people out and about, houses and shops which abut the street, and the presence of footpaths, straight roads, small blocks, and better public transport services. The review by Ewing and Dumbaugh (2009) also suggests higher density areas are safer in terms of incidence of traffic accidents. It is very difficult to isolate the impact of any one of these factors and this complexity is compounded by the undeniable importance of socio-economic, demographic and attitudinal factors in influencing travel patterns.

The key message here is that it is not density as such which will get people active. Rather, higher densities often shorten aggregate trip distances. This conclusion is supported by the meta analysis of Ewing and Cervero (2010) which suggests that several of the variables that often go hand-in-hand with population density, impact travel demand more than simple population density per se. Increasing levels of density alone will not serve to promote more active transport without increased mixing and connecting uses to bring services and other destinations closer to where people live and work.

Having discussed the idea that density is more than likely a proxy for other built environment variables in its ability to encourage physical activity, there are potentially some specific aspects of density that will encourage people to walk and cycle. The ability for higher density areas to provide more 'eyes on the street' (Jacobs 1961 p. 66), for example, is one aspect of density which has a tangible relationship with physical activity. Higher densely populated areas contain more people which in turn contribute to both the perceived and actual safety often required to encourage physical activity. This accepted planning wisdom has been confirmed by Galvez et al. (2010) in the context of children's active commuting to school. Children with many friends within walking distance of their school were more than twice as likely to actively travel to school. Additional studies confirm that seeing people out and about engaging in physical activity, is likely to encourage others to be active (Robinson 2005; Galvez et al. 2010).

Sample Policy

'As a guide, the following minimum residential densities are suggested:...

- 20 to 30 dwellings per site hectare for areas in 400m of neighbourhood centres and 250m of main bus routes; and
- 30 to 40 dwellings per site hectare for areas in 400m of town centres and metropolitan railway stations.'

WA Planning Commission, Liveable Neighbourhoods 2004 p. 9 E1.

Sample Evidence

'The evidence for the relationship between density and weight status is mixed, regardless of the level of analysis.'

Robertson-Wilson and Giles-Corti 2010 p. 24.

Destinations and Mixed Uses

Key Message: Destinations give people a place to walk to. Replacing uniform urban form with a variety of uses can lead to shorter distances between origins and destinations, thereby encouraging active forms of transport.

Mixed land uses can result in shorter distances between origins and destinations, which generally encourage people to be more physically active.

Radbone and Hamnett (2003) cite a variety of studies matching travel survey data to travel behaviours for residents in neighbourhoods with mixed and single-use characteristics. This work consistently found associations between mixed use development and active travel behaviour. The TRB Report (2005) also cites research which found positive correlations between land use diversity and physical activity, with particular reference to walking for transport. This conclusion is supported by Davison et al. (2008) who cite Kerr et al. (2006) and McMillan (2007) to suggest that children are more likely to walk or bicycle to school in areas with a diverse land use mix. While Bauman and Bull (2007) do not distinguish between recreational and utilitarian physical activity, their review concludes that there is a significant relationship between populations living with shops and services nearby and physical activity. Black and Macinko (2008) in reviewing Mobley et al. (2006), Frank et al. (2004) and Saelens et al. (2003) also come to the conclusion that an easy walk from home to commercial areas has a significant correlation with increased walking, as well as lower population level body mass index (BMI). The meta-analysis conducted by Leck (2006) found mixed land use and the provision of destinations to be an overwhelmingly significant built environment element influencing active travel behaviour. So too did the review by Gebel et al. (2005) of Cervero and Duncan (2003), Foster and Hillsdon (2004), Frank et al. (2005) and Hoehner et al. (2005). Consistent with prior work, Ewing and Cervero's (2010) meta-analysis found that walking is most strongly related to measures of land use diversity, intersection density, and the number of destinations within walking distance.

To address the issue that mixed uses, like density, often serve as a proxy for a variety of travel influencing socio-demographic variables, the TRB Report (2005) cites a study by Frank and Pivo (1994). This investigation employed multiple regression techniques to analyse data collected on a regional basis. Partial correlations showed that both density and land use mix were significantly and positively related to mode share by public transport and walking for work trips, and negatively to work trips by car. Ewing and Cervero's (2010) meta-analysis was able to quantify this conclusion by calculating the elasticity of travel behaviour to built environment interventions. This study's key conclusion is that propensity to walk for transport is most elastic (i.e. sensitive) to employment-housing balance and distance to shopping and services. These are both features of an urban landscape characterised by mixed use.

Sample Policy

'Neighbourhood structure should have the following characteristics:

- size and shape generally defined by a five minute walk from the neighbourhood centre to its perimeter, typically 400m...
- the centre acts as a community focus with a compatible mix of uses, including retail...community facilities and open spaces such as a small square...'

WA Planning Commission. Liveable Neighbourhoods 2004 p. 7 E1.

Sample Evidence

'Access to post boxes, bus stops, convenience stores, newsagencies, shopping malls, and transit stations within 400 m (OR 1.63-5.00) and schools, transit stations, newsagencies, convenience stores and shopping malls within 1500 m (OR 1.75-2.38) was associated with participation in regular transport-related walking. A dose-response relationship between the mix of destinations and walking for transport was also found.'

McCormack et al. 2008 p. 33.

Small Scale Urban Design and Facilities

This section considers the importance of the form and character of street networks, together with facilities and infrastructure, in enabling safe and convenient physical activity.

Street Networks

Key Message: Grid street patterns decrease distances between origins and destinations. Decreased distance between commonly accessed uses encourages utilitarian physical activity.

There have been a number of studies that have attempted systematic comparisons of traditional and contemporary suburban neighbourhood structures to determine the way they influence physical activity. Specifically, researchers have endeavoured to analyse activity inducing differences between traditional grid street layouts and curvilinear, or 'dendritic', networks of more contemporary suburban neighbourhoods. See for example Southworth and Owens 1993, Frank 2000, Randall and Baetz 2001, Radbone and Hamnett 2003, Wendel-Vos et al. 2007 and Ewing and Cervero 2010. Evidence suggests that legible and direct street networks are particularly important in encouraging active transport in more vulnerable demographic groups such as children and the elderly. Citing Timperio et al. (2006), Davison et al. (2008) conclude that children are more likely to walk or bicycle to school when the route is direct and navigation of steep roads minimal. Children are also more likely to actively commute to school in walkable neighbourhoods characterised by grid street patterns with higher intersection densities (Kerr et al. 2006, McMillan 2007). In relation to the elderly, Hall and McAuley (2010) examined the determinants of whether a cohort of 128 UK based women aged over 65 attained 10,000 steps every day. Using Geographical Information Systems (GIS) and pedometer data, they conclude that participants who did not achieve 10,000 steps per day reported significantly less walkability, expressed as street connectivity, compared with those who achieved the daily 10,000 steps.

In general, research on street networks concludes that grid-like patterns with high intersection densities create better street connectivity, decrease distances between origins and destinations, and are more navigable. These are all characteristics of streets which welcome and encourage walkers and cyclists.

Sample Policy

'The street network should provide a high level of internal connectivity...The street network should have no more than 15 percent of lots fronting culs-de-sac... Culs-de-sac should be laid out, so that pedestrians and cyclists can have through access.'

WA Planning Commission. Liveable Neighbourhoods 2004 p. 8 E1 and p. 8 E2.

Sample Evidence

'Using cross-sectional (*n*70) and longitudinal (*n*32) data (collected 2003–2006), associations of neighborhood design and demographics with walking were examined...In terms of street-network patterns, moving to an area with fewer culs-de-sac was associated with about 5,303 more steps per week (757 more steps per day).'

Wells and Yang 2008 p. 317.

Infrastructure and Facilities

Key Message: Well maintained footpaths and bike paths encourage walking and cycling for transport, as does the provision of bike parking and other end-of-trip facilities. A perception that cycling is unsafe because of traffic, and a perception that walking is unsafe because of exposure to crime, are key infrastructure related deterrents to walking and cycling for transport and recreation.

A wide range of detailed design features in the built environment allow people to feel safe, confident and comfortable when walking or cycling. Feeling safe, confident and comfortable increases people's propensity to walk and cycle as a form of travel. The infrastructure and facilities to achieve this are discussed here.

Designing for Confidence and Comfort: the importance of infrastructure

Heinen et al. (2010) cite the studies of Noland and Kunreuther (1995), Pucher (1998), Dickinson et al. (2003) and Martens (2007) which found that commuting cyclists consider safe bicycle parking to be important. This is further confirmed by Pucher et al. (2010) who reviewed 139 research papers to conclude that bike parking will generally facilitate increased cycling, especially if it is secure and undercover. Interestingly, Pucher and Buehler (2009) found that secure bike parking is more of an issue in countries lacking a strong, traditional cycling culture, including Australia. This study also highlights the importance of end-of-trip facilities in the workplace, including showers and lockers, to encourage active commuting. In addition, provision of facilities in the workplace sends a strong signal to employees of employer acceptance of active commuting.

Infrastructure, such as off-road cycle paths, is important to cyclists, particularly beginner cyclists. The question of what infrastructure to provide is very much related to safety (Krizek et al. 2009). A comprehensive analysis by Pucher (2001) suggests that countries with more separated and off-road cycling facilities have a higher modal split share of cycling and greater levels of bicycle safety. Preferences for particular cycling facilities, however, differ across socio-economic groups, and between experienced and non-experienced cyclists. Inexperienced cyclists, women and younger cyclists tend to consider off road bicycle infrastructure to be more important (Krizek et al. 2005; Daley et al. 2007; Garrard et al. 2008; Krizek et al. 2009; Heinen et al. 2010). For experienced cyclists, bicycle lanes are not considered to be any more desirable than wide curb lanes (Taylor and Mahmassani 2000; O'Connor and Brown 2010). Continuous networks are also deemed important by inexperienced cyclists and for those commuting by bike where time is an issue (Heinen et al. 2010; Winters et al. 2010).

The presence of well maintained footpaths emerges in the literature as a significant, positive correlate to walking (as analysed by the TRB Report 2005). Bauman and Bull (2007) cite presence of footpaths as having a consistent association with physical activity generally. Davison et al. (2008) indicate that footpath provision is important to encourage active transport to school. Krizek et al. (2009) also allude to the importance of footpath provision in supporting both utilitarian and recreational physical activity, as does the review of Saelens and Handy (2008). Krizek et al. (2009) explain that while quantification of the relationship between footpath provision and walking is complex, the relationship is strong enough to justify policy change.

Designing for Safety

Safety, both perceived and real, is of paramount importance to all forms of active travel and locality based recreational physical activity. Crime is often cited as a barrier to exercising outdoors and to active commuting (TRB 2005; Ferreira et al. 2007; Black and Macinko 2008; Mendes De Leon et al. 2009; Durant et al. 2010). Parental perception of crime is also given as a reason for discouraging children to actively commute to school (Davison et al. 2008; Ding et al. 2010; Galvez et al. 2010; Carver et al. 2010b). Crime and fear of crime are further discussed in Section 5.2 (The Built Environment and Connecting and Strengthening Communities).

Traffic safety is considered important in encouraging active transport. Characteristics of the built environment undoubtedly either hinder or support the provision of safe traffic environments (Carver et al. 2010b). The TRB Report (2005) and Black and Macinko (2008) found that the decision to walk is correlated with the speed of automobile traffic, as is the decision to cycle (Heinen et al. 2010). This inference is interesting considering Australia maintains some of the highest automobile speed limits in the world. The results of a six year long Canadian study of 500 adults found that perceived traffic danger was a major predictor of increased BMI (Berry et al. 2010).

Parental perceptions of traffic safety have been consistently deemed instrumental in predicting children's active commuting to school, as well as their general physical activity levels. For an Australian example see Andrews 2010; for a Swiss based study see Bringolf-Isler et al. (2010). Rodriguez (2009), Galvez et al. (2010) and Carver et al. (2010a) suggest that educational programs are effective in combating parental perceptions of safety as a barrier to increased physical activity in children, particularly active commuting to school. Jerrett et al. (2010) used a quasi experimental approach to examine the relationship between measured traffic density near the homes of children and attained BMI over an eight-year period. They found that increased traffic density within a 150 metre radius around a child's home, led to significant positive associations with BMI. This result applied to both sexes at age 18 and persisted after numerous confounding variables were controlled. The inference is that increased traffic results in less independent child mobility – generally walking or cycling. These results were confirmed recently in Australia as part of the longitudinal Melbourne based Children Living in Active Neighbourhoods ('CLAN') study. Cross sectional data from 440 children was used to compare physical activity levels with parental safety concerns, including those associated with active travel to school. The study concluded that parental restriction of physical activity due to safety concerns results in lower levels of physical activity for children outside school hours. Interestingly, this was particularly true for adolescent girls (Carver et al. 2010b). Indeed, the overarching conclusion is that the behaviour of parents, their attitudes to health and physical activity, together with their perceptions of safety, are more influential on children's physical activity than elements of the built environment per se. Policy interventions targeting parental role modelling and support for healthy parental behaviour are therefore important associates of any built environment modifications (Crawford et al. 2010).

The importance of safety in encouraging active travel to school was further reviewed by Faulkner et al. (2009). Their analysis of nine studies found that children who actively commute to school accumulate significantly more daily physical activity than their chauffeured school mates. Faulkner et al. (2009) also concluded that active commuters to school did not necessarily have lower incidence of overweight and obesity. Despite this, they join with numerous other researchers in recommending that a focus on active school transport is still appropriate given that adequate participation in physical activity during childhood is critical to the prevention of chronic disease later in life (Frumkin 2003; Dannenberg et al. 2003; Cooper et al. 2010; Pabayo et al. 2010).

Sample Policy

'Schools need full width concrete path paving around the main entrance...The full width concrete paved areas are... linked directly to the adjacent path paving network.'

Blacktown City Council, NSW, Engineering Guide for Development 2005 p. C-7.

Sample Evidence

'As children develop and are given more independent mobility, it appears that the way neighbourhoods are designed particularly in terms of proximity and connectivity to local destinations...and the presence of footpaths becomes a determinant of whether children are able, and are permitted by their parents, to walk and use destinations locally.'

Giles-Corti et al. 2009 p. 995.

Rebuilding Physical Activity into Everyday Life - Incidental Movement

Key Message: Stair climbing is physical activity which can easily be integrated into everyday life. Visible stairways signed by point-of-choice prompts are able to increase the rate of stair climbing.

Little is known about designing buildings to encourage incidental physical activity. Considering the amount of time individuals spend indoors – particularly in schools and at the work place – building design can potentially provide people with opportunities to be physically active (TRB Report 2005).

Kahn et al. (2002) identified six studies on the effectiveness of point-of-decision prompts to encourage stair use as a substitute for taking escalators or elevators within buildings. The studies were conducted in the USA and the UK and in covered settings such as shopping malls, train stations and universities. The review reports a range of effects from a 5.5 percent net increase to 128.6 percent increase in stair use.

Findings from several of the studies suggest that prompts should not only advocate stair use but also articulate the benefits. Two studies reported different levels of effectiveness for obese and non-obese people. Although the signs were effective in both groups, the median net increase in the percentage of people taking the stairs was greater among the obese group. Among obese people, a sign that linked stair use to the potential for weight loss showed a higher increase in stair use than a sign linking stair use to general health benefits (Kahn et al. 2002). The TRB Report (2005) also emphasises the capacity of stair use to provide a low cost way to integrate physical activity into daily routine, particularly stair wells in the workplace. These findings have been confirmed by a 2010 systematic review of 25 studies on the effectiveness of point-of-choice prompts to increase the rate of stair climbing in the general population (Nocon et al. 2010). Point-of-choice prompts in this study were posters and banners at public transport stops, shopping malls and office buildings. Of the 32 results for escalator settings, 28 reported a significant increase in stair climbing. However, the results were not as convincing for elevator settings. A study by Eves et al. (2009) on the effect of the width of stair wells and stair use in railway stations echoes this conclusion. They demonstrated that people are generally willing to use the stairs instead of an escalator in peak periods if the width of the stair well is sufficient to cater for demand.

A major barrier to the implementation of point-of-choice signage to increase stair use is that stairways are often hidden from public view, as well as being poorly lit and maintained. In extreme cases, stairways are secured to prevent access. It is important to note that differently abled persons have varying capacity for stair useage. We believe that this has to be considered in designing buildings to encourage greater stair utilisation for the enhancement of physical activity levels of the entire population.

Sample Policy

'The design and location of escalators should be based on peak flow rates... Alternative access (adjacent stairs) is required.'

NSW Ministry of Transport Guidelines for the Development of Interchange Facilities 2008 p. 18.

Sample Evidence

'In five studies, the median increase in stair-climbing was 53.9%. The remaining study showed an unspecified increase in stair-climbing and also found that the signs were effective in getting those who were less active (as measured by responses to a brief survey) to take the stairs.'

Kahn et al. 2002 p. 77.

Recreational Physical Activity

Key Message: People with access to good quality and safe open space are more likely to be physically active.

Recreational Facilities and Open Space

The built environment provides opportunities for people to be active in public parks, walking trails and on foot paths and streets. Through land use zoning and regulation, the built environment can also support opportunities for recreation provided by indoor facilities from publicly operated leisure centres to privately owned health clubs.

There is substantial evidence that people who live close to a variety of recreation facilities are more physically active than those who do not enjoy such proximity (Wendel-Vos et al. 2007; Sallis and Glanz 2009). Bauman and Bull (2007) reviewed 13 studies to conclude that access to physical activity facilities is consistently correlated with physical activity levels. Black and Macinko (2008) cite Frank et al. (2004), Giles-Corti et al. (2005), Ellaway et al. (2005), Mobley et al. (2006) and Roemmich et al. (2006) as reporting that populations with better access to high quality open and green space are more likely to walk and undertake physical activity. Kaczynskl and Henderson (2008) reviewed 50 quantitative studies on the relationship between the provision of recreational spaces and physical activity to reveal a positive association between the two. Bauman and Bull (2007) summarised Davison and Lawson (2006) to conclude that living near parks, playgrounds, and recreation areas is consistently related to children's total physical activity. These conclusions are supported by Dunton et al. (2009), Galvez et al. (2010), Loukaitou-Sideris 2010 and Veitch et al. (2010). Galvez et al. (2010) further emphasise that children's parks and playgrounds need to be perceived as both safe and accessible.

Research suggests that people have specific ideas about their ideal outdoor area for physical activity. For example, in some States in the USA, basketball and racquet courts are preferred over baseball fields (Floyd et al. 2008). In an Australian context, Giles-Corti (2006b) has suggested that our penchant to interpret 'open space' as sporting ovals should adapt to include open areas that are well endowed with shade and landscaping to encourage walking as well as organised sport. This type of research can guide the design of recreation facilities and forms the basis for literature suggesting that the aesthetic quality of recreational areas is important (Galvez et al. 2010). The overarching implication is that to encourage physical activity, open space must be designed cognisant of local context and well maintained.

Despite the strength of this research, a recent study undertaken by Searle (2009) suggests the provision of local open space in various high density developments in Sydney falls well short of best practice recommendations. The study concludes that this under provision is a result of funding confusion and different local and State planning requirements.

Walking and Cycling for Recreation

The environments that encourage utilitarian walking and cycling are not necessarily conducive to walking and cycling for recreation. Perceived and actual safety remain of primary importance (Spangler-Murphy et al. 2005; Black and Macinko 2008), as does the provision of street networks that are legible and well maintained, with footpaths, shade and lighting (Powell et al. 2007 ; Saelens and Handy 2008). Aesthetics, however, replace destinations and network density, with recreational walkers not particularly interested in taking the most direct route (Agrawal et al 2008). The provision of special purpose walking trails is more likely to encourage recreational walking. Various studies throughout Australia demonstrate that people will use walking trails if they are provided (see for example Merom et al. 2008). A review by Kaczynskl and Henderson (2008) on associations between parks and physical activity found that provision of open space was more positively correlated with walking for exercise than recreation itself. More recently, Michael et al. (2010) found quite the opposite, concluding that open recreational spaces were not related to walking for a cohort of older men in the USA.

Sample Policy

'- Provide open spaces within safe, comfortable walking distances

- Locate public open spaces within a maximum of 500 metres walking distance from dwellings...
- Provide large local parks (1 hectare minimum) within 500 metres safe walking distance from all dwellings, and small local parks within 150 to 300 metres safe walking distance of all dwellings...'

National Heart Foundation (Victorian Division) 2004 p. 15.

Sample Evidence

'Within the physical environment, the availability of physical activity equipment is a convincing environmental determinant of vigorous physical activity/sports.... Other relevant environmental factors may be the availability, accessibility and convenience of recreational facilities.'

Wendel-Vos et al. 2007 p. 438.

5.1.5 Strengths and Weaknesses in the Research

Consistency of Measurement

The need for consistent and objective measurement of built environment and physical activity variables is a commonly cited weakness in research on the Built Environment and Getting People Active.

As an example, Kirk et al. (2010) recommend standardisation of measurement in seeking to characterise 'obesogenic' environments. This comprehensive review of 146 primary studies concludes that the 'environment may play a critical role in obesity development, prevention and management, but we have yet to determine the best method for measuring that effect accurately and consistently, or develop an appropriate theory to encompass this very complex and dynamic system' (Kirk et al. 2010, p. 116). There are other studies recommending consistency in measurement of built environment variables. These include Cunningham and Michael (2004) measuring the impact of the built environment on older people's physical activity, Davison and Lawson (2006) and Davison et al. (2008) measuring environmental characteristics associated with children's physical activity, and Pucher et al. (2010) and Heinen et al. (2010) analysing the built environment's impact on cycling.

There is also literature which recognises that standardised measurements, particularly of built environment variables, risk underestimating the diversity of people and place (Brownson et al. 2006; Brownson et al. 2009; Schaefer-McDaniel et al. 2010). This apparent conflict in the role of standardisation arises from the interdisciplinary nature of healthy built environment research – an issue further discussed below.

Regardless of the complexity of standardising measurement of the built environment, the literature consistently recommends standardisation of measurements of physical activity, with the most common request being the use of objective measures of physical activity instead of the more convenient option of self reported variables (Badland and Schofield 2005; Ferreira et al. 2007; Black and Macinko 2008; Cavill et al. 2008; Feng et al. 2010).

Evidence of Causality

Linked to the common call for standardisation is an identified need to establish that the relationship between the built environment and health is a causal relationship. Studies have consistently found a significant association between health and the built environment, generally through cross sectional research, however associations are insufficient to establish true causality[3].

Establishing non-spuriousness by removing confounding variables (such as residential self selection) is often cited as a major weakness in research on the health-built environment relationship (Tzoulas et al. 2007; Reynolds et al. 2009; Story et al. 2009; Ewing and Cervero 2010). The lack of longitudinal research required to prove time precedence is also identified as another missing element of causal proof (Humpel et al. 2002; Radbone and Hamnett 2003; Owen et al. 2004; Gebel et al. 2005; Brownson et al. 2006; Davison and Lawson 2006; Heath et al. 2006; van der Horst et al. 2007; Wendel-Vos et al. 2007; Black and Macinko 2008; Saelens and Handy 2008; Cao et al. 2009; Faulkner et al. 2009; Handy et al. 2009; Ogilvie 2009; Reynolds et al. 2009; Feng et al. 2010; Heinan et al. 2010; Pucher et al.

[3] To robustly infer causality, scientific research generally requires at least four kinds of evidence: statistically significant association, non-spuriousness (a relationship that cannot be attributed to another variable), time precedence (cause precedes effect) and causal mechanism (a logical explanation for why the alleged cause should produce the observed effect) (Cao et al. 2009).

2010 and Renalds et al. 2010).

The inability of the research agenda to date to establish true causality is a 'weakness' perhaps not of the research itself but of the seemingly unpredictable way people relate to their environments. Juxtaposed to the call for causality is research accepting that the randomised controlled trials often underpinning causal proof are impractical for studies on the built environment and health simply because it is impossible to randomly assign exposure to built environment modifications (Brownson et al. 2006; Bauman and Bull 2007). This scholarship suggests that the constant focus on causality is a weakness of the research agenda in itself. Further, attention would be better directed towards the establishment of a more practical standard of proof acceptable in the absence of causality (Gebel et al. 2005, Ogilvie et al. 2006;; Cavill et al. 2008; Story 2009).

Interdisciplinary Understanding

A lack of overarching disciplinary collaboration has also been identified as a weakness in the research (Weaver et al. 2002; Owen et al. 2004; Badland and Schofield 2005; Davison and Lawson 2006; Barton 2009; Brownson and Jones 2009; Feng et al. 2010; Galvez et al. 2010). In contrast to recommendations for standardisation and causality are recommendations to better understand the cultures and accepted wisdoms of the different disciplines involved in healthy built environment research. The recommendation for better interdisciplinary collaboration is consistently identified throughout this Review. It is both a common weakness in the literature to date, and an opportunity for healthy built environment research into the future.

Synergies and Scale

Finally, research points to the need to better understand synergies between social, cultural, environmental and economic drivers, as well as between the geographical scales at which these drivers operate (Radbone and Hamnett 2003; Duncan et al. 2005; Heath et al. 2006; Krizek et al. 2007; Tzoulas et al. 2007; van der Horst et al. 2007; Black and Macinko 2008; Davison et al. 2008; Barton 2009; Cao et al. 2009; Ewing and Dumbaugh 2009; Story et al. 2009; Falconer et al. 2010 ; Schaefer-McDaniel et al. 2010; Feng et al. 2010; Heinan et al. 2010; Kirk et al. 2010). One of the research themes identified relates to the policy mix needed to influence physical activity. Research to date generally fails to articulate frameworks to explore this policy mix and the synergies between actors influencing health and the built environment.

5.1.6 HBEP Opportunities for Future Research

Pursue Research on Ways to Work Together

Major opportunities exist to develop the interdisciplinary nature of healthy built environment research. This should focus on how the current knowledge of the relationship between health and the built environment might be best implemented. Recent research addressing this emerging opportunity is discussed in Section 6 (Professional Development). Detailed strategies for promoting interdisciplinary collaboration are also listed in Story et al. (2009).

Explore the Evidence Required to Justify Policy Change

A part of interdisciplinary collaboration is exploring the varying standards of evidence used by different disciplines to justify and provoke change. Cavill et al. (2008) uses decision making in transport planning as an example, highlighting that '...transport policy decisions are taken every day and sometimes on approaches that often lack transparency and scientific rigour' (Cavill et al. 2008 p. 298).

Governance of the built environment is contested – economic, political and popular agendas must be pieced together alongside scientific evidence to effect change. Evidence requirements need to be articulated and understood between disciplines. Once this has occurred, better ways to present the evidence can be explored. Cost benefit analysis, environmental and social impact assessment and demand analysis are just some of the research tools that could be used to demonstrate the benefits of modifying the built environment to get people active. These different standards of proof can be pursued outside of evidence of true causality.

Pursue Opportunities to Monitor Interventions

A contemporary focus on 'how' to change built environments for health should not replace empirical research. Opportunistic monitoring of relevant interventions should be undertaken, particularly to analyse the impact of interventions over time (Gebel et al. 2005; Story et al. 2009). Research is currently emerging from quasi-experimental and longitudinal studies around the world, including the RESIDE project in Perth, WA (Giles-Corti et al. 2007), the CLAN study in Melbourne (Crawford et al. 2010) and the HABITAT study in Brisbane (Burton et al. 2009). With partners Landcom, the National Heart Foundation of Australia and NSW Health, the HBEP has obtained funding for a three year ARC Linkage grant to also conduct a longitudinal study tracking residents' behaviour over time in a number of developments in NSW. This project commenced in 2011.

Ways to identify opportunistic monitoring of interventions and establish surveillance systems for change present practical research opportunities. Some authors recommend maintenance of an information repository for current research (Davison et al. 2008; Story et al. 2009). This repository could be on-line and act as a reporting platform that will make 'lessons learned' available as quickly as possible. This search for answers needs to extend beyond post-project analysis. A method to improve awareness of proposed modifications to the built environment to encourage physical activity needs to be established. In Australia this will mean a mechanism for researchers to be in contact with local strategic planners and consent authorities so that when opportunities arise for intervention monitoring they are not missed.

5.1.7 Policy Implications

- Policies modifying the built environment to encourage health outcomes need to be embedded within an integrated suite of changes. It would be rare for a built environment modification on its own to result in immediate behavioural change.
- Policies to increase land use densities need to be conceptualised as policies which bring uses, and not just people, closer together. Higher densities should be pursued in the context of both the existing macro (regional) urban framework of services and infrastructure, together with the micro urban fabric of design features that make higher densities liveable.
- There is strong research to suggest that visible stairways signed by point-of-choice prompts will increase the rate of stair climbing. A policy to ensure new buildings are designed and developed with visible stairways might be a good catalyst to develop tangible policy based partnerships between health and planning.
- There is consistent evidence that infrastructure and facilities such as well maintained and connected footpaths, bike paths and open spaces will encourage physical activity. Policies to support the development and maintenance of this infrastructure should be supported. Policies to make these environments safe (and perceived as safe) from crime and traffic will also encourage physical activity.

5.1.8 Summary of Key Messages

The Policy Mix Required

Research on encouraging physical activity follows socio-ecological models of behaviour and concludes that a mix of social, economic, political and built environment policies is required to influence physical activity.

Accessibility and the Importance of Distance

Keeping trip distances short through mixed use and compact development will make active transport a more viable option, more often.

The Surrogate of Density

Higher density areas may display environments conducive to physical activity. However, increasing the residential density of the built environment alone will not necessarily encourage increased physical activity. Density, mixed use and micro-design elements *in some combination* are most likely to influence levels of physical activity.

Destinations and Mixed Uses

Destinations give people a place to walk to. Replacing uniform urban form with a variety of uses can lead to shorter distances between origins and destinations, which encourages active transport.

Street Networks

Grid street patterns decrease distances between origins and destinations. Decreased distance between commonly accessed uses encourages utilitarian physical activity.

Infrastructure and Facilities

Well maintained footpaths and bike paths encourage walking and cycling for transport, as does the provision of bike parking and other end of trip facilities. These facilities need to be provided as part of a package of policies aimed at encouraging behaviour change, for example educational programs and restrictions on motor vehicle use. Perceptions that cycling is unsafe because of traffic, and walking is unsafe because of exposure to crime, are key infrastructure related deterrents to walking and cycling for transport and recreation.

Recreational Physical Activity

People with access to good quality and safe open space are more likely to be physically active for recreation.

Rebuilding Physical Activity into Everyday Life – Incidental Movement

Stair climbing is physical activity which can easily be integrated into everyday life. Visible stairways signed by point-of-choice prompts are able to increase the rate of stair climbing.