Scoping paper:
Improving walkability to increase physical activity, and healthy and environmentally friendly lifestyles

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1. Background to topic

Over the last ten years a growing number of studies have examined the relationship between walkability and physical activity and/or BMI. In the absence of a universally agreed definition, Leslie et al. (2007) provide a useful description of walkability, conceptualising it as "the extent to which characteristics of the built environment and land use may or may not be conducive to residents in the area walking for either leisure, exercise or recreation, to access services, or to travel to work" (2007, p. 113). The three main components of walkability are generally considered to be: residential density, land use mix and street connectivity (see for example: Van Cauwenberg et al. 2011). Their impact on physical activity (PA) or BMI may be assessed individually, or aggregated with other outcomes to form a composite index such as the walkability index.

In addition to these three main components, there are a number of other elements of what is commonly termed the 'built environment' or 'physical environment', which also affect the walkability of the neighbourhood. These include: presence of footpaths/sidewalks, street lighting, amenities (benches etc.); safety (traffic and crime); access to green/open space, recreational facilities; aesthetics; population density; employment density; degree of urbanisation; neighbourhood type; and degree of urban sprawl.

Elements of the built environment which affect walkability may be measured objectively, subjectively or using a combination of the two approaches. Objective measures often use information collected from geographic information system (GIS) mapping tools, which may then be used to generate a walkability index at the neighbourhood or individual level. Alternatively, trained observers may conduct a field audit of the neighbourhoods, documenting specific aspects against a checklist (Charreire et al. 2014; Schaefer-McDaniel et al. 2010). The different measures comprising the walkability index and their individual weightings vary between studies. Measures used to assess objective walkability are listed below. The categories of 'proximity' and 'connectivity' are often used to classify measures included in walkability indices.

- Proximity
  - Density (e.g. housing unit density, retail density)
  - Land use mix
  - Commercial/retail floor area
- Connectivity
  - Street network (e.g. block size, intersection density, number of intersections)

Subjective measures are based on individuals' perceptions of their neighbourhood and are obtained through questionnaires or in-depth interviews. In most cases study participants are not asked outright if they consider their neighbourhood to be walkable. Instead, they are generally asked a

series of questions related to elements of both the built environment and the social environment. The most frequently used survey internationally is the Neighborhood Environment Walkability Scale (NEWS) (Van Cauwenberg et al. 2011).

Similarly, PA and BMI can be measured objectively (e.g. accelerometers to measure PA, or clinical measurements of height and weight) or subjectively (through self-reporting). Much of the literature also differentiates between two main types of walking. Utilitarian walking, or walking for transport, characterises walking done to access services, workplaces, public transport, and shopping etc. In contrast, walking itself is the purpose when it is done for recreation or leisure. It is important to distinguish between these different domains of PA to avoid obscuring evidence of relationships when results are aggregated (Van Cauwenberg et al. 2011). This, however, can only be done through self-reporting of PA which raises problems of validity (Van Cauwenberg et al. 2011). For example, the percentage of significant associations between objective measures of neighbourhood environment and PA in children was found to be higher when PA was assessed subjectively (66%) than objectively (33%) (Ding & Gebel 2012).

As noted previously, there are numerous elements of the built environment that affect the walkability of a neighbourhood. However, for the purposes of this scoping paper, it was necessary to limit the number of measures included. The focus of this scoping paper is on the impact of the built environment on utilitarian walking (walking for transportation through which individuals have the potential to meet daily PA requirements as part of their everyday routine). Therefore, elements that are more commonly associated with recreational walking (e.g. neighbourhood aesthetics and parks) have been excluded. In addition elements which are partly covered by other measures (e.g. traffic safety is partly covered by the measure on sidewalks), as well as aspects of walkability covered by other scoping papers related to active transport have also been excluded.

This scoping paper will focus on the following elements in urban settings:

- Footpaths/sidewalks/trails/pathways
- Street connectivity
- Land use mix
- Population/residential density
- Walkability/pedestrian indices

2. Intended policy impact

It is expected that modifications to elements of the built environment affecting both objective and subjective measurements of how walkable a neighbourhood is will lead to increases in PA. Changes in BMI are unlikely to be significant in the short-term but may have an impact over the longer term. In addition, it is expected that there will be positive impacts on social capital, mental health and safety; and reduce carbon emissions, crime, and traffic-related pedestrian injuries (Hunter et al. 2015; McCormack & Shiell 2011). Furthermore, interventions to improve the built environment are likely to be sustainable in the long term (Mayne, Auchincloss & Michael 2015; McCormack & Shiell 2011).

3. Current policy status

a. Australia

Overview

Due to Australia's federal system, responsibilities for urban planning and design are split between the three levels of government: federal; state or territory; and local. State/territory and local governments have the main responsibility for urban planning and statutory land use planning development approvals, with the Australian Constitution giving principal responsibility for planning and managing cities to state and territory governments (Department of Infrastructure and Transport 2011). However, the federal government has recently become more involved through its infrastructure program and urban policy development (Dodson 2013).

There is evidence of general support across all levels of government as well as among relevant NGOs and industry bodies, for changes to the built environment that will support increases in active transportation. Increasing active transport is promoted for a range of reasons and includes: cost savings; improvements to health (including obesity) and wellbeing of residents and liveability of neighbourhoods and cities; increases in PA; environmental benefits (e.g. decreases in pollution); and supporting equity by providing better access to services. Neighbourhood characteristics which are commonly recognised as being conducive to active transport include: presence of footpaths; availability of destinations/land use mix; street connectivity; increases in density, especially around public transit hubs and along routes; safety; and availability of public transport.

No enforceable regulations regarding elements of the built environment that facilitate walking for transportation were identified. However, there are a number of policies, guidelines and resources across all levels of government that recognise the linkages between the built environment and health and the importance of encouraging and enabling active transportation. Some of these are briefly outlined here and in Appendix 1. Additional guidelines for both the Australian and international contexts can be found here: urbandesign.org.au/protocolframework/principles/walkable.aspx.

Of the current projects being implemented, most of these relate to increasing/improving physical infrastructure for walking and cycling, such as Brisbane's *Active Communities* program. There is anecdotal evidence that density in Australia's major cities is increasing, however, the specific reasons for this occurring and the effects that this is already having on PA does not yet appear to have been evaluated. One of the reasons for this is that many changes to the built environment, with the exception of specific infrastructure for walking and cycling, is likely to occur gradually over time, rather than arise as the result of specific projects.

Collaborative

The first report of the Moving People 2030 Taskforce details a whole of system approach to the issue of transport in Australia (Moving People 2030 Taskforce 2013). Active transport is a key focus of the report, with the taskforce acknowledging the benefits accruing through savings to the economy, improvements in liveability, enhancement of health, and protection of the environment. Specifically, the role of urban density and land use mix in determining travel behaviours and transport outcomes are recognised.

Healthy Spaces & Places is another collaborative project, this time between the Australian Local Government Association, the National Heart Foundation of Australia and the Planning Institute of Australia (*Healthy Spaces & Places* n.d.). Initial funding was provided by the Department of Health

and Ageing. The resource provides various groups (e.g. developers, health advocates and local councillors) with information on how to make cities that encourage PA and active transportation in order to improve health and wellbeing. Land use mix, mixed density and connectivity are considered essential elements of a healthy place. Higher density along public transport routes and near activity centres is advocated. This tool is referred to and recommended by a number of other reports, such as The State of Victoria's *Plan Melbourne: Metropolitan Planning Strategy* (2014).

Federal

In 2011 the federal Department of Infrastructure and Transport published a national urban policy document *Our Cities, Our Future* (Department of Infrastructure and Transport 2011). The purpose of the policy is to improve the productivity, sustainability and liveability of Australia's cities and investing in active and public transport is recognised as important for all three goals. For productivity and liveability, increasing density along transport corridors, interchanges, as well as transport and activity centres is noted as a priority (Department of Infrastructure and Transport 2011). Support for improving the walking environment features heavily in the section on liveability. For example, the policy announced a new funding program, the *Liveable Cities Program*, which among other things will provide support to projects which incorporate walking and cycling infrastructure to enhance local networks (Department of Infrastructure and Transport 2011). The document also notes the correlation between low quality environments and poor public health outcomes including obesity. Furthermore, it notes that while health promotion campaigns aim to increase PA, many residential environments are car dominated and not conducive to recreational or transportation walking (Department of Infrastructure and Transport 2011). Pollution, greenhouse gas emissions, traffic congestion, road safety and sedentary lifestyles are all noted as negative consequences of increases in car usage. Reductions in traffic congestion, improvements to public health and obesity prevention, and a reduction in energy use and greenhouse gas emissions are noted as benefits from active transport, which is a priority area of the document.

The 2013 ministerial statement *Walking, Riding and Access to Public Transport* acknowledges the wide range of benefits, including public health, of active transport, and details the actions the Australian Government will undertake to increase the proportion of people travelling in this way (Department of Infrastructure and Transport 2013). According to the statement, "incorporating exercise into travel has been identified as a highly effective means to increase daily physical activity, which can help individuals to maintain better health" (Department of Infrastructure and Transport 2013, p. 9). Actions to increase active transport have been grouped under four key principles: plan, build, encourage and govern, which acknowledge the importance of connectivity, convenience, safety and creating awareness of active transport options. The statement proposes that active transportation could be increased by focussing on 20-minute catchments (two kilometres walking and five kilometres riding) around major activity centres, for example through investing in construction and safety of paths in these areas. The importance of providing good pedestrian and bike access to public transportation is acknowledged, and it is even considered to be more cost-effective than investing in park+ride and kiss+ride facilities.

State

Sydney's Walking Future outlines a number of strategies designed to specifically increase walking for transport for trips under 2km (Transport for NSW 2013). The report notes that people who live in Sydney's inner suburbs spend on average more time walking than residents of outer suburbs, and attribute this to higher population density which promotes walkable environments. The document recognises that land use, street connections and mix of public transport options available

need to be considered together. One element of the policy is to invest in connecting walking routes within two kilometres of activity centres and public transport interchanges. For example, the $306m Wynard Walk to connect Wynard Station to Sydney Harbour is currently under progress. Similarly, Brisbane City Council's *Active Communities* program focusses on providing accessible walking and cycling routes to key locations (Brisbane City Council 2014).

The State of Victoria's metropolitan strategy for Melbourne was released in 2014. Nine strategic principles underlie the plan, one of which is "Living locally – a '20-minute' city" (State of Victoria 2014). The basic premise of this is that people should have access to a range of services, jobs and amenities within a 20-minute trip. Already commercial and residential zoning are being reformed, and the plan undertakes to make neighbourhoods more pedestrian friendly as well as locate the majority of new residences within walking distance of public transport. (State of Victoria 2014). Three new residential zones have been introduced by the State Government and in 2014 municipalities were required to designate which areas should have their neighbourhood character protected, and which areas should allow for moderate and increased growth and density. All municipalities have been required to designate at least part of their residential zones as growth zones (City of Yarra n.d.). While much of the focus of fostering the development of 20-minute neighbourhoods is on building economically vibrant and inclusive communities, the health benefits are also acknowledged. Specifically, the importance of connectivity, mixed-use and density are noted as some of the key built environment elements that can promote PA. The report notes that tools being developed by the National Heart Foundation to help LGAs plan for better health will be useful in assessing planning approvals and the design of new neighbourhoods

In 1998 a trial of *Liveable Neighbourhoods* was introduced by the Western Australian Government (Western Australian Planning Commission & Department for Planning and Infrastructure 2009). It was subsequently adopted by the Western Australian Planning Commission (WAPC) as operational policy. This approach promotes interconnected street systems, street layout based on a walkability analysis; mixed-use, increases in density around public transport stops and activity centres, and pedestrian safety considerations among others. The impact of the policy on active transport behaviours of residents moving into new developments which had been deemed "liveable" by the Department of Planning, as compared with those moving into "conventional" and "hybrid" developments has been compared as part of the RESIDential Environments project (RESIDE), which commenced in 2003 (Hooper, Giles-Corti & Knuiman 2014). As part of this project, an evaluation of the Liveable Neighbourhoods Community Design Guidelines (LNG) was undertaken in 2014 (Hooper, Giles-Corti & Knuiman 2014), which found that none of the 19 "liveable" developments had implemented all of the requirements of the policy. However, they did find evidence to support a dose-response relationship between overall levels of policy compliance and walking behaviour. The WA Government was very receptive of the findings of the evaluation and has tasked the project team with developing 10 Key Performance Indicators (KPIs) as well as advice on which elements of the guidelines should be compulsory (Giles-Corti 2015).

Local[1]

While walking is now frequently incorporated into transport policies, some councils, such as the City of Yarra, have adopted specific walking strategies. In their 2005 strategy, the City of Yarra sets a policy basis for undertaking actions to increase walking in their jurisdiction (City of Yarra 2005).

[1] A more thorough search of local government websites is required to identify current projects.

b. International

Internationally, the strong linkages between the built environment and population health, particularly with respect to active transportation, have also gained increasing recognition in recent years. However, again, there are more policy visions than actual examples of implemented projects, most likely due to the difficulty in having specific, time-limited interventions for other than changing pedestrian/cycling infrastructure. A few examples will be briefly described here (see also Appendix 1).

In 2006 an International Charter for Walking was developed out of the international Walk21 conference series. The charter lists community rights with respect to the design of their neighbourhood and lists specific actions which can help these be achieved, for example, providing connected, functional and safe walking routes (Walk21 2006). A number of city councils internationally have used this charter as a base from which to develop their own walking policy, for example, the Wellington City Council in New Zealand (Wellington City Council 2008). The New Zealand Government has also recognised the importance of walking in its 2006 Transport Strategy and its *National Walking and Cycling Strategy: Getting there – on foot; by cycle* (Wellington City Council 2008).

The City of Portland is currently implementing the 20-minute neighbourhood as part of the *Portland Plan.* The 20-minute neighbourhood was already included in the city's Climate Action Plan, which aimed for 90% of residents to be able to walk or cycle to meet all basic daily non-work needs by 2030 (City of Portland n.d.)

4. Evidence of efficacy/effectiveness

a. Overview of evidence

In the literature, a number of studies are concerned with the specific relationship between walkability and physical activity and/or BMI. However, it is more common for walkability to be considered as one element of a study related to the built environment more broadly. This is particularly true for systematic reviews that examine this relationship. In order to reduce confusion, for the remainder of the paper the term, 'measures of walkability' will be used where authors have referred to a number of built environment variables at once, and 'walkability index' will be used to refer to composite measures. It is important to note that composition of walkability indices typically vary across studies but systematic reviews rarely comment on differences in results between different types of indices. Description of the index used will only be included where results from studies have been listed for use in modelling.

The evidence presented here comes predominantly from systematic reviews published from 2011 onwards. Where more detailed information was required, the original papers were also sourced[2]. In addition, important studies undertaken but not included in the reviews (for example papers relating to the Residential Environment Study (RESIDE) in Western Australia), studies recommended by experts in the field, and papers referred to by policies and guidelines listed in the previous section that provide useful data, were also included.

Randomised control trials are considered the gold standard in Evidenced Based Medicine, however, when considering the built environment, it is all but impossible to undertake such a study. The best evidence in this field therefore comes from 'natural' or 'quasi' experiments – where data is collected from residents of a certain neighbourhood before and after a modification or addition is made to the built environment, or where another neighbourhood unexposed to the change is used as a control.

[2] Due to time constraints it was not possible to locate all the papers to which the systematic reviews referred.

Longitudinal studies that follow participants who move neighbourhoods also offer promising results. Natural or quasi-experiments examining the association between PA and modifications to the built environment were found to have greater positive associations, the longer the follow-up time (Mayne, Auchincloss & Michael 2015). Hunter et al. (2015) also noted the need for follow-up at a minimum of 12 months post intervention (to allow for novelty to wear off) and recommended longer term follow ups, especially for major interventions.

The vast majority of evidence, however, come from cross-sectional studies. While there are a number of limitations with studies of this nature, strong study designs, particularly those that adjust for neighbourhood self-selection, provide important evidence regarding the association between the built environment and PA and/or BMI. Due to the limitations of the evidence, this section of the paper is therefore exploratory in nature. Rather than focussing on evidence from interventions, the paper seeks to identify positive associations between the built environment and PA or BMI and use this to inform the design of a new intervention suitable for economic modelling.

Grasser et al. (2013) conducted a systematic review investigating the association between different GIS-based measures of walkability and its individual components (density, land use mix, connectivity), and active transport and measures of weight in adults. They found that population density, intersection density and walkability indices were most consistently correlated with active transport (Grasser et al. 2013, p. 615). This is consistent with other studies which found that overall, measures of the physical environment were more frequently associated with transportation PA than recreational PA (Van Holle et al. 2012; McCormack & Shiell 2011). As the concept of walkability was developed in the field of transportation planning (Grasser et al. 2013), it is therefore unsurprising that stronger associations are found with transport-related PA than recreational PA.

In their review, Durand et al. (2011) mapped environmental features onto the ten principles of smart growth, as defined by the Smart Growth Network. A range of measures were mapped onto principle three - 'create walkable neighbourhoods' - however, the only one which was specified was sidewalk availability. The authors(2011) found 80% (n=28) of studies showed no significant association between studies which assessed a walkable neighbourhood measure against PA levels. 17% (n=6) of studies found results in the expected direction and 1 study found results in the opposite direction. When examining the relationship specifically to walking, 50% (n=30) were non-significant, 47% (n=28) were expected and two were in the unexpected direction.

Limiting their review to studies examining the relationship between the built environment and PA in adults aged 65 or older, Van Cauwenberg et al (2011) found a number of positive associations. Although these were inconsistent and mostly non-significant, the authors suggest that this may result from methodological flaws, rather than the absence of a relationship between built environment and PA in older adults. In particular, the high prevalence of non-significant relationships may be due to the focus of most studies on total physical activity, rather than on specific domains (Van Cauwenberg et al. 2011).

In order to strengthen the evidence regarding the relationship between the built environment and PA, McCormack and Shiell (2011) conducted a review of studies which addressed the issue of neighbourhood self-selection. Neighbourhood self-selection is thought to be a major confounding factor, as it is believed that people who prefer walking are more likely to choose to live in neighbourhoods that are conducive to walking. While associations between the built environment and PA were more mixed after taking into account neighbourhood self-selection, consistent positive

associations with PA were found with land-use mix and composite walkability indices (McCormack & Shiell 2011). The quasi-experimental studies also provided some evidence that changes to the built environment precede changes in levels of PA. However, results were inconsistent and a number of methodological flaws remained. In a subsequent systematic review by Grasser et al. (2013) a total of 16 papers explored the relationship between objective measures of walkability and walking for transport. The authors noted that self-selection was not accounted for by all studies, however, where it was, the association with walking for transport remained significant, albeit sometimes moderated. This is consistent with results from the West Australian RESIDE project, which found that associations persisted after adjusting for self-selection (Hooper, Giles-Corti & Knuiman 2014).

Although the CRE is focussed on obesity, relatively few studies examined the relationship between body mass (or composite indicators such as BMI) and elements of the built environment. Durand et al. (2011) contend that a reason for this is that body mass is the furthest downstream measurement and therefore more likely to be affected by a range of other factors (such as eating habits), thus making it an imperfect measure in cross-sectional studies. Indeed, in their review, Mackenbach et al. (2014) found no consistent associations between physical environmental factors and weight status. This finding is supported in the reviews by Grasser et al. (2013), and by Ferdinand et al. (2012) who found that where body weight or BMI was used as the outcome variable, studies were less likely to find a relationship to the built environment than studies using PA. There are likely to be several reasons that explain why weight-related measures are inconsistently and infrequently related to built environment measures of walkability. These include: the longer follow-up time required to find measurable changes in weight; cross-sectional design of most studies making it difficult to infer causality; substitution of a more vigorous form of PA to walking; confounding factors (e.g. self-selection); changes in eating habits; and methods of data collection.

Footpath/Sidewalk/Trail/Pathway[3]

Mayne et al. (2015) found that improvements to paths/trails were generally positively associated with increases in PA in three studies, however, one study found no significant association. Hunter et al. (2015) found mixed results across 2 studies which assessed the impact of building a pathway/trail alone (other built environment interventions were a combination of building pathways and making other improvements to urban green spaces and were not considered in this paper). In one study where a 2.9mile greenway/trail was retrofitted at a cost of $2.1m, intervention changes between experimental and control groups were significant for total PA (p=0.001), walking (p=0.001) and cycling (p=0.038). Another study which developed 5miles of greenway, found no significant difference between intervention and control groups. However, an overall increase in walking and PA in both groups was found. It appears likely that in this instance, differences in study design and measurement of variables (e.g. objective vs. subjective measurement of PA) may account for differences between studies rather than differences in the specific design of the trail.

Scheepers et al. (2014) also found mixed results across two studies. One study found a negative association between building a neighbourhood trail and PA. Approximately five months after the intervention, walking had decreased from 13.7% to 9.9% and there was almost no change in bicycle use. This was the only intervention included in their review that had a negative effect on mode shift to active transport. A lack of signage and public information may help explain poor uptake (Scheepers et al. 2014). The authors of the study also note that the length of the trail may not have

[3] It should be noted that trails and pathways are sometimes implemented for specifically recreational/leisure purposes. However, depending on location and design, they may also provide important improvements in accessibility and have therefore been included in this section.

been significant (only a 1 mile segment of an existing network), there may have been a lack of 'destinations', and lack of other amenities (Burbidge & Goulias 2009). The authors caution that simply installing a trail is not enough, it must be carefully designed and incorporated into overall community design (Burbidge & Goulias 2009). McCormack and Shiell (2011, p. 7) support this position, stating that "whether or not pedestrian and cyclist infrastructure lead to increases in physical activity behaviour might depend on the type of attributes and the extent of the environmental modification undertaken and the type of physical activity behaviour evaluated".

Oliveira et al (2014) found evidence of a strong association between sidewalks and PA in children. In most of the studies included, built environment elements and PA levels were measured subjectively. In a review of qualitative studies regarding the relationship between the physical environment and PA in older people, Moran et al. (2014) found that sidewalk presence and continuity were preferred by older adults, especially those which were separated from other modes of un-motorised transport (bicycles, rollerblades, skateboards etc.). McCormack and Shiell (2011) identified one study which found a positive relationship between sidewalks on both sides and non-work trips by walking/biking. However, after adjusting for neighbourhood selection, this was no longer found to be significant. In support of the hypothesis that providing pedestrian infrastructure will result in some people switching from car use to active transport, Scheepers et al (2014) identified one study that found 21.5% of users of new sidewalks had switched from being single occupant vehicle users to pedestrians.

In a Western Australian study, which was part of the RESIDE project, the association between sidewalk availability and both walking for transportation and walking for recreation was examined (McCormack et al. 2012). After controlling for self-selection, the study found that sidewalk length was associated with a 2.97 percentage point increase in the probability of participation in walking for transportation. For each 10km increase in sidewalk length, it was also found that walking for transportation increased by 5.38 min/week and overall neighbourhood-based walking increased by 5.26 min/week, but no association was found with minutes of walking for recreation.

Another Western Australian study investigated the cost-effectiveness of installing sidewalks to increase levels of transport-related walking (Gunn et al. 2014). The presence of sidewalks on either one or both sides of the street were found to be positively associated with transport-related walking at the thresholds of 60 min/week and 150 min/week. The minimum intervention, which involved making sure each street had one sidewalk, was found to be the most cost-effective, with an average cost-effectiveness ratio of $2330/person for the threshold of 150 min/week and $674/person for the threshold of 60min/week. However, population density was found to be a key driver of the cost-effectiveness of the intervention, with cost-effectiveness increasing substantially when population density was increased by 50%.

Street Connectivity

Grasser et al. (2013) found four papers (based on three studies) which demonstrated a positive association between intersection density and walking for transportation. Similarly, McCormack and Shiell (2011) identified three studies which found positive associations between connectivity and PA. However, in a quasi-experimental study a negative association in women was found.

For children, Oliveira et al (2014) found four studies which reported positive associations between street connectivity or street density with PA. In contrast, the review by Ding et al. (2011) found inconsistent results. When street connectivity and PA were measured subjectively, only 55%

of studies found positive associations with children and no consistent association was found for adolescents. Of studies examining the association between objectively measured street connectivity and reported PA, 48% found positive relationships in adolescents (Ding et al. 2011). In the case of older adults, the review by Van Cauwenberg et al. (2011) found mixed results regarding objectively measured street connectivity and PA. One study found a positive relationship to total walking when street connectivity was measured at the neighbourhood level. However, when it was measured at the resident level (800m buffer radii) no effect was found by the same study and one other.

Grasser et al. (2013) identified three studies which examined the relationship between intersection density and weight related measures, however mixed results were found. Similarly, the three publications assessing the impact of the number of intersections, also found mixed results.

Land use mix

Land use mix was one of two environmental measures found by Mackenbach et al. (2014) to be consistently and significantly associated with BMI or overweight status. In all five North American studies, reduced land use mix was related to more obesity, while a UK based study found no significant association. Giles-Corti et al (2012) also found evidence of a strong positive association between land use mix and walking for transportation. Similarly, McCormack and Shiell (2011) found five studies which found positive relationships between land use mix and PA. Only one found a negative relationship after it adjusted for preferences. In a RESIDE study, an increase of 6.1min/week of walking for transportation was found for each additional type of transport-related destination gained after relocation (Giles-Corti et al. 2013).[4] This attenuated to 5.8min/week after adjusting for self-selection.

Grasser et al. (2013) found mixed results in their review, with two studies finding a positive association with walking for transportation and two studies finding no significant association. The review by Durand et al. (2011) also found no evidence of a consistent association. The effect of land use mix on total PA was found to have no effect in 87% (n=26) of the studies, an effect in the expected direction in 10% (n=3) of papers and an effect in the unexpected direction in 1 study. Where walking was the outcome measure, 52% (n=32) were in the expected direction, 47% (n=29) were non-significant and one was in the unexpected direction.

In older people, having access to a variety of destinations such as general shops, libraries, mailboxes and senior centres among others were noted as stimulating their walking (Moran et al. 2014). In children a positive association was found between objectively measured land use mix and reported measures of transport related PA or walking in 66% of the studies identified in the review by Ding et al. (2011). The results for adolescents were similar, with 63% of studies finding a positive association (Ding et al. 2011).

In regard to weight related outcomes, Grasser et al (2013) identified four studies that used the entropy index[5], with two finding significant negative associations, while the other two had mixed results. Only a small number of studies identified in the review by Durand et al. (2011) had examined the effect on body mass, and 80% (n=8) of these found no effect, with one study found for each of expected and unexpected results.

[4] Seven transport related destinations: post offices, bus stops, delicatessens, supermarkets within 800m of participant's home; train stations, shopping centres or CD/DVD stores within 1.6km (Giles-Corti et al. 2013).

[5] The variety of different uses in a neighbourhood (Litman 2015)

Population/residential density

In their systematic review, Grasser et al. (2013) found three papers which reported on the Twin City Walking Study and found a positive association between gross population density and walking. Some minor associations were also found between housing unit density and walking for transport, in the same study, but results had not been adjusted for cofounders (Grasser et al. 2013). In the SMARTRAQ study, housing unit density was found to be the strongest predictor of walking for transport (Grasser et al. 2013). McCormack and Shiell (2011) found two studies, one cross-sectional and one quasi-experimental, which showed a positive relationship between population density and walking.

In a review commissioned by the National Heart Foundation of Australia, the authors examined the impact of density on health (Giles-Corti, Ryan & Foster 2012). They found strong evidence to support the association between higher residential density (and associated higher land use mix) and increased transport-related walking. However, as the authors recognise, density per se is unlikely to be important for influencing transport-related walking. Rather, density supports land use mix as the economic viability of local businesses is dependent on sufficient residential density (Giles-Corti et al. 2013; Giles-Corti, Ryan & Foster 2012).

When residential density and PA were measured objectively, inconsistent associations were found for children, with only 44% of studies finding a positive association (Ding et al. 2011). However, when PA was reported, 68% of studies found a positive association with transport related PA or walking (Ding et al. 2011). In adolescents, the evidence was even stronger, with 80% finding a positive association (Ding et al. 2011). Inconsistent associations were also found when both residential density and PA were measured subjectively, with only 43% finding positive associations in children. This clearly demonstrates how differences in measurement of variables can affect study findings.

In regard to weight related measures, two studies found significant negative associations between gross population density and weight-related measures, but a third only found evidence of this in men (Grasser et al. 2013). One study found housing unit density was negatively associated with BMI, but a second study only found evidence of this association in men (Grasser et al. 2013).

Walkability/pedestrian indices

Mackenback et al. (2014) identified 19 studies which examined the relationship between walkability and overweight or obesity. The only study of these to be based in Europe found no association, although there was an association to different domains of PA. Of the other studies, which were all undertaken in North America, 8 found associations between higher walkability and reduced BMI or obesity, three did not find statistically significant associations, and five found inconsistent results. Grasser et al. (2013) also found inconsistent results in their review.

In their systematic review of European studies, Van Holle et al. (2012) also found walkability to have some of the most convincing evidence of a relationship to total PA and walking for transportation out of a number of physical environment measures. Similarly, In their recent systematic review on the relationship between objective measures of the built environment and childhood obesity, Casey et al. (2014) found that of objective spatial measurements of the built environment, walkability neighbourhood indices had a significant association with weight status most often. All four studies identified by McCormack and Shiell (2011) examining the relationship between a walkability or pedestrian index and PA, found positive associations. However, one of these studies showed that

irrespective of whether they lived in a high or low walkable neighbourhood, those who preferred less walkable neighbourhoods were less likely to walk for any purpose (McCormack & Shiell 2011). Two of these studies only found positive associations with transport-related walking, but not recreational walking. Grasser et al. (2013) found a correlation between walkability indices and walking for transportation in four papers using data from three studies. Two studies showed a positive association to weekly minutes of walking. The third study showed no association to weekly minutes of walking, but found that 4.2% of the variance in the frequency of walking for transportation could be explained by the walkability index.

In their evaluation of Western Australia's LNG, the RESIDE project team found that every 10% increase in overall compliance resulted in an increase in the odds of participants doing any walking for transport by a factor of 1.53 (p=0.007) (Hooper, Giles-Corti & Knuiman 2014). The odds of doing any walking for transport increased by a factor of 2.48 (p=.003) for every 10% increase in compliance with the movement network element of the guidelines, which includes street connectivity measures. In another RESIDE study, each unit increase in the walkability index was associated with a 2.16 percentage point increase in walking for transportation, but not with walking for recreation.

Impact on industry

Increasing land use mix has been included in a number of policies and guidelines as a way to create thriving neighbourhood economies. Improvements to the walking environment has also been found to have a positive economic impact in a number of studies (Sinnett et al. 2011). However, local retailers frequently underestimate the importance of pedestrian activity, many believing that more of their customers come from further afield and travel by car than is actually the case (Sinnett et al. 2011). A negative impact may be felt by shopping centres and other shopping areas which are designed to be accessed by car.

Government revenue from tax on motor vehicle fuel is expected to decrease as people switch from motorised to active transport. However, if money saved on fuel is spent, rather than saved, states may only experience a small change in GST collected (Ker et al. 2011).

Some suggestion has been made that increases in active transportation will lead to productivity increases. These are mainly expected to stem from improvements to health as well as reduced road congestion.

b. Potential to use evidence as the basis for an intervention

McCormack and Shiell (2011) have noted the lack of evaluations in the literature regarding built environment interventions and their effect on PA. In particular they draw attention to the lack of evaluations concerning changes to elements of the built environment that are most consistently related to levels of walking (e.g. pedestrian connectivity, population density, and land use mix). In their opinion there is also "a dearth of data on the economic cost of improving neighbourhood walkability…and the potential subsequent health care savings resulting from improvements in health" (McCormack & Shiell 2011). Consideration will therefore need to be given to sourcing cost estimates for built environment interventions that can be used in the modelling.

The systematic reviews discussed in the previous sections provide valuable evidence of the existence of relationships between various elements of the built environment and PA. As the majority of these studies do not provide quantitative data at either the individual or aggregate level,

original studies will be reviewed to quantify the relationship between different aspects of the built environment and PA levels which can then be used in the modelling.

When examining the evidence and considering possible interventions, it is necessary to take a number of issues into consideration.

i. There is likely to be difference between urban and rural settings. Studies focussed purely on rural settings were, however, not included in this paper.
ii. Need to be careful whether total PA is increasing or whether people are substituting walking/biking for another form of PA.
iii. Regarding the marginal health benefit per kilometre of active travel a range of factors will need to be taken into account including: current PA levels of individual, whether the activity is undertaken at a sufficiently strenuous level and the frequency of the activity (Department of Transport and Main Roads QLD 2011).
iv. It is important to acknowledge the range of factors which may act as moderators of the relationship between the built environment and levels of PA (Mackenbach et al. 2014). This may include people's preferences regarding type of neighbourhood as well as a general preference for being physically active. Oliveira et al. (2014) and Ferdinand et al. (2012) found evidence of parents' safety perceptions to be a moderator of the relationship between the built environment and child PA and obesity risk. Similarly, (Moran et al. 2014) found that sidewalk characteristics (e.g. quality, maintenance, gradient, obstacles) act as moderators on PA levels in older people. Qualitative studies are useful in this regard, as they are able to provide possible explanation as to why presence of a particular built environment element (e.g. sidewalk) may not consistently explain PA behaviour unless quality aspects are also taken into account (Moran et al. 2014).
v. Given that outdoor PA is being measured, weather conditions have the potential to affect results. There has been some evidence of weather conditions affecting PA levels in children (Oliveira et al. 2014) and older adults (Moran et al. 2014).
vi. Results may differ depending on whether the environmental variable is measured objectively or subjectively. In particular, it seems that more research is required to better understand the relationship to PA when perceptions of walkability are lower than objective measures (Ding & Gebel 2012). Casey et al. (2014) suggest that combining objective GIS measures with subjective measures of walkability may assist with better understanding of the relationship between the built environment and obesity. Durand et al. (2011) found it difficult to determine whether objective or perceived measures of the environment were more important determinants of PA or body mass. If the latter, they note that education or marketing campaigns are likely to be important interventions in order to make residents aware of the resources available to them. On the other hand, if objective measures are more important, then modifications to the built environment would be necessary. In reality, they believe that a combination of the two approaches is likely to be required. One RESIDE study found that perceived and objective neighbourhood attributes were independently related to walking (Giles-Corti et al. 2013). The authors argued that this suggested that if changes to the built environment are also perceived as being favourable changes, then the impact on walking will be greater.
vii. Elements of the built environment may exhibit different relationships with PA depending on the broader context. For example, it appears that in the European context neighbourhood aesthetics, traffic- and crime-related safety are not important for PA (Van Holle et al. 2012). A number of systematic reviews question the applicability of findings, which are generally

dominated by studies in the USA, to other contexts (Van Cauwenberg et al. 2011; Gomez et al. 2015; Grasser et al. 2013)

viii. Scheepers et al. (2014) argue that depending on the type of change made to the environment, a combination of intervention tools may be necessary. For example, a public information campaign may need to accompany the opening of a new neighbourhood trail. Indeed, they found that generally a combination of intervention tools (physical, economic, legal, communicative) was more effective than single tools (Scheepers et al. 2014). The present paper excluded such interventions in the interest of simplicity, however, this is something which should be taken into consideration when modelling interventions.

ix. Differences, or lack of information provided, regarding the definition of the neighbourhood also makes it difficult to compare results across studies. As noted by Casey et al. (2014), there are a range of parameters required for calculating geographic accessibility, including neighbourhood definition and type of distance considered, both of which have a number of ways to measure them. In particular, there are numerous difficulties associated with defining the appropriate size and shape of the neighbourhood under consideration (Casey et al. 2014). The literature and/or expert opinion should be sought prior to modelling this intervention and the limitations of whatever method is chose should be taken into consideration.

x. Care needs to be taken when deciding on the level of density in order that benefits to health outweigh potential harm (Giles-Corti, Ryan & Foster 2012). Higher density developments need to be well planned and buildings well designed. In particular, consideration needs to be given to safety concerns, opportunity for social interactions, and exposure to pollution. For modelling, it might be necessary to assume that this is the case.

xi. Socio-economic status should also be considered as a potential confounder or mediator (Casey et al. 2014), however it is not consistently taken into account by studies.

xii. Benefits may take time to accrue and reduce costs on health system. For example, changes in BMI resulting from increases in PA are unlikely to occur immediately and will depend on previous levels of PA. A 2011 Queensland report recommends using an accrual period of five years for health benefits (Ker et al. 2011).

xiii. It is possible that health benefits may also accrue from a reduction in sedentary behaviour which are independent of effects of PA. This, however, was not considered by the scoping paper.

Furthermore, it is important to note that systematic reviews have identified a number of limitations with the available evidence. As previously noted, there has been a reliance on cross-sectional studies in this field. This makes it difficult to assess causality (Ferdinand et al. 2012; Giles-Corti, Ryan & Foster 2012; Grasser et al. 2013), particularly with regard to neighbourhood self-selection (Ding & Gebel 2012). Even when natural experiments are used, methodological issues remain (Mayne, Auchincloss & Michael 2015). These include only having a comparison group post intervention and short follow-up period (Mayne, Auchincloss & Michael 2015).

Another major problem is the lack of homogeneity between studies, making comparison across studies impossible (Casey et al. 2014; Gomez et al. 2015). In particular there are vast differences in choosing, defining and measuring variables (Van Cauwenberg et al. 2011; Hunter et al. 2015; Mackenbach et al. 2014; McCormack & Shiell 2011; Scheepers et al. 2014), especially environmental variables such as neighbourhood size . Furthermore, few studies provide information concerning the validity/reliability of measures (Mackenbach et al. 2014). While neighbourhood self-selection has been identified as a potential cofounder, and found to attenuate the relationship between measures of the built environment and PA (McCormack & Shiell 2011), it has not been consistently taken into account by studies (Casey et al. 2014; Grasser et al. 2013). In addition,

studies rarely provide rationale for sample size calculations (Hunter et al. 2015) and not all studies differentiate between different types of PA (Moran et al. 2014).

Evidence of exposure – active transportation

Measuring time spent on active travel is very difficult. Estimates of total time spent on active transportation are likely to come from individual studies using self-reported data. The ABS collects data on modal split for journey to work, however, it does not capture walking done as part of another travel mode which is likely to be significant (GTA Consultants 2011). In its analysis of the Victorian Survey of Travel and Activity (VISTA) 2007-08, BusVic found that users of public transport on a particular day spent on average 41 minutes walking and/or cycling per day, thus meeting daily PA requirements (BusVic 2010). Consideration will therefore need to be given to variations in proximity to public transport stops for residents within intervention neighbourhoods.

In Australia's capital cities, around 3.8 per cent of journeys to work are completed by walking only, however, this varies between cities (Department of Infrastructure and Transport 2011). Distance between home and work has been found to be the single major factor in influencing commuter behaviour in Australia's capital cities (Department of Infrastructure and Transport 2011). Of those who live within five kilometres of their workplace, 18.7 per cent walk and 3.5 per cent cycle (Department of Infrastructure and Transport 2011). While increases in land use mix will likely provide some people with job opportunities closer to home, many people are likely to continue to commute to work by car.

The importance of having a range of destinations within walking distance is widely recognised. Ideally destinations should be within 400m but distances of up to 1.6km are also able to be walked. In Melbourne 75% of trips below 400m are walked (Victoria Walks Inc. 2015). In the local government areas (LGAs) of Melbourne City and Yarra, 70% of trips under 2km are walked, while for outer suburbs this drops to 25% (Plan for a walkable Melbourne: Victoria Walks submission to Metropolitan Planning Strategy. 2013). Data for NSW also shows that walking for travel is more common in denser, inner urban areas (GTA Consultants 2011). In line with this, the Moving People 2030 Taskforce argues that walking for trips less than 2km are the most cost-effective options for individuals (Moving People 2030 Taskforce 2013).

Variable	Study	Results for use in modelling
Avg. number of minutes/week of active transportation		Total Work/Education
Avg. number of times/week of active transportation		
Avg. number of minutes of active transport associated with using public transport	(BusVic 2010)	41 minutes/day
Avg. number of times per week taking public transport		
Avg. walking/cycling speed	(Giles-Corti, Ryan & Foster 2012)	4.8km/hour 12.9 km/hour
Time willing to spend to travel to public transport using active transport	(Department of Infrastructure and Transport 2013)	10 minutes walking or riding Approximate equates to 800m walking or 2-3km riding.

Footpath/sidewalk/trail/pathway

Variable	Study	Results for use in modelling
2-hour counts of directly observed PA in the neighbourhood	(Fitzhugh, Bassett Jr. & Evans 2010)	• Pre- and post- intervention changes between intervention and control neighbourhoods were significantly different for total PA (p=0.001). walking (p=0.001) and cycling (p=0.038) • PA in the intervention neighbourhood was significantly higher (p=0.028) than in the control neighbourhoods after intervention. • Increase in PA levels in the intervention neighbourhood (p=0.000), median increase 8.0 counts.
Walking for transportation	(McCormack et al. 2012)[a]	Each 10km increase in sidewalk length associated with: • 2.97 percentage point increase in probability of walking for transportation (p <0.05), elasticity 0.224 • 5.38min/week increase in walking for transportation

[a] Refer to paper for more potentially useful figures

Street connectivity

Variable	Study	Results for use in modelling
Walking for transportation	(Li et al. 2008)	1-SD increase in intersection density associated with an increase in walking for transport by 20% and for errands by 11% in adults 50-75
Walking for transportation	(Hooper, Giles-Corti & Knuiman 2014)	10% increase in compliance with movement network element (of WA's LNGs), odds of participants doing any walking for transport within the neighbourhood increased by a factor of 2.48 (p=0.003)
BMI z-score	(Timperio et al. 2010)	Proportion of 4-way intersections within 800m of home negatively associated with change in BMI z-score among younger children (B = -0.01, 95% CI = -0.02, -0.003. p = 0.012)
Change in time spent walking for transport over two-year period	(Kamruzzaman et al. 2014)	Network connectivity (number of 3-way intersections) associated with increase in level of walking for transportation over a two-year period Coef = 0.027, t = 1.70, P>t 0.091
Walking for transportation	(Knuiman et al. 2014)	Per unit change in connectivity, odds of walking for transport increased (OR = 1.09; 95%CI: 1.03, 1.15) *See paper for different OR for different types of analysis methods

Land use mix

Variable	Study	Results for use in modelling
Walking for transportation	(Li et al. 2008)	1 unit increase in land use mix associated with 5.8 times more walking for transport ($p < 0.001$) and 1.5 times more walking for errands ($p = 0.047$) in adults 50-75
Odds of being obese	(Frank, Andresen & Schmid 2004)	Each quartile increase in land use mix associated with 12.2% reduction in the odds of being obese (OR = 0.878; CI = 0.839-0.919)
Overweight/obesity prevalence	(Li et al. 2008)	1 unit (i.e. 10%) increase in land use mix associated with 25% reduction in overweight/obesity prevalence in adults 50-75 ($p < 0.01$)
Walking for transportation	(Giles-Corti et al. 2013)	6.1 min/week (p=0.035) increase in walking for transport for each transport-related destination type that increased. 5.8min/week (p=0.045) after adjusting for self-selection
Walking for transportation	(McCormack, Giles-Corti & Bulsara 2008)	For each additional destination (utilitarian or recreational) within 400m or 1500m, an increase in transport-related walking of 11.88 and 10.91 min/fortnight.
Walking for transportation	(Knuiman et al. 2014)	Per unit change in land-use mix, odds of walking for transport increased (OR = 1.21; 95%CI: 1.12, 1.30) *See paper for different OR for different types of analysis methods

Population/residential density

Variable	Study	Results for use in modelling
Mean travel walking (MET minutes per week)	(Forsyth et al. 2009)	Greater OR of walking in high density compared with low density areas. White: OR = 1.97; 95%CI = 1.14 – 3.43; p = 0.02 Non-white: OR = 1.99; 95%CI 0.54 – 7.34; p = 0.3
Change in time spent walking for transport over two-year period	(Kamruzzaman et al. 2014)	Increasing residential density associated with increase in level of walking. Coef = 0.393, t = 2.26, P>t 0.025
Travel walking (METS)	(Oakes, Forsyth & Schmitz 2007)	Twice the odds of increased travel walking in high density compared with low density areas OR = 1.992, 95%CI = 1.296, 3.060
Walking	(Frank et al. 2008)	Those living in the highest density areas were more likely to walk (17.6%) at least once over a two-day period than those in the middle (7.3%) and lowest (4.3%) tertiles of density. Those in highest density areas also more likely to walk if the roads were also well connected and there was greater land-use mix.

Walkability/pedestrian indices

Variable	Study	Results for use in modelling
Walking for transportation (minutes)	(Van Dyck et al. 2010)	Residents of highly walkable neighbourhoods walked 80mins/week (210%) more for transport than residents of low walkable neighbourhoods (self-reported). Residents of highly walkable neighbourhoods undertook 49min/week more MVPA (accelerometer derived)
Walking for transportation (minutes)	(Sallis et al. 2009)	Respondents in highly walkable areas walked 31mins/week more than residents in low-walkable areas. Significant difference for both high- and low-income neighbourhoods, but differential was larger in high-income neighbourhoods.
BMI ≥ 25	(Sallis et al. 2009)	Odds of BMI ≥ 25 35% higher for those in low compared with high walkability neighbourhoods (p=0.007). OR=1.35, 95%CI:1.09, 1.69 Note: no significant association found for BMI ≥ 30
BMI	(Frank et al. 2006)	Walkability explained 1.4% of the variance in BMI. * This is from a different paper using data from same study (NQLS) as Sallis et al.
Active transportation (minutes)	(Frank et al. 2006)	5% increase in walkability associated with a 32.1% increase in minutes of active transportation, but only 4.7% increase in MVPA minutes.
Walking for transportation	(Owen et al. 2007)	Weekly frequency of walking for transport independently associated with neighbourhood walkability (b = 0.02, p < 0.001). Relationship was not modified by neighbourhood self-selection.

Cost Benefit Analysis

A 2011 report for the Queensland Government into the cost and health benefits of active transport attempts to address the problem of non-motorised transport being traditionally undervalued in economic evaluations of transport policies (Ker et al. 2011). The report provides a useful guide to applying benefit-cost analysis (BCA) to active transport. The BCA approach is used by the Australian Transport Council of Ministers, however, it has only relatively recently been applied to non-motorised transport. According to the report, the key impacts are: increase in active transport, and decrease in car use. The report provides useful estimates relating to costs and benefits of car use and active transport. For example, the benefits accruing to health and fitness for each kilometre walked are estimated at 104-207 cents (2010 prices) (Ker et al. 2011). Another study for the Queensland Government from the same year looking at the benefits of including active transport in infrastructure projects also provides useful estimates of costs and benefits for providing bike and walking paths (Department of Transport and Main Roads QLD 2011). Findings from this report were subsequently used by the Department of Infrastructure and Transport in the 2013 Ministerial Statement (Department of Infrastructure and Transport 2013). The report notes that health benefits of active transport will also accrue to people who continue to use motorised transport, for example, through the reduction in vehicle emissions and reduced travel times (Department of Infrastructure

and Transport 2013). Health benefits accruing from walking were estimated by the report to be $1.68 per kilometre (sensitivity range $1.23 - $2.50) (Department of Infrastructure and Transport 2013). Other studies have estimated benefits from less than $0.50/km up to almost $4.00/km (Department of Infrastructure and Transport 2013). Benefit-cost ratios were developed for a number of infrastructure projects, however, they were not designed to increase walkability of neighbourhoods. A study commissioned for Living Streets in the UK also presents a list of benefit-cost ratios from transport projects in the UK, however, again these interventions were mainly focussed on infrastructure development and looking at total health benefits rather than being obesity specific (Sinnett et al. 2011). The same is true for an earlier commissioned piece of work by PricewaterhouseCoopers (PwC), which developed a methodology for the NSW Premier's Council for Active Living (PCAL) and the NSW Department of Environment, Climate Change and Water (DECCW) to allow walking initiatives to be subject to cost-benefit analysis (CBA) (PwC 2010).

c. Description of potential intervention

Possible interventions are necessarily different for new and established suburbs. As it is theoretically possible to design new suburbs from scratch in accordance with urban design guidelines, which have already been developed, the more difficult option is to change existing neighbourhoods to make them more walkable. The intervention considered as part of this scoping paper will therefore focus on improving walking for transportation in existing neighbourhoods. However, this is not to say that an intervention for new suburbs should not be considered. As shown in a recently released transport walkability index, the new area of Docklands in Melbourne scores poorly due to low street connectivity and land use mix (Giles-Corti et al. 2014).

There are a number of interventions that could be implemented to improve measures of walkability in neighbourhoods. However, as noted previously, some of these, such as installing footpaths are unlikely to be cost effective, especially with the present low densities of most Australian cities. Measures to improve street connectivity in existing suburbs are also likely to require significant public investment, and depending on land availability, may not even be feasible. Compared with increasing street connectivity, it is much easier to facilitate increases in density and land use mix. There is strong evidence which supports the existence of positive associations between density, land use mix, as well as walkability indices (which include both of these elements), and PA. In addition, as described earlier, there is significant existing government support for these sorts of measures. It was therefore decided to use the City of Melbourne's 2010 report, *Transforming Australian Cities for a More Financially Viable and Sustainable Future*, which proposes increasing density and land use mix along transport corridors as the basis for this intervention.[6]

Using the recently released transport walkability index (Giles-Corti et al. 2014) it will be possible to select two sites in Victoria for modelling the intervention. Access to full information will shortly be available on the Community Indicators Victoria website (The University of Melbourne n.d.). One site will be assessed as having low street connectivity, and the other as having high street connectivity (see Figure 1). Current density and land use mix should be similar for both areas and have the potential to be increased. Modelling will then be done to show the expected changes in PA resulting from increases in density and land use mix along the two identified transport corridors. Modelling should use two different estimates of density as well as two different neighbourhood sizes[7], in order to have a range of values.

[6] This was decided in consultation with Billie Giles-Corti

[7] There is considerable literature regarding the different methods of defining neighbourhood size. This should be consulted when modelling the intervention. Given that the focus is on walking for transportation, the size of the neighbourhood should reflect people's willingness to walk in terms of time and distance. A method for calculating developable sites along urban corridors has been detailed in the study Transforming Australian Cities for a More Financially Viable and Sustainable Future (Adams 2010).

Figure 1 *Neighbourhood Connectivity (Source: Giles-Corti et al. 2014)*

High Connectivity

Low Connectivity

In order for this change to come about, state and territory governments would need to make changes to zoning laws (including types of categories) and LGAs would need to re-classify areas under their jurisdiction. Due to time constraints, it was not possible to obtain an in-depth understanding of the full extent of changes to planning regulations which would be required. Rob Adams, Director of City Design at the City of Melbourne may be able to provide some guidance.[8]

5. Feasibility of the intervention's implementation in the Australian context

As demonstrated in section 3 of this paper, there is already significant political will across all levels of government to make changes to the urban environment to encourage active transportation. While addressing the issue of obesity is rarely specified as a reason for promoting active transportation, overall health benefits are frequently acknowledged.

Increasing the political acceptability of this intervention are the substantial cross sector benefits. This intervention has the potential to relieve pressure on traffic congestion and lack of housing. Already, Australia is one of the most urbanised countries in the world, with more than three quarters of the population estimated to be living in cities with a population greater than 100,000 in 2010 (Moving People 2030 Taskforce 2013). Our cities are also growing, with almost 60% of national population growth between 2001 and 2010 concentrated in Sydney, Melbourne, Brisbane and Perth (Moving People 2030 Taskforce 2013). This trend is expected to continue. According to the Moving People Taskforce (Moving People 2030 Taskforce 2013), many local councils and state governments are already encouraging higher residential density along transport corridors, albeit mainly to manage travel demand rather than to increase PA. Increasing density along urban corridors is expected to only require changes to approximately 3% of the existing footprint of Australian cities, while achieving significant benefits in liveability, sustainability and economic productivity (Adams 2010).

Securing public acceptance is likely to be more difficult than political acceptance. Residents can often be very protective of their existing neighbourhood features and character and be resistant to change. It will be necessary assure the community that while density along public transport

[8] Rob Adams is also on the Built Environment TAP. Billie Giles-Corti could facilitate contact if required.

corridors will be increased, the surrounding areas will not be affected (Adams 2010). In addition, clear visualisations will assist in assuaging concerns that increasing density equates to high rise (Adams 2010). Residents may also be averse to increasing land use mix. At least one study has identified an association between the proportion of land associated to shopping/retail and increases in residents perceptions of crime risk (Foster et al. 2013).

Heritage issues are likely to be concerns of LGAs as well as residents. Changes in density will need to take into account neighbourhood character and streetscape. For example, the City of Yarra, while supporting increases in density, has recommended building height limits, for example 12 metres along Smith Street.

Changes to planning laws, in particular concerning zoning, will be required. As noted previously, changes have already been made regarding zoning in the State of Victoria. This is an area which should be looked into, in order to better understand the nature of changes required. However, this could be quite time consuming as the requirements will differ between states.

6. Stakeholders

a. Policy makers/regulators

- Municipal association of Victoria
- State/territory departments of transport, planning and infrastructure
- Australian Local Government Association

b. Industry

- Planning Institute of Australia
- VicRoads
- Property Council of Australia

c. Advocates

- Victoria Walks
- Victorian Pedestrian Advisory Council
- National Heart Foundation
- Walk21

d. Academics

- Dr Billie Giles-Corti (University of Melbourne)

7. Issues specific to this intervention

a. Modelling

As already noted, there are a number of issues with the literature, in particular the lack of homogeneity in measuring variables, inconsistent consideration of confounding factors and reliance on cross-sectional studies. A number of factors have been identified as mediating the relationship between levels of PA and elements of the built environment. These include perceptions and actual safety (traffic and crime related), quality and maintenance of infrastructure, climate, topography, and neighbourhood aesthetics. A number of assumptions around potential co-founders and mediators would therefore need to be included in the model.

A distinction may need to be made between benefits accruing to new and existing residents of intervention areas. It is possible that people who choose to move into areas conducive to active transport will be people who already have a higher preference for PA. While existing residents will also benefit, even after the change, their PA levels may not be as high as those moving to the area. A report for the Queensland Government may provide assistance with making assumptions about the types of people who are likely to switch to or increase their PA as a result of the intervention (Department of Transport and Main Roads QLD 2011). In addition, it is possible that PA may actually decrease if higher density and increase in land use mix means people are living closer to their destinations. This is likely to be true for people who prefer active transport.

The majority of studies were conducted in the USA, Canada or Australia. There appeared to be no differences based on location of study as to whether or not an association was found between PA and elements of the built environment. However, the size of the association may differ based on specific locational contexts, for example existing public transport infrastructure and general population cycling levels.

Following from their evaluation, the RESIDE project team is currently working to establish a hierarchy of the individual LNG requirements in order to provide "could – should – must" requirements regarding development of walkable areas (Giles-Corti 2015; Hooper, Giles-Corti & Knuiman 2014). Progress of this work should be followed and used to inform modelling of the intervention.

Modelling of this intervention is likely to be quite complex as there is no single intervention. Rather, density and land use mix will be increased over time as opportunities for development become

available. It will also be difficult to determine costs and who they are borne by. May need to compare cost of developing different types of housing.

b. Other issues (e.g. equity)

By focussing on creating environments supportive of walking for transportation, the type of PA which is targeted by the intervention is incidental. Therefore, financial and time commitments of undertaking PA are unlikely to be prohibitive. However, the overall impact on equity from this intervention is unclear. On the one hand, the intervention supports active transportation, which has the potential to significantly reduce household transportation expenses (Department of Infrastructure and Transport 2011). It also provides opportunities for social interaction and improves access to a range of services (Australian Local Government Association et al. 2010). According to the South Australian Department of Planning and Local Government, "evidence shows that accessible local facilities (when combined with a safe and attractive street system with an appropriate degree of connectivity) enhance social equity by reducing the need to own a car to get access to services" (2010). Furthermore, increasing density will decrease public transportation costs per capita and make public transport available for a larger percentage of the population (Moving People 2030 Taskforce 2013). Increasing land use mix will also provide more job opportunities for people closer to home.

On the other hand, however, the potential of intervention sites along transport corridors is greater in inner LGAs due to a higher proportion of tram and bus lines (Adams 2010). Research by BusVic found that residents of Melbourne's outer suburbs had the lowest average minutes of walking and cycling for transport per person, which was attributed to lower public transportation coverage (BusVic 2010). The intervention may therefore favour people from certain socio-economic groups. Here it is again important to consider the type of new housing that will be built and who the new residents are likely to be. This will also affect the type of services which are provided in the area and the market segment that they target. It may be possible that low-income residents do not benefit to the same extent as high-income residents if there are no affordable stores in their neighbourhood.

8. Intervention's potential to meet intervention selection criteria

a. Potential impact on addressing the problem of obesity

The intervention's potential to increase transport-related PA and improve overall health is quite high. Incorporating PA into daily routines through active modes of transport may overcome perceived time barriers to participation in PA (Moving People 2030 Taskforce 2013). However, it is more difficult to predict its impact on addressing the problem of obesity due to confounding factors (e.g. diet) and the likelihood that this change will not occur immediately. It is also difficult to assess how this intervention may work as a preventive measure, with people exposed to environments conducive of walking being less likely to become obese in later years.

It is important to note that the impact of this intervention will be quite localised and will not affect the PA behaviour of the entire Australian population. Increasing density and land use mix along transport corridors is likely to only impact those people living in the neighbourhood. However, increasing density will increase the number of people affected, unlike interventions which only address infrastructure such as footpaths. In addition, cross sector benefits are significant and should not be ignored.

b. Relevance to current policy decision making

State and territory governments already support improving environments supportive of walking. For example, the Victorian Department of Transport, Planning and Local Infrastructure website states that "the Victorian Government is committed to developing and promoting walking for transport" (Department of Transport, Planning and Local Infrastructure 2015). The intervention is not proposing anything that has not already entered both political and public discourse. Several examples of existing policies, guidelines and resources were provided earlier in this paper. This intervention is not only good for health, but also good for environmental sustainability, which is another issue high on the policy agenda.

c. Availability of evidence of efficacy/effectiveness to support the analyses (using a broad definition of evidence)

There is some anecdotal evidence to suggest that local and state governments are already facilitating increases in density and land use mix along transport corridors, however, a more thorough search of grey literature is required to fully understand where, why and how this is occurring, and to find out if any evaluations have already been undertaken.

The majority of evidence comes from cross-sectional studies, which presents a number of issues. However, this is the best evidence available and demonstrates positive associations between density, land use mix and PA. Given the large number of studies undertaken in this field, clear criteria for study selection will need to be developed when identifying figures for use in modelling and it may be necessary to run the model with figures from different studies in order to obtain a range of estimates.

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Appendix 1: Current Policy Status

NGOs and Industry

In 2004 the Victorian Division of the National Heart Foundation released *Healthy By Design: a planners' guide to environments for active living* (National Heart Foundation of Australia 2004). This is a resource aimed at local governments to help them re-design existing neighbourhoods as well as develop new ones. It recognises the importance of local destinations in supporting walkable neighbourhoods as well as integrated walking routes, lighting, signage and seating among others. The National Heart Foundation has also recognised the import role community design plays in encouraging PA and has developed a range of resources for assessing walkability and planning environments for active living (Heart Foundation 2011). In a commissioned survey of adults in Sydney, Melbourne, Adelaide, Brisbane and Perth, they found that healthy neighbourhood features (e.g. footpaths) would influence many people's decisions about where to live (Heart Foundation 2011).

In 2010 five groups, the Australian Local Government Association, Bus Industry Confederation, Cycling Promotion Fund, National Heart Foundation of Australia and International Association of Public Transport released a report, *An Australian Vision for Active Transport* (Australian Local Government Association et al. 2010). This report sets out a number of steps for the Australian Government to take in order to promote active transport in Australia, and argues that significant cost savings could arise through the resulting increases in PA.

Creating Places for People: an urban design protocol for Australian cities, takes a collaborative approach to best practice urban design in Australia, and was developed by peak community and industry organisations; state, territory and local governments; and the Australian Government (Australian Government 2011). Being *walkable* is one of the twelve principles of the protocol, falling under the pillar of liveability. The protocol recognises the importance of small block sizes and a variety of land uses in encouraging people to walk.

Victoria Walks, a health promotion charity, lists destinations and diversity; density; connectivity and personal safety as key design issues which need to be addressed in order for a neighbourhood to be conducive to walking (Victoria Walks Inc. 2015). The charity provides advice through various advisory committees, reference groups and advocacy forums as well as developing resources for families, schools, businesses, and councils. In its submission to Victoria's Metropolitan Planning Strategy, Victoria Walks advocated for increases in density around activity centres and public transport which are planned at the metropolitan (not local) level (Plan for a walkable Melbourne: Victoria Walks submission to Metropolitan Planning Strategy. 2013).

Federal

The 2009 technical report by the Obesity Working Group of the National Preventative Health Taskforce lists a number of potential initiatives to address Australia's obesity problem. One of these calls for reshaping the environment towards healthy options, what is referred to as a 'settings approach' (National Preventative Health Taskforce, Obesity Working Group 2009). The report identifies proximity of residents to shops and schools, connectivity of streets and population density as elements of urban design positively associated with PA and calls for long-term measures to address the 'urban obesity-promoting environment'.

In 2009 the House of Representatives Standing Committee on Health and Ageing released a report, *Weighing it up: Obesity in Australia.* The report identified urban planning as key area where action

must be taken in order to address the problem of obesity in Australia (House of Representatives Standing Committee on Health and Ageing 2009). In its 2013 response to this report, the Australian Government agreed with the recommendation that "the Federal Government work with all levels of government and the private sector to develop nationally consistent urban planning guidelines which focus on creating environments that encourage Australians to be healthy and active" (Australian Government 2013, p. 15). In underscoring its commitment, the report refers to the National Urban Policy – *Our Cities, Our Future*, *Creating Places for People – an urban design protocol for Australian cities*, and the *Healthy Spaces and Places* tool.

State

In New South Wales (NSW), the Premier's Council for Active Living, provides another resource in the form of planning and design guidelines, which outline key considerations for the design of urban places (NSW Government n.d.). It includes such things as a well-connected street network in order to encourage people to walk. Furthermore, in 2011 *NSW 2021 A Plan to Make NSW Number One* was released by the NSW Government. In addition to aiming for an increase in the amount of walking undertaken for short trips, the plan notes a commitment to developing a specific walking strategy for the state (NSW Government n.d.). The importance of creating walkable environments was also enshrined in Sydney's 2014 metropolitan strategy *A Plan for Growing Sydney* under Goal 3: A great place to live with communities that are strong, healthy and well connected. Higher density and enabling land use mix are noted as important elements of urban centres generally, as is specific infrastructure for walking.

In its 30-year plan for greater Adelaide, the South Australian Government outlines a shift in urban form, to one which is modern, efficient and sustainable (Department of Planning and Local Government 2010). Concentrating new housing and increasing density along transit corridors and public transportation, as well as creating mix-use precincts around transport networks are key elements of the plan. While not the only reason for the shift to a focus on development around transit corridors, the link between built environment and health outcomes, including obesity, is acknowledged. In particular, creating environments that reduce dependence on cars as a means of transport is a strong feature of the plan.

In a study commissioned by the Victorian Department of Transport and the City of Melbourne to examine how metropolitan Melbourne can meet the expected population increase, six ingredients of liveable and sustainable cities are identified (2010). Three of these - mixed use, density and connectivity – are key elements, which have been identified elsewhere, of walkable neighbourhoods. The authors of the study argue that density is the most important element for a range of reasons, including lower carbon footprint and more equitable access to social services. The study advocates increasing density not only around rail infrastructure (which most cities are already planning for), but also along road based public transport corridors.

International

In 2010 the City of New York released *Active Design Guidelines: Promoting Physical Activity and Health in Design.* The guidelines specifically recognise the important role both architectural and urban designers play in addressing obesity and related diseases (City of New York 2010). The guidelines focus on creating opportunities for PA in everyday activities, which will have beneficial effects both for health and environmental sustainability. Land use mix, street connectivity, and density are all recognised as important components of active design.

More recently, London developed a transport action plan which specifically focuses on the linkages between transport and health (Transport for London 2014). In particular, the benefits PA gained through walking and cycling as part of people's everyday routine is emphasised. The plan notes that it is possible to achieve recommended levels of PA through active transportation, however, this data is infrequently captured by statistics.