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Housing and Driveway Design: as if children mattered

Patricia Austin

School of Architecture and Planning
University of Auckland, New Zealand

Corresponding email: pm.austin@auckland.ac.nz

Michael Shepherd

Starship Children's Hospital
Auckland District Health Board, New Zealand

Julie Chambers

Starship Trauma Services
Auckland District Health Board, New Zealand

Abstract:

Driveway runovers continue to be a leading cause of paediatric death and serious injury in New Zealand and Australia. Human factors (child and driver), vehicle factors (rearward visibility) and environmental factors (driveway design and context) contribute to the risk of driveway runovers. Previous research in Auckland has considered the contribution of a range of built environment factors to the risk of runovers. (Shepherd et al, 2010) The research identified a significant increase in the risk of injury with longer driveways; with driveways exiting onto a local road and / or cul de sac; with an absence of sheltered parking (such as a carport or garage) and with additional parking areas on the property. The presence of a separate pedestrian pathway from the footpath to the front was associated with a lower risk. Other studies (eg Roberts et al, 1995) have demonstrated an association between driveway (or play area) fencing and a reduced risk of driveway injury.

This paper argues that the built environment characteristics, contributing to driveway runover risk, are to be most commonly found in three typologies of residential built form; and that the risk is compounded by household resources, both at the macro-scale (housing affordability as a driver of residential form) and at the household-scale (unaffordability of driveway fencing or of sheltered parking). The first typology can be found in post-war suburbs developed without a garage or with a separate garage located at the rear of the property. The second typology can be found in the lower-cost suburbs developed during the 1970s and 1980s, often using a battle-axe layout, to minimise the costs of public residential roads. The third typology has occurred in the last decade in our urban areas, with infill residential

developments, with long (often shared) driveways and little or no consideration given to children's play areas on site.

Introduction

Driveway runovers continue to be a leading cause of paediatric death and serious injury in New Zealand. Every two weeks a child is hospitalised with serious injuries resulting from contact with a vehicle driving on a private driveway. On average between four and seven children are killed annually in the same way. (Safekids NZ, 2002) Most children injured in driveway incidents are toddlers, aged about two years old and when death does not occur, the injuries they receive are often severe. Parents, family members, friends and neighbours are usually the drivers. (Murphy et al, 2002) These events have a devastating impact upon families. Maori and Pacific Island children are significantly over-represented with 66% of the incidents. Households with higher than average numbers of children and households living in private sector rental properties and Housing New Zealand dwellings are also over-represented. (Murphy et al, 2002)

Epidemiological analysis suggests there are likely to be several potentially modifiable factors preceding the injury. These are:

- Vehicle design – particularly poor rearward visibility
- Human – lack of driver awareness and supervision of playing children
- Environmental – including the driveway, the street and the available play areas

The first part of the paper describes research in Auckland designed to investigate the contribution of a range of built environment factors to the risk of runovers. (Shepherd et al, 2010) A significant increase in the risk of injury was identified with longer driveways; with driveways exiting onto a local road and / or cul de sac; with an absence of sheltered parking (such as a carport or garage) and with additional parking areas on the property. The presence of a separate pedestrian pathway from the footpath to the front was associated with a lower risk. Other studies (eg Roberts et al, 1995) have demonstrated an association between driveway (or play area) fencing and a reduced risk of driveway injury.

The second part of the paper argues that the built environment characteristics, contributing to driveway runover risk, are to be most commonly found in three typologies of residential built form that, in different ways, are associated with responses to housing affordability. It seems that the built environment risk is compounded at the household-scale by the lack of resources to provide formed driveways, fencing and sheltered parking, and at the macro-scale, by central government policies, local plans and subdivision designs in response to housing affordability. The possible contribution of policies and plans to deliver more affordable housing to increasing the built environment risk of driveway runovers is explored.

Research on Driveway Runovers

New Zealand, Australia and North America have the highest rates of vehicle-related child pedestrian driveway accidents in the developed world. (Partrick et al, 1998, Cowley et al, 2005) Safekids estimate that deaths in New Zealand due to such accidents average between four and seven deaths per year. It has been estimated that there are an average of 11 driveway runover fatalities a year in Australia, (Australian Transport Safety Bureau, 2006) a country with more than 5 times the population of New Zealand.

In New Zealand the majority of driveway incidents occur with children less than 4 years old, with a typical scenario involving a 2-year old child. (Roberts, 1995 and Safekids, 2002) The involvement of younger children in driveway runovers has also been noted in Australian and American research. (Brison et al, 1988, Silen et al, 1998) Hockey et al (2003) report that in

Australia, half of all transport related deaths of children under 5 years are driveway runovers. Parents, family members, friends and neighbours are most likely to be the drivers of the vehicles involved; making up more than 85% of the drivers involved in such events in an Auckland study. (Safekids, 2002).

Poor rearward visibility is a feature in driveway runovers, and appears to be related to type of vehicle involved. Findings from two American studies are similar: Pinkney et al (2006) identified a higher incidence and severity of injuries associated with four-wheel drives, vans and trucks in driveway accidents relative to their much lower overall ownership levels; and Fenton (2005) identified the significant overrepresentation of these vehicles, and also noted that the number of driveway runover cases had increased over the last four years of the study, in line with the increase in sports utility vehicles. In Auckland, vans, four-wheel drives and light trucks were involved in 28% of the accidents reviewed and only comprised 6% of all vehicles in the urban region. (Murphy et al, 2002)

Socio-economic and cultural factors may result in higher levels of risk of child injury. In their Auckland research, Roberts et al (1995) calculated that children from lower socio-economic groups to be over five times at risk of being involved in such accidents, and estimated Maori children to be at close to four times the risk of driveway injury. Murphy et al (2002) have also shown the high incidence of those with lower socio-economic status, in driveway accidents in their Auckland region study. Maori and Pacific Island children were over-represented at 66% of the incidents, compared with their 34% population proportion; and there was a significantly higher level of rental properties, and of Housing New Zealand dwellings. (Murphy et al, 2002)

Built environmental features have been suggested as part of the reason why New Zealand, Australia and North America have the highest rates of driveway runovers in the developed world. Murphy et al (2002) found driveway accidents to be uncommon in Europe. They believed longer driveways and the high proportion of subdivided properties contributed to the higher incidence in New Zealand. In several studies specific environmental features have been identified; these include lack of fencing of driveways, and lack of separation from the dwelling or children's play areas. Research undertaken by Roberts et al (1994) to identify the environmental contributions to child pedestrian accidents in Auckland included 25 cases that occurred in residential driveways over a one-year period. For 75% of the injury cases there was no separation of the driveway from the children's play area – the first time that this factor had been identified. A further case-controlled study was undertaken, of 53 cases (where children were killed or hospitalised) over a period of 26 months in the Auckland region: the absence of physical separation of the driveway from the children's play area was associated with a threefold increase in the risk of driveway-related child pedestrian injury. (Roberts et al, 1995)

Poor documentation on the environmental characteristics of incident sites was noted by Holland et al (2000) in their retrospective study of 55 cases of injured or killed children over the period 1995-2000 admitted to the New Children's Hospital, New South Wales. Documentation of access limitation to the driveway was available in only three cases; in two cases this involved a front door only, and in one case a fence gate, all of which had been left open. A further retrospective case study was undertaken by Holland et al (2006) examining the cases of 36 children injured over a 3-year period between June 2002 and May 2005, and admitted to the same hospital in New South Wales as in the earlier study. Interviews with 26 caregivers and scene visits were undertaken. The study found that the majority of homes (22; 85%) had no separation between the dwelling, external play areas and the driveway. Even when a separation was present, this had been circumvented. (Holland, 2006)

Murphy et al's retrospective study of all 77 events in which children were injured by a vehicle in a driveway in Auckland between January 1998 and October 2001, found that none of the

driveways had fencing or were physically separated from the main house. In addition, inspections of 43 of the accident sites found driveways that were “frequently easily accessible from both the front and back of the house” (Murphy et al, 2002)

The evidence on the risk associated with driveways shared with other properties is less clear. Roberts et al (1995) case control study of 53 cases (and 159 controls) in Auckland found that “children living in homes with shared driveways were also at a significantly increased risk.” In contrast, Murphy et al (2002) reported that 21% of the 77 incidents reviewed occurred on shared-access driveways but found “...no correlation between multiple residences using a single driveway and increased frequency of the accidents”.

Case Control Study Auckland 2003 - 2006

A detailed study was undertaken in Auckland designed to investigate the possible contribution of a range of built environment factors to the risk of runovers. This was a case-control study, with analysis based on 81 cases, identified from coroners’ reports and hospital admissions data, and 181 controls. The cases were the properties where paediatric driveway injuries (requiring hospital admission or resulting in death) involving children less than 7 years old occurred in the Auckland region, from January 2003 to December 2006. Controls were selected from the addresses of children presenting to the emergency department with a non-driveway injury.

Details of these cases and controls were obtained from three sources: the Coroner case records, Starship Children’s Hospital Trauma Database, and Middlemore Hospital admission system. All paediatric trauma cases in the greater Auckland region will be covered by either Starship or Middlemore Hospital. Starship receives children from North, West and Central Auckland and Middlemore Hospital receives children from East and South Auckland requiring care for minor trauma or orthopedic injuries, transferring more severe trauma cases to Starship Hospital.

Information on built environment factors on all of the sites was obtained from the following sources: to-scale satellite images, visual site inspection, city council building consent office records and Housing New Zealand records; the latter two sources being used to determine whether modification of the site had occurred since the date of the injury, and to ensure that the data collected related to the injury date. A range of data was collected on built environmental factors to form the database for analysis including the context of the site; the characteristics of the driveway; the access relationships between the house doors and parking areas; visibility and obstructions to drivers’ views; access restrictions such as fencing and gates; shared and adjacent driveways and turning areas; and types of dwellings.

The following built environment factors were found to be significant:

- Driveway exiting onto a local road (5-fold increase in risk)
- Driveway exiting onto a cul de sac (2.5-fold increase)
- Driveway length >12 m (2-fold increase)
- Driveway length >20 m (2-fold increase)
- Additional parking on the property connected to but separate from the driveway (3-fold increase)
- Absence of sheltered parking (2-fold increase)
- Driveway running along a boundary (3-fold increase)

A separate pedestrian pathway on the property was associated with a lower risk of injury (2-fold reduction). Details of the data analysis and findings can be found in Shepherd et al (2010)

The feature most strongly associated with driveway runover was the road type. It is hypothesized that local roads and cul de sacs may result in a lower level of parental supervision, and that with easy access onto the roadway, vehicle speed is likely to be higher and driver concentration lower than when exiting onto a busy road. The median driveway length for the control properties was 12 metres, with dwellings on rear sites having driveways greater than 20 metres long. A two-fold increase in risk was found for driveways longer than 12 metres and for driveways longer than 20 metres. A longer driveway may allow vehicles to reach greater speeds, increase the chance of children playing on the driveway, or allow more vehicles to park and move on the driveway. Additional parking may result in more vehicle manoeuvring, including driving on non-driveway surfaces. An absence of sheltered parking may result in a more rapid entry of the driver to the vehicle, reducing the time to scan the property for children. Driveways running along boundaries may result in drivers focusing on the boundary fencing when reversing rather than on the driveway itself. A separate pedestrian pathway may be a proxy marker for a separation of the driveway from the pedestrian areas of the property. For further details of this aspect of the research and a discussion of these findings see Shepherd et al (2010).

So what has housing affordability got to do with the built environment risk factors?

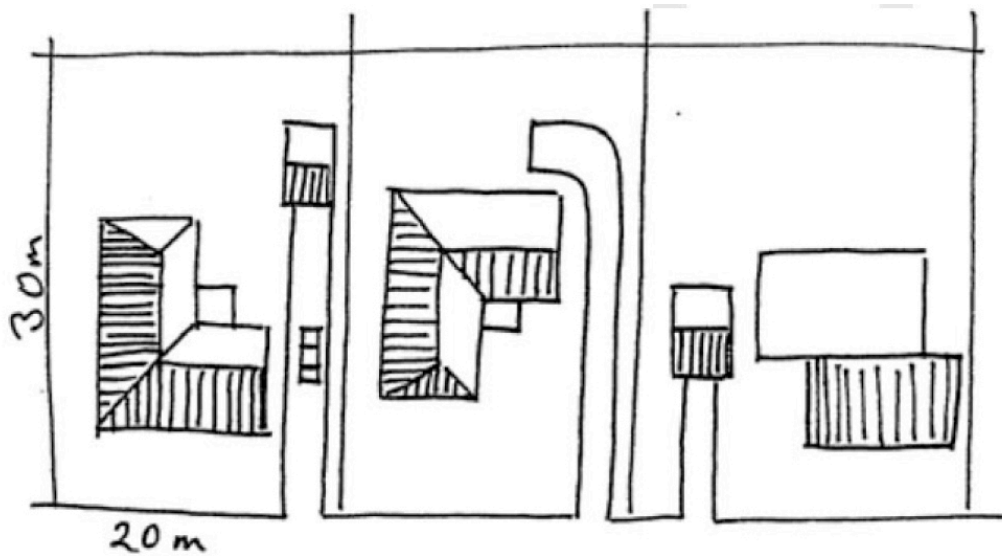
Housing affordability may be a contributory factor to these risk factors at several different levels. At the micro-level of the household, it is likely that households with limited resources are less able to modify their properties with fencing, to separate play areas from driveways, and less able to provide formalised driveways, parking areas and sheltered parking. This is partly because of the costs involved in construction but also because households with limited resources are more likely to be living in rental properties and are reliant on their landlords for provision of facilities on site or for permission to modify the property. At the macro-level of housing policies, local council plans and sub-division designs to address various aspects of housing affordability, it is possible that they may have contributed to:

- non-existent formal driveways and / or parking areas on properties
- poor relationships between house doors, play areas, driveways and parking areas
- longer driveways and driveways along side boundaries
- pedestrian routes through vehicle turning areas / along driveways
- lack of separated play areas for children.

These potential contributions to built environmental risk can be investigated for Auckland by considering three critical residential built form typologies.

Type 1: Historically Auckland has had a low-density built form resulting in a preponderance of single detached houses, often with minimal front fencing. For housing built in the 1930s-70's, it is relatively common to have long formal and informal driveways, extending from the road past the front lawn and side of the dwelling to a garage or carport in the rear.

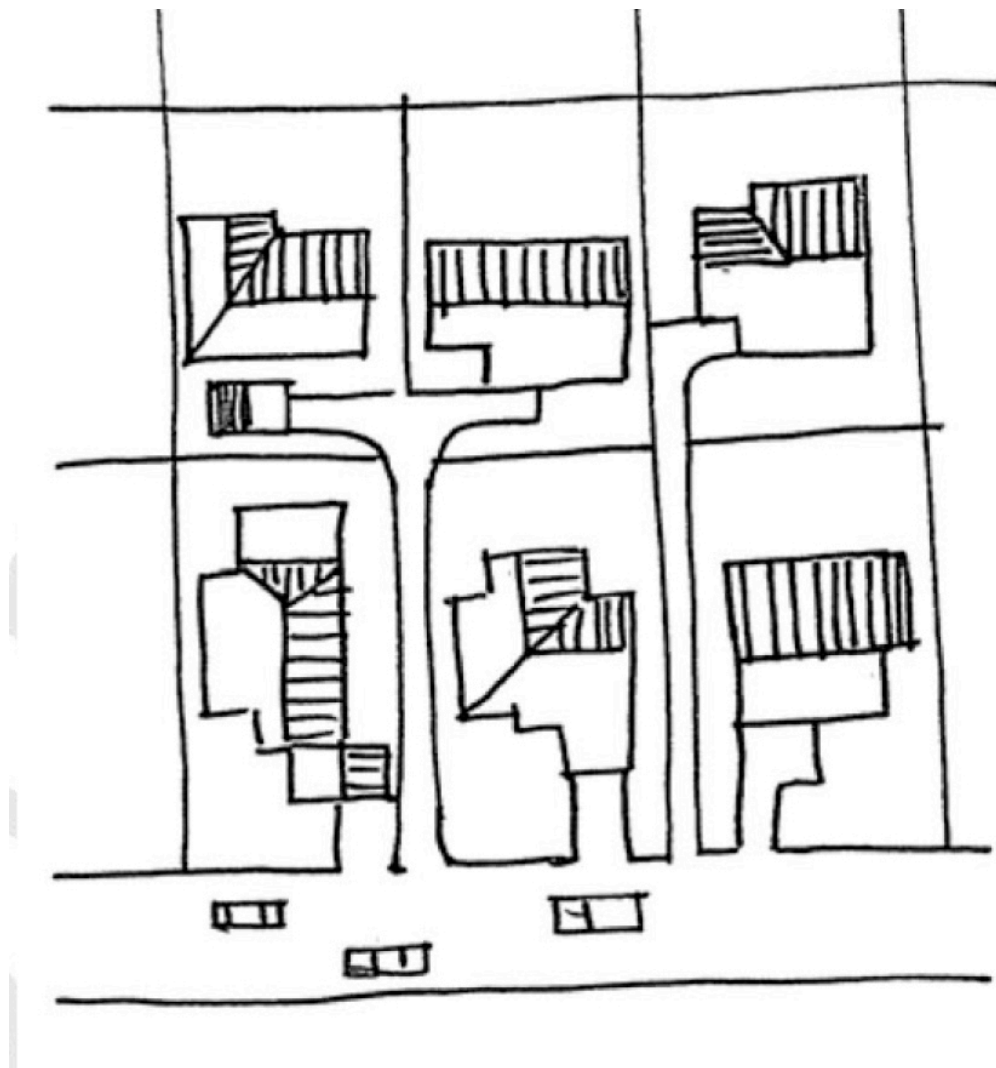
Figure 1: Typical 1970s suburban development



Type 2A: In some new suburban greenfield subdivisions in Auckland, from the 1970s on, a pattern of development was adopted with narrow road frontages for the front property and long side-driveways accessing rear single-detached dwellings. These are known as battle-axe lots.

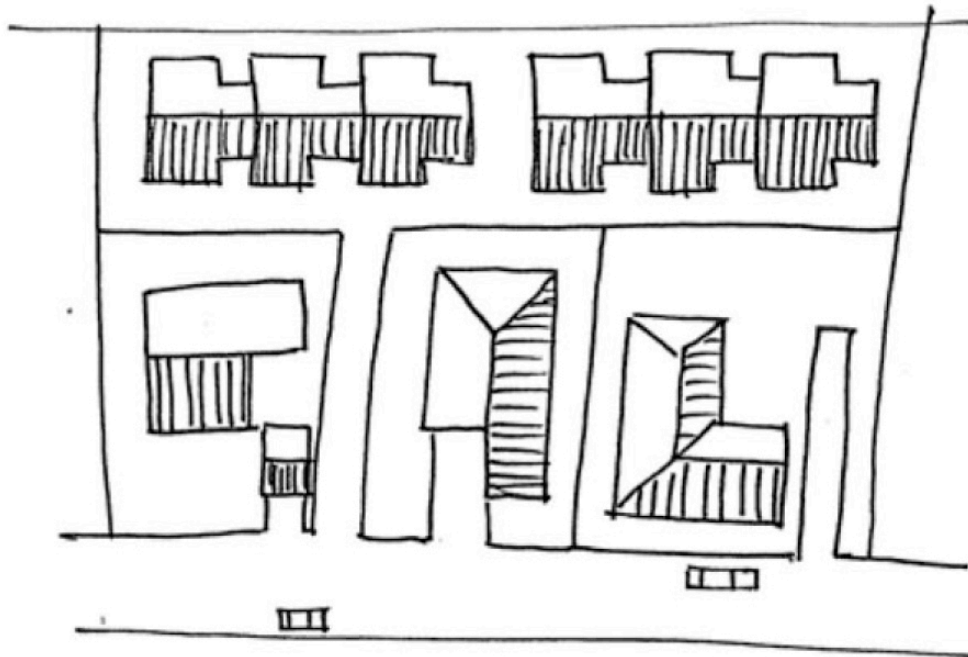
Type 2B: A common form of intensification of the existing urban areas in the mid-1980s on involved the subdivision and development of the rear of existing properties, accessed by long driveways running along the side boundaries of the sites, resulting in a similar battle-axe lots residential layout.

Figure 2: Battle-axe lots



Type 3: From the mid-1990s, there has been extensive development of terrace housing and 3-storey 'town-houses', often on infill sites zoned for commercial development. These developments utilise shared driveways and turning areas to access internal garages or parking areas.

Figure 3: An example of medium density infill terrace housing at the rear of existing dwellings accessed by a shared driveway



Type 1: Post-war suburban development, housing affordability and the New Zealand dream

In the post-war period, government policy supported access to affordable suburban housing for low to moderate-income families. This housing came in the form of newly constructed single-storied three-bedroom stand-alone houses on 750 – 1,000 sq metres, provided on networks of local streets and cul de sacs. In order to meet the needs of marginal owner-occupiers, the government introduced 3% interest rate loans in 1958, and allowed capitalisation of the family benefit a year later, giving families the means to make a deposit on the purchase of the property. Builders worked within the government’s loan constraints. As a result concrete paths, fences, clothes lines, storage sheds, driveways and garages were seen as extras, as they were not covered by the subsidised loan. (Macpherson, 1997) Many of the households would have been stretched to meet mortgage payments and few of the purchasers would have the finances to put these ‘extras’ in place, for many years. And their addition, if it took place, did not always have regard for the separation of children from moving vehicles.

The system of subsidised government backed loans did not keep up with inflation. By the mid-1970s, the builders’ standard plans for dwellings were being squeezed onto smaller sections (down to approximately 400 sq m), and any ‘extras’ were still on top of the basic house price. This shrinking of the post-war suburban dream often resulted in narrow sites or oddly shaped sections at cul de sac heads. The space on the site for the driveway was pushed to the side boundaries. The entrances to dwellings were not clearly defined, for example: “... verandahs, porches or canopies were skimpy or omitted entirely on the grounds of economy”. (Reynolds and Bonny, 1976) This contributed to poor relationships between the dwellings’ entrances and exits, children’s play areas and, if added, driveway and parking areas. During the 1980s and 1990s households, that could afford to do so, may well have purchased a freestanding detached garage from one of the specialist companies that provided garages and finance packages. Garages provided the opportunity to expand domestic and community

space, taking precedence over car storage, (Macpherson, 1997) and, as a result, were not necessarily located on the property with regard to car movements. Thirty plus years later, many properties in Auckland still have no sheltered parking and have unformed driveways with multiple car movements on site, or long driveways running along side boundaries ending in parking areas to the rear of the dwelling.

Type 2A: Suburban sub-division and the efficient use of land

The Australian Joint Venture for More Affordable Housing (JVMAH) published 'Guidelines for Cost-effective Residential Land Development' in 1986. This publication, which was influential in Auckland, advocated a reduction in lot size; maximizing the usable private open space by minimising the space set aside for driveway and car parking area; placing the carports on zero lot line (ie side boundaries); and a greater use of battle-axe lots "... to maximize number of allotments served by available road frontage." (JVMAH, 1986)

The JVAMH guidelines were supported in New Zealand by the National Housing Commission, which published its own guidance on 'Alternative Housing Options: Two for One' in 1986. Numerous examples of battle-axe lots developed from the 1980s onwards can be identified in Auckland. This type of subdivision can and does result in complex patterns of vehicle movement at cul de sac heads, often involving reversing vehicles. The built environment at some of these heads includes multiple driveways from neighbouring properties; driveways along boundaries (from 12 – 20 plus metres); little or no fencing between driveways; no fencing between driveways and play areas; and several car-parking areas on individual sites.

Type 2B: 1980s on: Residential intensification seen as a response to housing affordability

Residential intensification in Auckland was well under way by the mid 1980s, with half of the building permits in 1985 being for cross-leases, minor dwelling units or new multi-units on site. Housing affordability was identified by the Auckland Regional Authority (ARA) as a major driver: '... residential consolidation is believed ... to reduce housing cost pressures arising from shortages...' (ARA, 1987) More than half of the local council ordinances concerning on site vehicle parking required driveways to be long and extend to the rear of dwellings: for example '...no part of a parking space shall be located within a front yard, side yard, outlook area, outdoor living area or service court.' (ARA, 1987). None of the local council ordinances at that time specified physical separation between the living courts, driveways or parking areas.

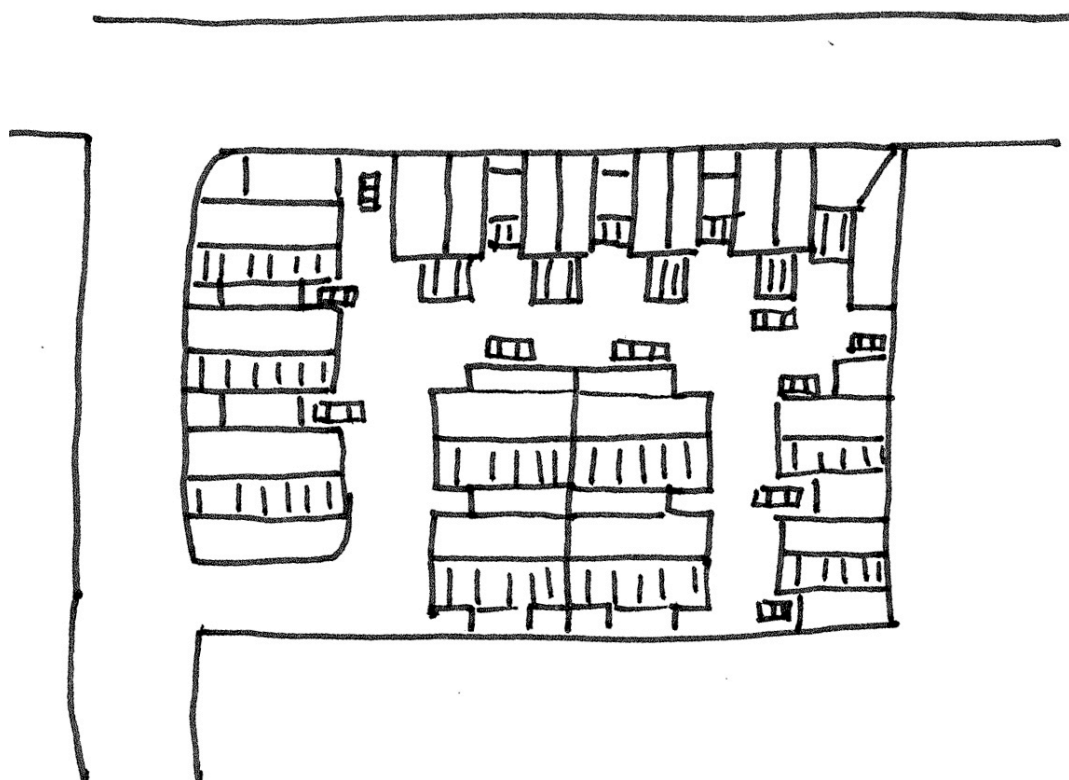
Australian guidance on intensification was influential in the early 1990s and in several cases was incorporated into the first generation of District Plans produced under the Resource Management Act 1991. The New South Wales Dual Occupancy Design Solutions Manual (1994) provides examples of "Preferred Design Solutions" which can be identified in Auckland's current built form. A common feature of these preferred solutions is the development of a dwelling on the rear site accessed by a long driveway running along a side boundary. This driveway is the only pedestrian route for the rear dwelling and easy access is shown from the exits and entrances to the dwelling both to the driveway and to the vehicle turning round area – where vehicles would be reversing. Fencing to restrict access to the driveway is not identified on the various preferred solutions. In the preferred solution for wedge-shaped sites, the combination of driveways, vehicle turning areas and garages takes up more than a third of a site for two dwellings. Potential children's play areas are squeezed to the edge of the site and there are no restrictions (such as fencing) limiting access to the driveway area. Pedestrians wanting to reach the street have to walk through an area designed for manoeuvring vehicles.

Type 3: Mid 1990s on: Ongoing residential intensification

The Auckland Regional Growth Strategy was adopted in 1998 and included support for residential intensification at transport nodes and along corridors.

The Growth Strategy was based on the premise that housing affordability would be primarily addressed through housing choice, and costs per unit would decrease with town houses, terrace houses and apartments on smaller sites. Developers saw the opportunities for residential developments in the form of terraces and small apartment buildings on commercially zoned sites. Limited guidance or controls were provided by the councils in the region for quality residential environments on these sites. As a result, in many of these developments, communal space is dominated by car manoeuvring (and reversing) areas; there are no separate pedestrian routes through the site to the street; and the provision of separated children's play areas is non-existent.

Figure 4: Terrace houses with all communal space dominated by car movement.



Housing and driveway design as if children mattered?

As noted in the introduction to this paper, the factors contributing to the high rate of driveway runovers in Auckland include vehicle design, human error and built environment factors. Our previous research, using a case control study, identified the built environment factors that had contributed to the risk of driveway runovers of children in Auckland. (Shepherd et al, 2010). These built environment factors are not found in all of Auckland's residential areas but can be identified in particular with various housing typologies that have been developed over time as different responses to the provision of more affordable housing. The three typologies examined have in different ways contributed to ill-conceived layouts from the entrances and

exits of the dwelling to the car maneuvering areas; with children's play areas either non-existent or adjacent to driveways and reversing areas. The problems are compounded for low-income families, as they may be unable to afford to modify their sites (or may not have the landlords' permission to do so) by forming driveways, and erecting fencing to separate driveways from play areas.

Cooper Marcus and Sarkissian's 1986 seminal work *Housing as if People Mattered* includes the following: 'the designer's minimal task is to provide ... parking for each dwelling that is ... clearly separated from pedestrian and play areas...' In Auckland, it would seem that inadvertently, implementation of policies and plans to address housing affordability concerns have ignored or compromised this minimal task.

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