Living on the Edge

Transport sustainability in Perth's Liveable neighbourhoods

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1 Abstract

Following World War Two, land use and transport policy and practice in most major Australian cities was modelled on the US experience. As such, these cities have become characterised by urban sprawl (indicated by segregated zoning and low development densities) and car dependence. In Perth, Western Australia, these characteristics are particularly evident despite, or perhaps because, unlike most American cities, the city has a strong regional planning system. Car dependence and sprawl are in turn linked to dependence on fossil fuels for transport energy. Increasingly, too, links are being found between conventional planning outcomes and public health. For example, research has linked car dependence with a variety of health conditions including respiratory illness, overweight and obesity. Moreover, research is increasingly linking sprawl and car dependence with social justice issues because people on limited income and with decreased mobility struggle to undertake activities of daily life In response to these concerns the Western Australian planning system introduced Liveable Neighbourhoods, a new design code, which was intended to reduce car dependence and sprawl. This code has its roots in New Urbanism and appears to have been taken up more rapidly in Perth than elsewhere. This paper reports on the first large-scale assessment of transport sustainability in Perth's Liveable Neighbourhoods and in a broader sense, evaluates the transport sustainability of New Urbanism and forms part of the RESIDential Environment (RESIDE) Project. This paper presents the findings of a travel survey (n=211), RESIDE participant perception survey (n=992) and environmental study. In total, 46 neighbourhoods (11 Liveable and 35 conventional) were compared. The research found that despite residents of Liveable Neighbourhoods (LNs) driving less and taking more walking trips relative to residents of conventional neighbourhoods (CNs), there was little else to indicate that LN is achieving its goals as transport VKT and fuel use was identical due to regional transport requirements. There was strong supportive evidence that LNs were not significantly

different in design to CNs. For example, there were few differences in perception of opportunity for more sustainable travel and residents of CNs actually had better access, on average, to key destinations, including shops (i.e. the average distance to key destinations was 2.2 kilometres compared with 2.5 kilometres in LNs). Also, residential lot densities were well below what were intended by LN and in both LNs and CNs the time for public transport to get people to work was over 90 minutes compared with around 30 minutes by car. The results reveal that to improve transport sustainability there must be significant revisions to the LN code and particularly its implementation. There is no evidence that at this stage of development, the new neighbourhoods are improving regional transport sustainability and only time will tell whether this improves as infrastructure in these new areas develops. In particular, residential densities and land use mix appear to be too low to encourage community self-sufficiency, indicated by few neighbourhoods being anchored by key destinations. These matters are not mandated in the LN guidelines making them powerless to bring significant change. More generally, the paper questions the extent to which New Urbanism can promote a sustainable transport agenda wherever it is applied without mandating for increased land use and transit, not simply local permeability and footpaths.

2 Background

Internationally, policy makers and researchers are showing increasing interest in the relationships between land use, transport, health and other sustainability issues. As such, there is a considerable amount of research now being undertaken, often from a cross-disciplinary perspective, which is seeking to explore these synergies. In the United States of America (US) and Australia, particularly, the interest in these relationships is being driven by understandings that conventional land use and transport planning is not sustainable. This is because many US and Australian cities have become characterised by urban sprawl (indicated by segregated zoning and low development densities) and car dependence.

Car dependence and sprawl are in turn linked to dependence on fossil fuels for transport energy (Newman and Kenworthy, 1999). Increasingly, too, links are being found between conventional planning outcomes and public health. For example, research has linked car dependence with a variety of health conditions including respiratory illness, overweight and obesity. Moreover, research is increasingly linking sprawl and car dependence with social justice issues because people on limited income and with decreased mobility struggle to undertake activities of daily living. In formulating the New Urbanism design approach, the American Congress for the New Urbanism aimed to address these problems. Through a suite of design changes, New Urbanism rhetoric suggests that car dependence and sprawl can be alleviated, with implied improvements in transport sustainability.

Perth, Western Australia was one of the first cities in the world to embrace this American style New Urbanism. Perhaps this is not surprising given it is internationally recognised as a low density sprawled city where residents depend on their cars for much of their travel. This follows the development of the 1955 Stephenson-Hepburn Plan and the subsequent Metropolitan Region Scheme (1963), which established a strong regional planning system for the city. From the 1960s, Perth's conventional suburbs have spread north and south for more than 120 kilometres, with urban systems having been designed assuming a high level of private motorised mobility amongst the public.

The State government responded to the dual issues of urban sprawl and car dependence by implementing the "Liveable Neighbourhoods" (LN) design code (see WAPC, 2004). This is intended to facilitate more sustainable urban development and associated transport patterns. The code is an interpretation of New Urbanism, tailored to the Western Australian context. Significantly, Perth had substantial growth occurring at the period that the planning community world-wide were being introduced to New Urbanism, a history of commitment to State intervention in the planning system which could enable a new design code to be introduced, and public servants who were positioned to

re-write the code and promote it to developers and planners. Some of the key transport-related intentions of LN are for:

- Street networks to be more permeable to reduce trip lengths
- Neighbourhoods to be more mixed use and dense to improve access, with services being anchor-points for the community
- Public transport services to be more accessible
- Neighbourhoods to be more self-sufficient, with there being greater opportunity for local trips

Together, these characteristics should encourage reduced trip frequencies (as trip purposes can be combined), trip lengths (access to the services integral to people fulfilling their life's work should be improved), travel times (given shorter distances to key destinations) and car use (trips by public transport, walking and cycling should be better facilitated).

In the late 1990s, LN was introduced as a voluntary code and was subsequently adopted by several developers. Key designers from the American Congress for the New Urbanism came to Perth during this period to provide their design advice. People such as Peter Calthorpe, Andres Duany and Peter Katz were visitors to Perth. The 11 LN projects evaluated in this paper are as big a selection of New Urbanist projects as could be found in any city. Therefore, they present a laboratory of urban planning, which needs to be evaluated.

This paper reports on doctoral research conducted between 2005 and 2008 as part of a Transport Sustainability and Health (TSH) study. The TSH study was a sub-study of the RESIDential Environments (RESIDE) project, which has been described elsewhere (Giles-Corti *et al.*, 2008). This paper assesses and reports on the transport sustainability of Perth's Liveable Neighbourhoods, by comparing aspects of design and transport-related data collected from 11 of RESIDE's 18 LN developments with data from a sample of conventionally-designed developments. A substantial review of literature published elsewhere (Falconer et al, 2007) also contextualises the present paper. In the present paper we focus on our research methods, results, discussion and policy implications.

3 Research method

3.1 Neighbourhood selection

The procedure for selecting neighbourhoods and households for inclusion in the TSH study was explained in an earlier paper (Falconer *et al.*, 2006). In total, 46 of RESIDE's 74 neighbourhoods were represented in the study, 11 of which were Liveable and 35 conventional. The number of LNs relative to CNs reflects the fact that there were many more conventional than Liveable neighbourhoods being developed in the metropolitan region at the time of the study. Figure 1 shows the distribution of the neighbourhoods throughout the metropolitan region. The northernmost neighbourhood is *Ocean Lagoon*, a CN, which is a straight-line distance of about 49 kilometres from the Central Business District. The southernmost neighbourhood is *Mariners' Cove*, an LN, which is about 65 kilometres from the CBD.

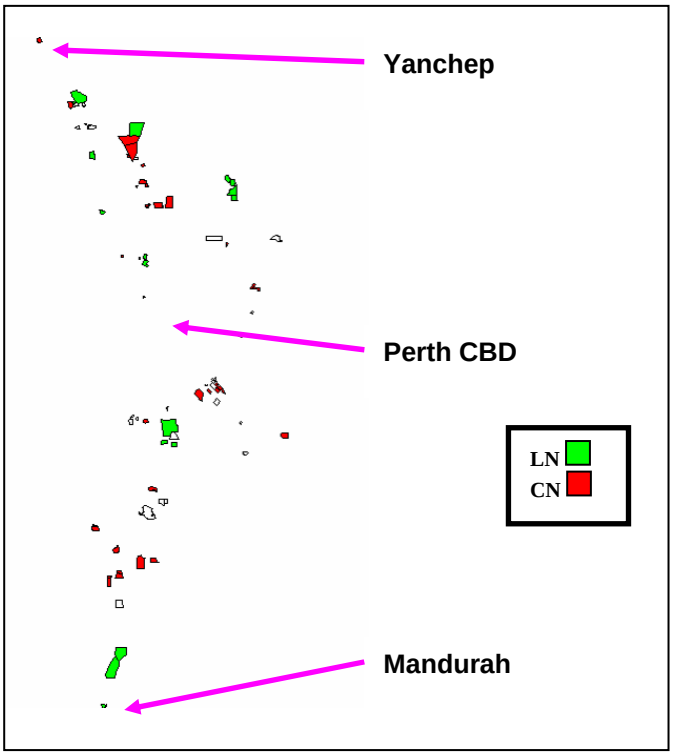

Figure 1 – Arc Explorer map showing the study neighbourhoods

3.2 TSH study components

Hoehner *et al.* (2005) argued that few studies have simultaneously assessed people's perceptions of their environment and objective environmental measures, and their relative association with levels of physical activity. The TSH study aimed to take this three-pronged approach to research, with transport behaviour in general being of interest rather than physical activity *per se*. The design of the study was informed by US research where self-reported walking behaviour and perceptual information and objective environmental measures were used to help define the concept of the walkable neighbourhood (Moudon *et al.*, 2006).

3.2.1 Travel survey

The travel survey was explained in detail in the earlier paper (Falconer *et al.*, 2006). A total of 211 people from 103 households completed travel surveys. Descriptives and bivariate statistical tests (chi squares for categorical data and t-tests for independent means for scale data) were undertaken on the trip-level, individual-level, household-level data and the transport energy use and emissions information. The transport energy use and emissions levels were generated from the travel survey data using a power-based model (Leung and Williams, 2000). Some multivariate (discriminant) analyses were also conducted to validate patterns of differences between LN and CN. The main findings of the travel survey are presented in section 4.

3.2.2 Perception study

The main RESIDE study provided perceptual data for *all* RESIDE participants (n=992) in the TSH study neighbourhoods (n=46), who completed RESIDE's first follow-up questionnaire in 2006. Perceptions are considered to be intermediary in the relationship between the built environment and travel behaviour. Perceptions rather than environmental features may be more predictive of travel behaviour, because people need to be aware of destinations and routes to reach them. It has been argued that people are "more likely to report the presence, rather than the absence of particular land uses when those land uses were closer to and more abundant around their homes" (Moudon *et al.*, 2006: s108).

One aim of the TSH study was therefore to consider whether there were consistencies between the environmental measures (actual opportunities), perceptual data (people demonstrating they are aware of opportunities) and the self-reported travel behaviour (people's transport reflecting both awareness and the provision of opportunities). In the case of LNs, residents should, amongst other things, be

undertaking relatively more local travel and using active modes more, which should be consistent with both higher relative awareness and provision of local opportunities (i.e. destinations to travel to).

The perception data included perceptions of access to local facilities, the walkability of the local street network and walking distances to the nearest key destinations[1]. Socio-demographic data were also obtained from the main study. The original variables relating to perceptions of walking distance to key destinations were also recoded to indicate whether or not they were perceived to be within a 15 minutes of people's homes (1=Yes, 0=No).

The modified NEWS scale[2], which was used in the RESIDE questionnaire, differentiated between local shops and supermarkets; doctor's practices and pharmacies; post boxes and post offices; and bus stops and train stops. For consistency, the variables were recoded to give a *shortest* perceived distance to each *type* of key destination (i.e. local shops, a medical facility, a postal facility and public transport). Descriptives and bivariate tests were run on the perceptual data to identify differences depending on neighbourhood classification. The main findings are presented in section 4.

3.2.3 Environmental study

Four sets of environmental measures were derived with the assistance of RESIDE's GIS analysts and transport professionals at Main Roads Western Australia (MRWA). The first set of measures related to access to key destinations. They were derived for RESIDE households who, as of May 2007, both had a family member who had completed RESIDE's first follow-up questionnaire and were located in one of the TSH study neighbourhoods (n=992: 323 in LNs and 669 in CNs)[3]. The method and choice of destinations was informed by similar work by Holtzclaw (1994) and development of the Land Use and Public Transport Accessibility Index (LUPTAI) (Pitot *et al.*, 2005). Holtzclaw's (1994: p15) neighbourhood shopping index (NSI) measured "the fraction of the community's population which has five critical local commercial establishments within ¼ mile [402 metres] walking distance".

Holtzclaw (1994) found that five destinations formed a credible measure of daily access: including fewer destinations was found to be significantly less reliable. Six destinations were chosen for the TSH opportunities index, as all could be anticipated to help anchor new neighbourhoods. Increasing the number of destinations from five to six also made the measures of access both more robust and a better proxy for land use mix. The selected destinations included:

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[1] Key destinations were matched with the environmental data.
[2] Refer http://www.ipenproject.org/surveynews.htm.
[3] That there were more than twice as many households in CNs than LNs included in the analysis is indicative of there being more RESIDE participants in CNs overall and many more CNs than LNs in the RESIDE neighbourhood pool.

- Local shopping (a supermarket, deli or local general store)
- Post facility (post box or post office)
- Daycare centre
- Newsagent
- Medical (doctor or pharmacy)
- Public transport stop (bus or rail)

Notably, a measure of green-space was not included in the TSH study. Previous studies have found that walkable neighbourhoods tend to be anchored by basic daily retail and food activities (Moudon *et al.*, 2006). Moudon and colleagues also found that access to open space, such as parks, may be associated with increased physical activity, but were not important as anchor points for walking for transport.

Key destinations (such as grocery stores) tended to be those associated with necessary rather than discretionary spending (Moudon *et al.*, 2006). The LN code is not very prescriptive about the type of retail activities that should be in local centres. Rather, the code states that:

> A small retail store with a bus stop and post box, with some associated home-based business opportunities and some higher density housing…[would be the minimum components] of a neighbourhood centre under LN (WAPC, 2004; p122).

The second set of environmental measures related to network permeability. These used the access-related data discussed above, being the network distance to destinations divided by the Euclidean. Permeability is a crucial factor in improving design to encourage more sustainable transport behaviour as it has the potential to significantly reduce the distance between homes, jobs and key facilities.

The third set of measurements related to residential lot density in the sample neighbourhoods. These were interpreted alongside the proxy measures of land use mix (access measures) to help evaluate activity intensity in the sample neighbourhoods. The measures of density were derived from information provided by and with the permission of the Western Australian Land Information Authority (Landgate) (2007). The principal reason for calculating residential lot density rather than population density was that census data, which is organised according to census collection districts (CCDs), could not be matched with households in the study neighbourhoods, because the CCDs and neighbourhoods had different boundaries.

Residential lot density was measured both with and without control for the size of the sample neighbourhoods and both with and without the inclusion of a neighbourhood with exceptionally large residential lot sizes (i.e. four summary tables of findings were generated). In each of the analyses, average lot sizes, lots per site hectare (equivalent to an *R* standard, which is the common density prescription used in statutory planning policies) and lots per urban hectare were calculated, depending on neighbourhood type.

The fourth and final set of measures related to work trip substitutability and was an important complement to the access data. These measures were developed for those of the 992 RESIDE participants who reported that they drove to work in RESIDE's first follow-up questionnaire. The participants must also have provided complete origin and destination data and reported working inside the metropolitan region. A total of 480 people (170 LN and 310 CN) met these criteria.

Work trips are the key daily, bounded trips that people make. Often, these will be regional rather than local trips, because of difficulties supplying specialised employment locally in sprawled cities. From a sustainability perspective, it is therefore important that people can undertake longer trips (for which it is not feasible to walk or cycle) by public transport without significant burden (measurable as a time sacrifice). While residents of LN are anticipated to have better access to public transport (measured by the opportunities indices), it is important that services then provide efficient access to other parts of the metropolitan region. A work trip substitutability measure was therefore a key gauge of this access potential.

Once more, descriptives, bivariate (and, where relevant, multivariate) tests were run to identify patterns of difference depending on neighbourhood classification. The main findings are presented in section 4.

3.3 Overall study design

The research was conducted across several phases. In April 2006, the travel survey was initiated. In June and October 2007, the perceptual and environmental data respectively were provided by RESIDE. The research procedure is summarised in Table 1.

Table 1 – A summary of the different research components and when research was conducted

Method	Description
Travel survey	**Cohort 1:** **1.** Recruitment – 11 April to 22 May 2006 **2.** Diaries posted – 22 May 2006 **3.** Follow-up – 9 to 20 June 2006 **Cohort 2:** **1.** Recruitment – 7 September 27 October 2006 **2.** Diaries posted – 27 October 2006 **3.** Follow-up – 17 November to 1 December 2006
Perceptual data	Accessed from the main RESIDE study. Data originally collected in RESIDE's first follow-up questionnaire. Data received June 2007
Environmental data	Accessed from the main RESIDE study. Data originally provided by Landgate and derived from the Perth metropolitan Yellow Pages. Information accurate for 2007. Data received October 2007 and March 2008

4 Results

In this section, the most significant findings of each component of the research are presented. Tables 2, 3 and 4 present the main findings from the travel survey, perception study and environmental study, respectively. Table 4 includes *p* values, with significant values emboldened.

There were some clear patterns of difference in trip characteristics by type of neighbourhood (particularly relating to mode use), although these were most distinguishable at the trip level. Residents of LNs reported a significantly higher proportion of walking trips (21% compared with 12%, $p<0.01$), whilst residents of CNs reported a significantly higher proportion of motor vehicle trips (81% compared with 72%, $p<0.01$), with differences especially evident when trips were for leisure purposes. This is despite average motor vehicle trip occupancy being lower when reported by residents of LNs ($p<0.01$). However, consistently, there were no significant differences in public transport use and cycling. Furthermore, residents of LNs were much more likely to travel shorter distances ($p=0.018$) and for less time ($p=0.011$), relative to residents of CNs. These findings notwithstanding, the data show that the residents studied used their cars for the great majority of trips regardless of the type of neighbourhood they lived in and had regional travel patterns.

At the individual level, the mode use differences tended to remain, although other differences diminished, with some losing statistical significance. Average individual daily vehicle kilometres travelled (VKT) were virtually the same and this can be attributed to the fact that residents of both types of neighbourhoods tended to report about the same amount of driving. The modal split differences can be misleading: residents of LNs tended to make a lot of walking trips *as well as* rather than *instead of* trips by car.

At the household level, no variables appeared useful for differentiating households based on the type of neighbourhood they were in. Analyses of the energy and emissions also did not yield many significant findings, which can largely be attributed to consistencies in average daily VKT. It is therefore difficult to conclude that residents of LNs reported travelling in a more sustainable way than residents of CNs.

The findings from the perception study reveal that whilst there were few differences depending on neighbourhood type (LN or CN), overall, participants perceived moderate barriers to local utilitarian walking and fairly long distances between their homes and key destinations.

The findings from the environmental study show that access to a range of facilities, most notably local shopping was much better in CNs than LNs, which is contrary to the intentions of the LN policy. However, access to public transport was notably better in LNs (although not necessarily in terms of a 15-minute walk), despite this being of limited use given the findings of the work trip substitutability analyses (see below). Street network permeability was found to be consistently better in LNs, which was anticipated by the LN policy.

Evaluation of the residential lot density data revealed some differences - mostly higher relative residential lot densities in LNs - but was suggestive of low residential lot densities overall. Indeed, the density data show that the LN code has failed to produce the recommended densities and this contributes to the suburbs remaining highly car dependent. Finally, and not unexpectedly, the work trip substitutability analyses found a heavy burden for residents of all neighbourhoods if they changed from motor vehicles to public transport. However, there was no pattern of difference depending on neighbourhood type.

Table 2 – Main findings from the travel survey

Characteristic	Finding	
	Liveable Neighbourhoods	**Conventional Neighbourhoods**
Other control variables	No significant differences	
Trip level modal split	Motor vehicle 72% Public transport 4% Walking 21% Cycling 3%	Motor vehicle 81% Public transport 4% Walking 12% Cycling 3%
Individual level modal split	Motor vehicle 72% Public transport 4% Walking 21% Cycling 3%	Motor vehicle 82% Public transport 4% Walking 12% Cycling 2%
Proportion of single-occupancy motor vehicle trips	49%	41%
Car ownership per person	0.82	0.78
Car ownership per household	1.83	1.97
Average trip distance	11.34	12.10
Short trips (<1.5km) as a proportion of an individual's travel	21%	15%
Short trips conducted by walking	69%	58%
Average daily private VKT	42.59	43.05
Energy use and emissions	Inconsistent pattern of difference	
Daily reported transport-related physical activity	20.41 minutes	12.39 minutes

Table 3 – Main findings from the perceptual study

Characteristic	Finding	
	Liveable Neighbourhoods	**Conventional Neighbourhoods**
Control variables	No significant differences	
Walkability of the local street network	Inconsistent pattern of difference	
Perceived distance to key destinations	Inconsistent pattern of difference, but typically long (with the exception of distance to the nearest public transport stop)	

Table 4 – Main findings from the environmental study

Characteristic	Finding		*p* value
	Liveable Neighbourhoods	**Conventional Neighbourhoods**	
Distance to daily shopping	3.3km	2.8km	**0.000**
Distance to newsagency	5.3km	3.3km	**0.000**
Distance to childcare facility	2.8km	2.8km	0.930
Distance to medical facility	1.4km	2.0km	**0.000**
Distance to postal facility	1.7km	1.4km	**0.000**
Distance to a public transport stop	510 metres	649 metres	**0.000**
Average network distance to a key destination	2.5km	2.2km	**0.001**
Average street network permeability	1.37	1.41	**0.002**
Average residential lot size*	603.44m^2	820.21m^2	**0.000**
Lots per site hectare*#	16.67	14.88	**0.000**
Lots per urban hectare*	8.81	8.64	**0.000**
Average residential lot size^	603.44m^2	646.62m^2	**0.000**
Lots per site hectare^#	16.67	15.58	**0.000**
Lots per urban hectare^	8.81	9.01	**0.000**
Work trip substitutability	No significant differences, however, the average work trip would be 2.74-2.97 times longer if made by public transport rather than private vehicle and would take 39.51-42.15 minutes longer (one way)		-

*with control for neighbourhood size

^with control for neighbourhood size and outlying conventional neighbourhood excluded

#equivalent to an *R* standard

5 Discussion

The self-reported data provided little evidence that the travel behaviour of residents of LNs is more sustainable. Whilst the mode use data consistently showed residents of LNs drove 9% less and made 9% more walking trips (in relative terms) than their counterparts in CNs, there was little difference in average daily VKT per person as the difference in walking was attenuated by the slightly lower occupancy in car travel.

The transport survey showed that residents of LNs reported significantly more transport-related physical activity than their counterparts (8 minutes more transport-related physical activity). Nevertheless, non-transport-related physical activity, such as team sports, was not controlled for. It is therefore difficult to conclude that the increased transport-related physical activity is related to neighbourhood design, because many 'short' trips were conducted outside of the people's neighbourhoods and aside from relatively good permeability, LNs did not appear to have a good mix of local destinations. More research is needed, however, to analyse the accessibility of greenspace and other leisure destinations to ascertain how these affect rates of walking. The data also revealed little evidence of differences in transport energy use or vehicle emissions. This appears to be attributable to the lack of difference in average daily VKT.

The perception and environmental studies revealed little evidence that the design of LNs is any more sustainable than CNs. The perception study found virtually no differences in people's perceptions of access, their local street networks or distances to key destinations, including shops, newsagencies, childcare, medical facilities, postal facilities and public transport stops. Thus, the findings suggest residents of LNs were not aware of relatively more opportunities for sustainable travel.

The environmental study found some planning deficiencies in the study neighbourhoods. Whilst street network permeability was found to be consistently better in LNs than CNs, access was significantly better in CNs. Distance to shops, for example, averaged 2.8km in CNs compared with 3.3km in LNs, whilst the *average distance to key destinations* was significantly lower in CNs (2.2km) compared with LNs (2.5km). Also, whilst residential lot densities in LNs were mostly higher than in CNs (depending on which controls were used), the overall finding was LNs simply are not dense enough to contribute to transport sustainability. The LN code targets residential densities of 22 dwellings per site hectare and 15 dwellings per urban hectare, with higher densities in strategic areas: i.e. 20-30 dwellings per site hectare within 400 metres of bus stops and local centres, and 30-40 dwellings per site hectare within 800 metres of rail stations (WAPC, 2004). The average of 16.67 lots per site hectare and 8.81 lots per urban hectare in the study LNs are 24% and 41% below the respective lower targets.

It is therefore no surprise to find that residents of the study neighbourhoods do not really have a viable public transport option. The findings of work trip substitutability analyses revealed significant time burdens for people if they were to use public transport rather than motor vehicles for the journey to and from work, irrespective of the neighbourhood they live in. With the average burden being between 39.5 and 42.2 minutes (one way), there is little reason to suggest people will willingly make the switch. It is not rational for people who are already commuting for 60 minutes per day using the car to increase their commute time to 140 minutes by switching to public transport. Overall, the environmental data show that there may actually be fewer opportunities for sustainable travel in the sample LNs than in the CNs, although both types of neighbourhoods score poorly.

Ultimately, at this stage of their development the study showed that LNs are not different to CNs in their land use and this is likely to be linked to the lack of significant differences in transport patterns. The literature suggests more activity-intense environments are associated with reduced VKT per capita but the TSH study has shown the sample neighbourhoods are not different in their activity intensity. The differences in self-reported transport behaviour are not associated with differences in the two kinds of neighbourhoods and may be related to individual attitudes. However, the results show that there is a strong likelihood of associations between deficient access - where there is a lack of inter-neighbourhood coordination, low densities and little mixing of land uses - and a necessity for residents to drive for most trips (even residents of LNs report a high percentage of car trips, even for local trips), and often for long distances. At this stage of the development, the data suggests that LNs are just another part of car dependent urban sprawl. Given these developments are new and some land use is still unfolding, further follow-up is required to investigate whether mixed used development follows the houses being built. This follow-up is planned and currently underway.

Furthermore, there is strong evidence of a gulf between the underlying LN principles and practice. This suggests that the design code is too flexible and developers are not observing some of the more important design criteria and/or that the existing policy is not the mechanism to promote sustainable transport. Even though the LN code may be helping to create a few small benefits for local permeability, it does not appear to be contributing to the creation of a sustainable city.

From a broader perspective, sustainable transport requires more than piecemeal development. Other researchers have identified that urban change is a slow process (Hickman and Banister, 2005). Given people often have regional travel patterns it would take time for urban change to influence people's behaviour. As such, it is vital that not only is a development code properly calibrated to contribute to the sustainability agenda but that it is consistently applied.

The research reported on in this paper opens new fields of inquiry relating to land use, transport and health in Perth and suggests a need for more research into people's transport decision-making and citywide policy-making. The wider implications of the research are that the Liveable Neighbourhoods Guidelines has had some limited successes in increasing local walking but has failed to address the more regional issues of car dependence and sprawl. Urban planning more closely modelled on the European experience, where there is strong policy support for transit oriented development (TOD), is probably required to begin addressing the sustainability issues touched upon in the background section of this paper and discussed at length in the literature (see Falconer *et al.*, 2006 for a summary of this literature).

6 Policy recommendations

The key policy recommendations arising from the research include:

- Longer term follow-up of the implement of the LN is required
  .
- It is critical that the LN code is reassessed. This may involve conducting further research, which is similar to the TSH study (to evaluate how the development code is being applied) and more policy-focused evaluative research (to assess how the code itself needs to be recalibrated to achieve the overriding vision of LN: i.e. are the quantitative guidelines sufficiently strong). The findings presented here suggest that the LN code is failing to produce sufficient density increases and mixed use neighbourhoods. This is signposted by the low provision of local services and low substitutability of transit for the car for work trips. It is anticipated that design trends in Perth will change (particularly as government and developers become more aware of sustainability priorities) and there will either have to be changes to the ways in which the code is interpreted or else it should be replaced by a more effective code.

- A retuning of LN to make it more prescriptive about density increases and mixing of uses should enable quality TOD. This would assist with neighbourhoods becoming more walkable and improve their regional transport access. Increased densities may be achieved by setting some minimums as well as maximums and *requiring* minimum residential lot densities in strategic areas, such as near to proposed centres. Mixing of uses could be achieved by requiring certain percentages of mixed-used zoning in new neighbourhoods and even facilitating development of multi-story units where street-level businesses are topped by dwellings. Success elsewhere (e.g. in Subiaco) demonstrates there is demand for high-quality, higher density and mixed used developments.

- With its present configuration, LN does not seem to be able to achieve the strategic-level coordination of neighbourhoods that is anticipated. The evidence suggests that coordination is an important prerequisite for access. Thus, regional planning and even redevelopment of areas may be required to enable the LN code to achieve the desired outcomes. When neighbourhoods (even LNs) are planned in an *ad hoc* way (particularly when they are small), it is difficult to ensure shops, places of work and other facilities are provided nearby. Suggestions for improving coordination include providing more incentives for private partnerships (such as tax concessions and expediting of applications) and more private-public collaboration. Overall, however, the most significant factor would be genuinely regional planning rather than piecemeal development. The *Network City* (DPI and WAPC, 2004) framework could provide the necessary perspective but it will require political will to implement. In Perth, the development of TODs rather than LNs (as they are presently being developed) should be the priority, as this would be likely to contribute to more regional integration. With the completion of the southern rail line, there are new opportunities for turning LNs into genuine TODs.

- The State government is presently developing integrated transport guidelines. These are an essential complement to development policy such as LN as they have the potential to ensure new infrastructure is properly linked with surrounding networks. If good transit (preferably light rail) can be built back into suburbs there is a good basis for improved regional sustainability and local walkability. Also, higher-quality walking and cycling networks are essential complements to increased activity intensities.

- LN should be geared more towards redevelopment of underutilised urban land, rather than greenfields development. This would be consistent with the objectives of *Network City*: to facilitate 60% of new growth in the existing urban area.

- Further education and workforce development of developers is vital to help sell the benefits of smarter, more sustainable growth. These can include improved returns (note again the successes in Subiaco), alongside environmental, social and economic benefits.

7 Conclusions

Evaluations of New Urbanism are rare, if any and the research reported on here is therefore both the first major evaluation of the transport sustainability of Perth's LNs and a major litmus test for the underlying New Urbanist approach. The findings of the research, particularly those relating to regional transport sustainability, can be used to reinform LN and may be used to reinform New Urbanism.

The findings reveals that whilst there are some small quantifiable benefits in transport behaviour between residents of Liveable Neighbourhoods and conventional neighbourhoods, there were few differences in key *indicators* of regional transport sustainability, including VKT, transport energy use and emissions. Moreover, the perceptual study showed little differences depending on neighbourhood classification.

Critically, too, the environmental study demonstrated access to key destinations in the study neighbourhoods is generally low. Whilst development is still unfolding in some neighbourhoods, there are not necessarily many opportunities to increase the land use mix. The lack of key destinations reduces the opportunity for more sustainable transport. Relatively poor access is almost certainly a product of low development densities and little mixing of uses in the neighbourhoods, which together attenuate any benefits associated with increased network permeability. Also, work trip substitutability analyses found a significant time burden for residents giving up the use of their car.

Overall, the core transport-related principles of LN are not reflected in the study neighbourhoods. The LN code is not doing what it was intended it should do for sustainable urbanism and the city is not benefiting from its present application.

These findings are of international significance and should suggest caution in New Urbanism as a mechanism to reduce car dependence and urban sprawl through a limited set of design changes. Improving sustainability in cities will require much more than LN (an application of New Urbanism) has been able to provide to date.

The paper has recommended that the Liveable Neighbourhoods code is reassessed. From a transportation sustainability perspective, a mechanism that implements the principles of *Network City* and facilitates TOD can make more of a contribution. This mechanism must be more prescriptive about increases in both population and service densities, and mixing of uses to promote neighbourhood vibrancy, access and support for transit services. Also, development needs to be strategically targeted towards existing urban areas and fringe development should be limited.

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9 References

Department for Planning and Infrastructure and Western Australian Planning Commission (2004) *Network City: community planning strategy for Perth and Peel*, September, Perth: WAPC, 122pp

Falconer R, Giles-Corti B and Lyons T (2007) Exhausting the city: implications of land use and transport in Perth, Australia *World Transport Policy and Practice*, 13(2), 78-105

Falconer R, Kenworthy J and Giles-Corti B (2006) *Model Suburbs? Investigating transport, health and quality outcomes in Perth/Peel's 'Liveable Neighbourhoods'*, paper presented at the PATREC Research Forum, 19 September, Perth, 17pp

Giles-Corti B, Knuiman M, Timperio A, Van Niel K, Pikora T, Bull F, Shilton T and Bulsara M (2008) Evaluation of the implementation of a state government community design policy aimed at increasing local walking: design issues and baseline results from RESIDE, Perth Western Australia *Preventative Medicine*, 46, 46-54

Hickman R and Banister D (2005) Reducing travel by design: what about change over time? Williams K (ed.) *Spatial Planning, Urban Form and Sustainable Transport*, Aldershot, England: Ashgate

Hoehner C, Ramirez L, Elliott M, Handy S and Brownson R (2005) Perceived and objective environmental measures and physical activity among urban adults *American Journal of Preventative Medicine*, 28(2S2), 105-116

Holtzclaw J (1994) *Using Residential Patterns and Transit to Decrease Auto Dependence and Costs*, San Francisco: National Resources Defense Council

Metropolitan Regional Scheme 1963, homepage [Retrieved: 05/10/2005] http://www.wapc.wa.gov.au/Region+schemes/default.aspx

Moudon A, Lee C, Cheadle A, Garvin C, Johnson D, Schmid T, Weathers R and Lin L (2006) Operational definitions of walkable neighbourhood: theoretical and empirical insights *Journal of Physical Activity and Health*, 3 (suppl. 1), s99-s117

Newman P and Kenworthy J (1999) *Sustainability and Cities: Overcoming Automobile Dependence*, Washington DC: Island Press

Pitot M, Yigitcanlar T, Sipe N and Evans . (2005) *Land Use and Public Transport Accessibility Index (LUPTAI) Tool – the development and pilot application of LUPTAI for the Gold Coast*, paper presented at the 29th Australasian Transport Research Forum, 27-29 September, Gold Coast, Queensland

Stephenson G and Hepburn J (1955) *The Plan for the Metropolitan Region: Perth and Fremantle, Western Australia*, report prepared for the Government of Western Australia, Perth: Government Printing Office

Western Australian Planning Commission (2004) *Liveable Neighbourhoods, 3rd ed.*, October, Perth: WAPC, 173pp [Retrieved: 27/05/2005] http://www.wapc.wa.gov.au/cgi-bin/index.cgi?page=/udmp/index.html