Model Suburbs?

Investigating transport, health and quality outcomes in Perth/Peel's 'liveable neighbourhoods'

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1 Abstract

Professionals and policy-makers are becoming increasingly aware that public health is inextricably linked with urban design and transport. An increasing number of links between the low density, heavily zoned, automobile dependent urban forms typical of many Australasian and North American cities, and poor public health have been identified. In Perth, Western Australia the State Government has responded to issues of urban sustainability by implementing the "Liveable Neighbourhoods" subdivision design code, which is intended to facilitate a more sustainable form of urban development. The code provides guidelines aimed at creating walkable environments, where housing is centred round services and facilities, and transit routes. In contrast, the conventional planning paradigm facilitates the growth of low density neighbourhoods, which feature segregated zoning and priority for private vehicles. This paper describes the Transport Sustainability and Health study which is being conducted in Perth. It discusses how residents of living 'liveable' and 'conventional' estates will be compared in terms of their travel behaviour characteristics and the environmental quality of their estate, and these characteristics will be related to selected personal health indicators in order to explore possible linkages. Fieldwork, which is being conducted in 2006, includes travel surveys, a visual audit and focus groups. The study will examine whether the "Liveable Neighbourhoods" subdivision design code has been fully implemented and is achieving measurable differences in transport behaviour and health outcomes, thereby contributing to the overall transport sustainability of Perth's newer suburbs. Early results of qualitative fieldwork will be presented and discussed in this paper. The study forms part of the RESIDEntial Environments Project (RESIDE) based at the University of Western Australia, a longitudinal project which aims to evaluate the impact on walking, bicycling and sense of community of neighbourhoods designed using liveable and conventional subdivision design codes.

2 Introduction

Over the last century and a half, there have been profound changes in the form of cities. One of the fundamental drivers of change has been the emergence of motorised modes of travel. In Western cities, particularly in the United States and Australasia, the development of collective means of motorised travel, including trains and streetcars was followed later by the development of cheap, readily available automobiles. The latter have become a private, flexible and freedom-providing alternative to the former.

Several decades ago, Wingo Jnr (1961) identified that urban land must be treated as a precious and scarce resource. It must be used in a sustainable way. It follows that care must be taken when incorporating more land into metropolitan areas. Unfortunately, due care simply has not been shown in many contexts, since cars have provided substantial freedom over space, for those with means to

purchase and run one. It is now clear that fundamental mistakes have been made in the way in which cities have been allowed to evolve. The physical arrangement of many cities in Australasia and the United States are not sustainable, not least because they are often sprawled and residents depend on cars for travel.

In this paper we will discuss how transport systems are inextricably linked to urban design, and show how the dual problems of sprawl and car dependence are increasing concerns. We qualify this by looking at oil dependence and how the twilight of cheap oil foretells an urban transport crisis. Further, we discuss how various health risk factors are linked to conventional transport patterns.

The three-pronged methodology of the Transport Sustainability and Health study will be introduced and early results from the qualitative components of the research will be presented. We will consider how the study design which will involve a comparison of liveable and conventionally designed neighbourhoods will answer questions about whether the "Liveable Neighbourhoods" design code is making a measurable difference to transport behaviour and health outcomes and the overall transport sustainability of Perth's newer suburbs.

3 How sustainable are our urban systems?

Land use and transport systems are inseparable. Physical changes to urban form, such as development of new housing precincts affect transport systems and vice versa. Many researchers acknowledge this association but remain undecided about the exact influence of various types of change (Newman and Kenworthy, 1999; Crane, 2000; Frank, 2000; Ewing and Cervero 2001; Saelens et.al., 2003; Sallis et.al., 2004).

Perth is a relatively young city, by both national and international standards. The Stephenson/Hepburn Plan (1955) was the first comprehensive metropolitan study conducted in Perth. It formed the basis of the Metropolitan Regional Scheme (1963), which continues to be the statutory planning mechanism for the Perth metropolitan region. The Plan – with its emphasis on low development densities (particularly outside of established nodes), segregation of land uses and a lack of a rigid urban growth boundary – provides the backdrop against which Perth's current problems with urban sprawl and car dependence have developed.

Rapid suburbanisation came later in Perth than in most other Australian cities. The 1950s and 60s were years when growth in car ownership and the 'quarter acre dream' held by many members of the community were key drivers of urban development in Perth (Jones, 2003). As Jones (2003: p315) states:

> Perth has embraced suburban development much more strongly than other cities in Australia and its influence on lifestyle and quality of life is pervasive

In 2004 the Department for Planning and Infrastructure and Western Australian Planning Commission reported that the average parcel size of land accorded to each dwelling was 789m^2. The average site density was 12.7 dwellings per net hectare of land (DPI and WAPC, 2004). This is very low by international standards and contributes to a range of social, economic and environmental problems, such as social isolation, car dependence and high utilities costs.

Many of Perth's new developments continue to occur on the fringes of the existing urban area and the city now extends for more than 120 kilometres along the Western coastline of Australia (Curtis, 2005). Some jobs and goods and services have decentralised along with the population. Shopping malls, for example, are scattered throughout suburban Perth. They have been built assuming large, dispersed population catchments and that people will access them by car. Generally, peripheral developments have been fuelled by extensive additions to and upgrades of metropolitan highways.

Transport planning in Perth reflects US practice, favouring the private motor vehicle all-too-often at the expense of other modes (DPI, 2000). For example, many of Perth's suburbs are not characterised by the provision of footpaths along local roads, even if there happens to be local facilities within walking distance of people's houses. Moreover, curvilinear streets and culs-de-sac have become common features within suburbia. The high level of car ownership and use in Perth reflects a culture of road building and affordable motoring, though this latter privilege is in its twilight.

Car ownership in Perth is high by international standards with 679 vehicles per 1,000 residents of Perth (Ashton-Graham, 2003). In 1991, 76% of all personal trips were being made by car (Curtis, 2001). In 2001, 80% of all trips were being made by car, as either driver or passenger (Socialdata Australia, 2001). A more recent analysis suggests that there are around 4.8 million trips made per day in the Perth Metropolitan Region, of which 5 out of 6 are made by car, as either driver or passenger (Planning and Transport Research Centre, 2005). This suggests an increasing reliance on the private vehicle for the period 1991-2005.

The rise in the ownership and use of cars contrasts with a decline in the use of public transport. From 1966 to 1995, the percentage share of public transport dropped from 20% to less than 7% (DPI, 1995).

Perth residents have a culture of driving, even for short trips. Recent calculations are that 48% of all trips by car cover less than 5 kilometres and 71% cover less than 10 kilometres (Wooldridge, 2005). Similarly, research has found that 72% of trips to local facilities are made by car, while only 21% are made by foot (DPI, 2000). Some trips require means to transport groceries and so forth (means which include a car boot), however it may be feasible for half or more of all trips made by car to be made by another mode, such as foot or bicycle (Ashton-Graham et.al., 2005).

In Perth, the sustainability of urban planning practices and dependence on private motor vehicles is of increasing concern. This is becoming more apparent as it is recognised that the twilight of cheap oil is upon us and there are a wide range of health issues associated with reliance on motor vehicles.

3.1 The twilight of cheap oil

There is substantial evidence to suggest that by the late 1990s, the majority of the Oil Producing Economic Community (OPEC) had reached peak sustainable output (Simmons, 2005). In 2003, global demand for oil was 80 million barrels per day and was growing at a rate of 3% per annum (Parker, 2005). Huge growth in the transport sectors of emerging countries, such as China, contributes to increasing demand, as does strategic stockpiling by some countries in anticipation of future price rises and oil shortages. The net outcome is continual rises in the price of crude.

The bulk of oil supply is sourced from small number of aging giant and super-giant middle-eastern fields. The portents are not good; Simmons (2005) reports that no new fields of any significance have been discovered in the last three decades.

Some researchers have argued that the production peak will be reached by 2020 (Campbell and Laherrère, 1998; Campbell, 2003). Fleay (2005) argues that the peak has already been reached. For certain, however, is that there is little potential for supply to rise to meet burgeoning demand and that the twilight of cheap oil is upon us (Simmons, 2005).

Parker (2005: p66) argues that "Australia has become addicted to cheap oil, especially for transport, which uses almost 80% of Australia's petroleum". Perth residents are no exception, relying heavily on oil for transport energy (Newman et.al., 1990). At 2003 rates of consumption, Australia's remaining economic reserves are only sufficient for the next 11 years (Parker, 2005).

Relative to other countries, Australia has high per capita energy consumption. For example, private passenger transport energy use per capita in a sample of Australasian cities, including Perth, averages

50% more than in many Western European cities (Kenworthy and Laube, 2005). Unsustainable oil consumption is an issue that needs to be dealt with now.

People's reliance on the private vehicle cannot be reconciled with decreasing stocks of oil and increased fuel prices. Unfortunately, this truism is not reflected in governmental policy, especially at the Federal level. There is a strong legacy of policies favouring motor vehicle transport, at the expense of alternative modes such as public transport, walking and bicycling (Laird, 2001).

At the finer scale, state and city governments, especially in Perth and Peel, have long favoured private vehicles in transport planning. Moreover, the sprawl pattern of development has made car travel necessary for many trips, as other modes are not *practical* alternatives.

The Liveable Neighbourhoods guidelines were initiated to create neighbourhoods where travel by alternative modes, especially bicycle or foot, is practical. The intention is for such neighbourhoods to be characterised by quality infrastructure for active mode users and a range of local destinations. These are critical requirements in a time when cheap motoring seems to be coming to an end.

3.2 Conventional planning and human health

Insufficient physical activity is associated with a variety of chronic diseases, including type-2 diabetes, overweight/obesity, mental health and cardiovascular diseases (Lee and Paffenberger, 2000; Frumkin et.al., 2004; National Heart Foundation, 2004). There is great potential for people to achieve a higher degree of physical activity throughout daily life if the public would undertake utilitarian travel by active modes. Frank et.al. (2004) have found that an increase in daily walking distance is negatively associated with the likelihood of a person being obese. In contrast, the amount of time spent in a car on a daily basis was positively associated with the likelihood of a person being obese.

In Australia, the proportion of people classified as overweight or obese rose alarmingly from 1980 to the end of the millennium. In 1999, 20% of persons aged 25 or older were categorised as obese (Australian Institute of Health and Welfare, 2001). The annual cost of health services to treat conditions associated with inactivity is conservatively estimated to be almost 380 million Australian dollars (Stephenson et.al., 2000).

US research has found a strong association between the overall urban form of the county within which a person lives and the probability that they are overweight (Ewing et.al., 2003). However, this association was not evident at the neighbourhood scale. This is unsurprising, considering the variability of urban form over space and differences in the personal circumstances of people within estates. People do not conduct all of their business within the estate they live in, particularly in a post-industrialist society in which much importance is placed on the private vehicle for mobility.

Vandegrift and Yoked (2004) point to an association between rising rates of obesity in the US and widespread suburban sprawl. They argue that sprawled, car dependent cities simply are not conducive to walking and bicycling. As a consequence, it is probable that people have become relatively inactive, through relying on private vehicles rather than their own power to get around (Wright, 2003).

Reliance on cars is a huge challenge for policy makers who seek to increase use of active modes for the health benefits they can afford (Hu and Young, 1999). Hillman (1997), and Gee and Takeuchi (2004) argue that car dependence has impacted on obesity levels, increased people's stress levels and affected people's mental health, especially that of children.

Apart from a number of potential health benefits associated with increased walking and bicycling, there are many health costs associated with motor vehicle travel. As well as being a sedentary mode, private motor vehicles with combustion engines are mobile sources of pollution (Cavill, 2003), pollution which, as we have discussed, is detrimental to public health.

Nikula et.al. (1995) note that the constituents of diesel exhaust fumes have been found to have carcinogenic properties. Combustion engines produce a range of pollutants including carbon monoxide, carbon dioxide, nitrogen oxide, sulphur oxide and particulate matter (Frumkin et.al., 2004; Krausse and Mardaljevic, 2005). Evaporation of fuels is also a source of pollution. Ozone, a gas which is harmful to people's health, also forms in the presence of pollutants from vehicles (Frumkin et.al., 2004).

Many researchers have identified links between airborne pollution sourced from the transport sector and adverse effects on people's health (Brunekreef, 1997; Katsonyanni and Pershagen, 1997; Cohen, 2000). Sallis et.al. (2004) have found that increased emissions resulting from dependence on the car for travel increases respiratory problems, particularly asthma in children. Evidence suggests that persons who are consistently exposed to high levels of particulate matter, a particular form of pollutant, may have their life expectancy reduced by 1 or even 2 years (Brunekreef, 1997; Dominici et.al., 2003) as well as suffer constant respiratory distress.

Motor vehicles also contribute to noise, water and visual pollution (Steiner, 1978; Hayden, 2004; Store, 2006). In contrast, public transport generally produces much less pollution, especially airborne pollution (Kenworthy, 2003) while active modes produce almost none. Walking and bicycling require nothing more than the input of kinetic energy.

If Liveable Neighbourhoods facilitate reduced need for travel by private vehicles, offset by greater potential for travel by active modes, there are likely to be a range of health benefits. Of concern, however, in light of the findings of Ewing and others (2003) is how much of an influence neighbourhood design may have, unless design change is region-wide.

4 Methodology

Given the complexity of the links between urban design, transport and health, and a range of aims and objectives of the Transport Sustainability and Health study (see Falconer, Kenworthy and Giles-Corti, 2006) it was clear that a diverse approach to research was necessary.

There are strong reasons for combining qualitative and quantitative methodologies. The rich, meaningful data captured using the former can be used to triangulate the statistical data collected using the latter (see Naess, 2005). The use of Geographic Information Systems can also aid analysis and add to data presentation. Following a discussion of the method for selecting the estates that would be included in the research, the remainder of this section describes the various components of the data collection process and the logic underlying each.

4.1 Selecting estates

The target population for this study was all persons currently residing in Perth/Peel's newly built conventionally-designed or liveable suburban estates. Kenworthy (1986) argues that using clustering techniques, such as Carlson's (1972) to reduce the number of estates that need to sampled from aids data manageability, while still ensuring robust, useable results are produced. Clustering involves grouping estates together based on pre-ordained commonalities. Put simply, like estates are grouped together. Subsequently, fewer estates (and therefore participants) can be included in the study, due to inter-estate similarities.

A number of considerations made it both impractical and unnecessary to sample from each and every recently built suburban estate in Perth/Peel. These considerations made unnecessary any sort of rigorous statistical clustering procedure to obtain a manageable sample size from the target population.

The TSH study is part of RESIDE. It was therefore planned for the study to recruit participants from

those households already involved in the broader RESIDE project. This provided the added benefits of access to existing data collected as part of the project and familiarity amongst participants with completing questionnaires. So as not to overburden RESIDE participants, it was decided early on that only those who were not due to receive a RESIDE questionnaire in 2006 were to be invited to participate. However, members of the sample needed to have completed the first follow-up RESIDE questionnaire, so it could be confirmed that they were not about to move out of their estate of residence.

As at 20 January 2006, a total of 663 RESIDE study participants were eligible for the study. A total of 26 persons were identified who were both potential participants and had been contacted by the Department as part of their *TravelSmart* programme. To avoid overlap, these persons were removed, leaving 637 potential study participants.

We then filtered all 'hybrid' estates from the sample and for the purposes of data manageability, all estates containing fewer than three RESIDE participants. After these processes a total of 497 prospective participants remained, distributed throughout 51 estates (see Table 1).

A power calculation was undertaken to assess sample size requirements (see *quantitative component*). This indicated that the sample size above was of sufficient size to detect a significant difference between liveable and conventional estates. Furthermore, excluding the estates with a small number of study participants improved the likelihood of being able to make *intra*-estate statistical comparisons, while not unduly affecting the ability to make meaningful *inter*-estate statistical comparisons.

4.2 Developing the qualitative components

An inductive analytical approach was identified as the most appropriate to be taken to the qualitative component of the research (see Patton, 2002). The first element was an environmental audit of a subset of the eligible housing estates. Four each of the conventional and liveable estates were audited. An example of walk-through analysis, the audit was designed as a means to capture rich data relating to neighbourhood quality (see MfE, 2006). It was an opportunity to visually reference a sample of both conventional and liveable estates, with the main aim being to obtain data relating specifically to micro-scale environmental characteristics.

The design of the visual survey was based upon the Liveable Neighbourhood guidelines (WAPC, 2004) and the Sustainable Urban Design Practical Fieldwork Project guide (2005) from Murdoch University. Extensive field notes were taken as part of the auditing procedure.

Easy coding and analysis was possible after the audit as data from different estates could be grouped according to common themes. Moreover, richness of description was important as it enables later discussion to be detailed. Local environments were audited under the following headings:

- Structure
- Neighbourhood structure
- Neighbourhood walkability
- Walkability to public transport and facilities

Table 1 – Break-down of prospective participants per estate type

Total count of estates: **51**	Total count of prospective participants: **497**
Number of Liveable Neighbourhoods in sample: **16**	Number of prospective participants in Liveable Neighbourhoods: **153**
Number of conventional neighbourhoods in sample: **35**	Number of prospective participants in conventional neighbourhoods: **344**

- Safety, surveillance and visual appeal
- Choice/flexibility/variety
- The extent to which design is responsive to the environment and culture
- Site-responsive design – character and identity
- Cost and resource efficiency
- Traffic

The visual survey is a useful, though limited means to objectively explore the extent to which the Liveable Neighbourhoods design criteria are producing communities which meet the underlying principles. Each of the eight estates selected was thoroughly audited. All of the streets within each were explored, providing rich information. The data collected is limited, however, because it relates to only a small group of Perth's new estates.

Furthermore, despite observation being a useful means to catalogue structural features and view interaction between subjects and their local environment, it is neither a means to gauge people's attitudes towards nor perceptions of their surrounds. This is because attitudes and perceptions are internalised and are inaccessible to the observer (Forward, 2003).

Focus groups were undertaken to assess the thoughts and perceptions of local residents. The focus groups allowed collection of rich personalised data, which in turn could be compared with the more objective, carefully coded data obtained from the visual surveys. A number of questions were used to guide the focus groups:

- Discuss the quality of your neighbourhood. How do you rate it as a place to explore by foot or by cycle? (keywords - *vibrancy, aesthetic appeal, sense of community, dullness, homogeneity, loneliness?*)
- Discuss the physical features of your neighbourhood. What words, thoughts or feelings do you attach to selected features?
- Do you feel you have access to a range of services and facilities in (or near to) your neighbourhood? Under what circumstances do you leave your neighbourhood in pursuit of services/facilities?
- What are the main considerations for you when you are deciding which mode to use to get to services and facilities? How accessible do you find public transport?
- What reasons are you aware of to want to engage in active transport? What do you feel you need to know more about (keywords - *pollution, safety, accessibility, different lifestyle options, health, energy, community interaction*) if anything?

A total of four focus groups are being run, between May and September 2006. Each has between 6-8 participants, so as to give individuals an opportunity to participate, but not unduly limit the range of subjectivities that were reported (see Krueger, 1988). Participants for the focus groups are being recruited through gatekeepers for Residents' Associations. Two of the focus groups have been undertaken with residents from conventionally-designed estates (Meve and The Grove). The remaining two will be undertaken with residents from liveable neighbourhoods (Brighton Beachside and Frankland Springs).

4.2.1 Selection of estates for qualitative research component

Two particular measures, estate size and distance from the central business district (CBD) were used to identify the degree of similarity between the 51 estates in the sample. Estate size was chosen because it was of interest to see how various characteristics of neighbourhoods were related to their size. Distance from the CBD was chosen because it has been found to be positively correlated with energy use (Newman, Kenworthy and Lyons, 1985; Naess and Sandberg, 1996). It was of interest to the study to see if aspects of the physical environment differed, depending on the distance of an estate from the CBD. It was hypothesised that the further an estate was located from the CBD, the more priority would be given to private vehicles.

This information was then used to aid selection. This procedure of organising the estates into taxonomies, or grouping estates by like characteristics (Webb, 1991) allowed a greater degree of variety in the selected group of estates than a straight random sample would have allowed.

Each estate was assigned to one of eight categories. Each of the categories is based upon various combinations of estate size and distance from the CBD, relative to the median values, and estate type. A single estate was randomly selected from each of the categories (using random numbers). Table 2 shows the selected estates, once this was done.

4.3 Developing the quantitative component

When undertaking travel behaviour research, a key data collection method is the travel diary.
Travel diaries can produce limited, yet robust findings (Burke, 2004). The findings are limited because they are almost exclusively numerical (or are categorised according to some kind of numerical system). Their robustness, however, comes from the fact that they can be subjected to rigorous statistical testing, which in turn can yield significant results.

The travel diary was similar in design to that used by Burke (2004) for research into gated communities in the context of Brisbane, and for the Perth Regional Travel Surveys 1976 and Perth and Regions Travel Survey 2002-2006. These are, in turn, representative of the innumerable similar household travel surveys that have been conducted around the world over the last 50 years as part of major land use/transport studies. The draft design was reviewed by Dr Peter Lawrence, a noted transportation modeller and travel diary specialist. Comments provided by Dr Lawrence in late 2005 enabled the instrument to be fine-tuned, as did professional advice received in February 2006 from transport and data analysis experts at Main Roads, Western Australia and the Department for Planning and Infrastructure.

Originally, the diary required each respondent to record their travel behaviour over the course of 7 days. This ensured that data relating to weekend activity would be included. Members of the second cohort will only be required to complete a 2 day diary, improve recruitment and completion rates (see section 4.3.3). All persons aged 5 years and over, in the households that the diaries were sent to, were invited to participate.

Table 2 – Selected estates for qualitative component

Liveable Neighbourhoods

Code	Explanation	Estate	Estate Code	Estate Size (hectares)	Distance to CBD (kilometres)
1	Large, long	Beaumaris	NW54	93.66	33.81
2	Large, short	Banksia Grove	NW30	461.26	27
3	Small, long	Brighton Beachside	NW44	18.9	37.38
4	Small, short	Frankland Springs	SW80	53.26	21.87

Conventional Neighbourhoods

Code	Explanation	Estate	Estate Code	Estate Size (hectares)	Distance to CBD (kilometres)
5	Large, long	The Grove	NW154	364.44	23.48
6	Large, short	Lansdale Gardens	NW12	194.68	15.78
7	Small, long	Meve	SW10	39.34	24.84
8	Small, short	Sheffield Park	E48	11.53	12.74

The instrument is an example of a trip and activity diary. It requires that respondents record their trip characteristics and trip purposes (see Goulias, 1997, and Pas and Harvey, 1997 for examples of such diaries). This enables more in-depth analyses to be conducted, once results have been compiled. For example, there is potential for mode choices for journey to work or shopping trips to be compared between individuals, households and estates.

The design of the diary ensured that a range of data relating to transport behaviour, individual health variables and energy consumption could be collected. Including variables in the diary relating to energy consumption will be very useful for later analysis of whether the transport behaviour of residents of liveable neighbourhoods is more sustainable than that of residents of conventional neighbourhoods.

Participants were furnished with a Frequently Asked Questions (FAQs) brochure to clarify the requirements of the diary. In particular, the information provided with the diary made it clear to participants that all parts of a trip chain should be documented. As the TSH study is particularly concerned with active transport, it was important that links of journeys done by foot were recorded. Hass-Klau (2003) notes that walking is typically underestimated in travel surveys, because it often serves as a linkage trip at the beginning and end of journeys. A clear request for participants to record such trips was a means to address this problem.

4.3.1 Recruitment

The study was initially powered to 85% to enable detection of a difference between groups of 0.4 standard deviations (i.e. n= 224 households). This count was a balance between maximising the likelihood that relatively small variability in results could be identified, while ensuring that the necessary sample size was not too great.

However, following this initial calculation, the figure was inflated to adjust for intra-estate clustering. This was necessary, as there was the likelihood that peoples' travel behaviour and individual health variables would be influenced by common environmental characteristics. The relevant formula was as follows:

1 + (m – 1) corr

In this formula, **m** is the average number of households per estate and **corr** is the degree of correlation between members of different households within the same estate. A total of 497 households were approached to participate in the study divided by 51 estates equals 9.75, or **m**.

A **corr** value of 0.05 was chosen, thereby assuming a relatively low degree of similarity between the travel behaviour of different households, due to common environmental characteristics. The output value was therefore 1.44. Thus:

1.44 x 224 = 323

This value was further inflated by 1.2, assuming a reasonable rate of refusal. The final value was thus 388. This was less than the total count of households approached for the study.

Finally, the figure was then inflated again to adjust for intra-household clustering. As more than one person was to be surveyed in most households, it was assumed that members of the same household would have some common lifestyle characteristics. This is especially important for later multi-variate analysis, using individual-level health and travel data. The formula to inflate the figure to control for intra-household clustering is as follows:

1 + (h - 1) corr

In this formula, **h** is the average number of persons aged 5 years or over per household and **corr** is the degree of correlation between members of the same household. The average household size in Perth has been estimated to be 2.7 persons, following estimates that the figure would decrease over the long term from 2.9 in 1991 (DPI, 1995). This is a useful estimate for the purposes of this formula, although children less than 5 years of age were not to be included in the study. A **corr** value of 0.6 was estimated, given a relatively high likelihood that members of the same household would have some common lifestyle characteristics. The output value was therefore 2.02.

Thus, the minimum number of households required to complete the study was 323. This figure, multiplied by 2.02 to control for intra-household clustering, could then be inflated by 1.2, again assuming a reasonable rate of refusal. Therefore:

323 x 2.02 = 652 (total number of persons required for the study)

∴ 652 x 1.2 = 782

This final output of 782 was the minimum number of persons, both RESIDE participants and others, who would need to be *invited* to complete the travel survey. Opportunely, this number was less than the number of people who could potentially complete a travel diary (497 x 2.7, minus a small number of people less than 5 years of age).

While it was expected that a number of diaries would, for various reasons, be ineligible for inclusion when returned, the difference between the required and expected numbers was sufficient for this to initially be no more than a minor concern.

Prior to sending out any formal requests for people to participate in the study, human ethics approval was obtained from both Murdoch University and The University of Western Australia. In March 2006, approval was obtained.

On Thursday 13 April, introductory letters were sent to potential participants, in conjunction with a consent form for the participants to complete and post back, an information brochure and a reply-paid envelope. On Wednesday 26 April, a follow up letter was sent to households who had not responded to the initial invitation.

4.3.2 Response rates

By 22 May, which was determined to be the cut-off for acceptances, to minimise the likelihood that the travel behaviour of participants would be affected by winter weather, a total of 88 households and a total count of 189 people had agreed to participate. By this date, 68 households had either declined to participate or were ineligible. Table 3 summarises the responses to the recruitment effort.

Table 3 – Response statistics

Households Approached	497
Estimated Households to Accept	414 (83.3%)
Estimated Total Person Acceptance	1,000-1,100
Actual Household Acceptance	88 (17.7%)
Actual Total Person Acceptance	189
Household Refusals/Ineligible	68
Household No Response	341 (68.6%)
Estimated Total Person Count After Attrition	170
Actual Number of Completed, Useable Diaries	106 (16.3% of required)
Total Number of Persons Required for the Study	652
Shortfall of Participants	546 (83.7% of required)

On Monday 22 May, when diaries were sent out to willing participants, it was assumed that there would be a 7-10% attrition rate, based on the experiences of other researchers. This is because some people either choose to pull out of the study or provide ineligible responses. The row fourth from bottom in Table 3 therefore contains the estimated total usable responses from this round of recruitment.

By mid July, only 105 completed useable diaries had been returned, following data cleaning and telephone follow-ups, where required. This is the third last entry in Table 4. A further 27 participants withdrew from the study, once they had received the diaries.

The total count of acceptances was thus far below projections. It was also far too small to achieve the level of statistical power required. In retrospect, no consideration had been given to non-responses and the willingness of RESIDE participants to volunteer to engage in the Transport Sustainability and Health study had been grossly overestimated. RESIDE guidelines do not allow for further contact to be made with other non-respondents because they are involved in a longitudinal study and it was important not to affect their participation in the main study. This has necessitated a second round of recruitment.

4.3.3 Increasing the Sample Size

We have identified an opportunity to overcome the shortfall of 546 participants (see final row, Table 3). A second cohort of participating households will be recruited from outside of those households involved in the RESIDE project. The second round recruitment strategy will be to identify neighbouring premises to the households approached in the first round. The reason for selecting a cohort in the houses neighbouring the RESIDE study participants, is that RESIDE has collected substantial data on environmental characteristics of the neighbourhoods. The sampling strategy for the additional cohort enables the TSH study to continue to use these data.

Other researchers have found an *acceptance* rate following 'cold' mail recruitment for travel surveys to be a little more than 20%. To cover the current shortfall of 546 participants, conservative estimates would be for a total of 2,730 households to be approached, divided by an approximation of acceptances per household. The first round recruitment has shown the average acceptance rate to be 2.15 per household. Thus, 2,730 divided by 2.15 is approximately 1,270. While the second round recruitment procedure needs to be refined, it is estimated that around 1,270 more (non-RESIDE) households will be approached to participate in the study, most likely in spring, to avoid the seasonal effect of winter weather. This information is summarised in Table 4, below.

This number will likely be further inflated somewhat to account for a small number of vacant or unoccupied sites, non-residential land uses and other, ineligible premises. While ethics approval has already been obtained to enable this second phase to proceed, the exact details of the procedure are still being developed. It has been decided, however, that the diary administered to the second cohort will be a two day diary. This is to increase acceptance and completion rates. Following discussions with RESIDE's biostatisticians, a diary requiring participants to record travel on one weekday and one weekend day will offset the need to increase the sample size.

Table 4 – Calculating the sample size for 2nd round recruitment

Shortfall of Participants (Total required – Projected total from 1st recruitment round)	546
Conservative Rate of Acceptance	20%
Preliminary Number of Households to be Approached (Shortfall of participants divided by 0.2)	2,730
Projected Acceptance Rate per Household	2.15
Actual Number of Households to be Approached (Preliminary number of households divided by 2.15)	1,270

5 Early results of qualitative fieldwork

The qualitative fieldwork involved eight of the fifty-one estates in the main study. Preliminary analysis of the environmental audit suggests little difference in environmental characteristics between liveable and conventional estates. Most notably, at this stage, development densities and mix of uses are low in both types of estate. This is important from a utilitarian travel perspective. Moreover, both types of estates assessed tended to have weak anchor points, relying on small areas of parkland, often with water features, rather than local commercial centres. Neighbourhood radii tended to be too big for it to be practical for residents on the outer edges of estates to be able to walk to the centre.

Noticeable differences between the two types of estates include footpaths on one side of streets in liveable neighbourhoods, with dual footpaths on main streets, while many streets in conventional estates have no footpaths at all. Moreover, in the liveable estates there are fewer curvilinear streets and culs-de-sac in liveable estates compared with the conventional estates.

The focus groups have yielded rich data from the resident perspective. Residents of both types of estate seem to hold an affinity towards their estates and see them as unique. They found them walkable, social spaces, but conceded that they have to drive to get to work and to access services. They appeared walkable only if people wished to walk for leisure. Although only at the initial stage of analysis, one interesting comment was made by a resident of The Grove, a large conventional estate around 45 minutes by car, to the north of the city. It encapsulates our perspective of urban design and transport sustainability issues in Perth:

> With regard to general amenities and the availability of public transport in the area, we generally felt the estate was pretty good. However, this is only because we have other facilities such as sports, social clubs, restaurants, churches, movies, major shops, etcetera within easy driving distance. Without a car, this estate and probably many others would have little to offer. If you relied on public transport you would live a pretty barren existence in the burbs. I guess what I'm saying is that suburban estates are not really self-contained. You need to have a car to gain access to wider community services and amenities. Basically, without a car you don't have a community lifestyle. If petrol went to $100 a litre and no one could afford to run a car anymore, what sort of communities would we have? Certainly not self-contained "villages" where you could live, work, shop, etcetera (The Grove Focus Group, 2006)

6 Summary and future directions

Throughout this paper we have linked urban design with transport patterns and various health indicators. We have discussed how conventional planning practices have produced cities that are not sustainable: residents rely on private vehicles for the great majority of their travel, which in turn has tangible effects on public health. These outcomes are evident in Perth.

Given adverse health implications and other sustainability issues, including the continually rising price of oil, in Perth, Western Australia the State Government has responded by implementing the “Liveable Neighbourhoods” design code. This code is intended to facilitate more sustainable form of urban development and less reliance on private vehicles for travel.

We have discussed how the Transport Sustainability and Health study combines qualitative and quantitative research components to investigate how travel patterns may differ depending on a person’s neighbourhood of residence, whether selected health variables are related to a person’s travel behaviour, the extent to which environmental quality is associated with different types of travel behaviour, and to examine the access potential provided by public transport services. The results of our research will answer questions about whether the Liveable Neighbourhoods design code is making a measurable difference to the sustainability of Perth’s newer suburbs.

We have gone on to present the results of preliminary analysis of our visual audit and focus groups. Based on the sub-sample of estates included in RESIDE, early indications suggest that there are few differences in environmental characteristics between liveable and conventional neighbourhoods and peoples' attitudes towards their particular estates of residence. However, this will be further examined in the main study and monitored over time as the infrastructure in these estates changes.

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