Trip Chaining: Understanding How New Zealanders Link Their Travel

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An important note for the reader

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We would also like to recognise the individuals within these and other organisations whose comments helped us to focus the output from this project into the areas of greatest interest and usefulness to them. In particular, we appreciate the assistance from Peter Stopher (Institute of Transport Studies, University of Sydney), our peer reviewer, who provided timely and thoughtful advice on the project in its formative stages and later on the reporting.

Contents

Executive Summary

This research report describes the reformulation during 2003-2004 of the LTSA's 1997/1998 New Zealand (Household) Travel Survey trips database into trip chains and tours and provides some preliminary results using the reformulated datasets. The reformulation required us to create definitions and programming sequences for the key elements of the new datasets (segments, trip chains, tours, main mode and main purpose) as well as a new tour classification scheme, which acknowledges the distinctive travel patterns for different tour purposes.

The Nature of Short Trips

Trip chains describe how New Zealanders link their travel between "significant" locations, namely home, work or education, and other activities where they remain more than 90 minutes. A trip from home, stopping at a shop for a newspaper and travelling on to work is an example of a trip chain. Highlights of our trip chain analysis include:

- 48% (of all trip chains) are only one segment and a further 33% are two segments.
- 22% are less than 2 km in length and 51% are less than 6 km.
- 90% use only one mode of transport (48% are vehicle driver trip chains; 25% are vehicle passenger and 13% are walking).
- Of the chains with vehicle driver as the main mode, 13% are less than two kilometres long and 42% are less than six kilometres.
- Fairly equal numbers of trip chains have the purposes of Subsistence (work or education), Maintenance (personal business, shopping, etc) and Discretionary (social, recreational, leisure) – 24%, 21% and 24% respectively.

"Tours" describe how New Zealanders link their trip segments in a round trip that begins and ends at home. A simple tour could consist of leaving home, travelling to work and returning home again at the end of the working day. Tours may consist of multiple segments, either for the same purpose (e.g. a "multi-part" work tour) or for a mix of purposes (e.g. a "composite" work tour, containing non-work segments). Key fundamentals from our tours analysis include:

- 56% (of all tours) are simple, two segment tours (e.g. home–activity–home); a further 17% are three segment tours.
- 28% are less than 4 km in total and 53% are less than 10 km.
- 84% use one mode of transport; 47% are vehicle driver tours.
- 66% have a main purpose other than work or education.
- 23% are for work purposes; nearly half of these are simple two segment tours and over 75% have "vehicle driver" as the main mode.
- 10% are for education purposes; 86% of these are completed by 3 to 17 year olds.

We examined the relationship between vehicle driver tours in terms of their length and the type of tour in order to identify what potential there is for encouraging environmentally friendly mode use, particularly walking and cycling. Nearly all walking tours (98%) in New Zealand are less than 10 km in total; 83% are less than 4 km. With respect to cycling tours, nearly one-half (48%) are less than 4 km, while 82% are under 10 km. This suggests that targeting vehicle driver tours of less than 10 km is a reasonable proposition.

We found that 19% of vehicle driver tours are less than 4 km and 46% are less than 10 km in total length. When examined by type of tour, we established that "simple" vehicle driver tours of all types were far more likely than composite or multi-part vehicle driver tours to be less than 4 km long. Nearly 68% of all simple non-work/non-education vehicle driver tours are less than 10 km, compared with 46% of simple work tours and 40% of simple education tours.

Examining vehicle driver tours that are under 4 km in length (i.e. averaging less than 2 km "each way") seems reasonably comparable in principle to the New Zealand Transport Strategy emphasis on vehicle driver trips (segments) less than 2 km. The results are markedly different however: 33% of vehicle driver segments are less than 2 km, but only 19% of tours with vehicle driver as the main mode average less than 2 km each way.[1] Such differences have important implications for analysis of sustainable transport. Furthermore, the alternative of considering trip chains up to 2 km long also delivers a result markedly lower than 33%; only 13% of chains with vehicle driver as the main mode are less than 2 km.

Potential New Performance Indicators

We demonstrated the potential to develop new performance indicators using the trip chain and tour datasets, presenting baseline performance indicators for walking-only and cycling-only trip chains less than 2 km long in the three major cities. For example: in Wellington 58% of trip chains less than 2 km long are walked, and in Christchurch 6% of trip chains less than 2 km long are cycled. More general *national* performance indicators of increasing cycling and walking mode share, based on main mode, can also be derived using the new datasets.

School Travel

We considered trip chains involving the travel of children to and from school, both from the perspective of the children going to school and, in the cases where the children were passengers in a vehicle in Auckland, Wellington, and Christchurch, the vehicle driver. We believe this to be the first assessment of mode share or purpose of children's travel *from* school, either nationally or by disaggregated groups. Referring to children's (aged 5-17) travel to and from school, we found that:

- 85% leave home and go straight to school (no interim stops are made on the way).
- Trip chains from school are more complex than those going to school.
- In the three main centres, there is a significant contrast between how some age groups travel to school and from school.
- Dramatic differences in mode use for trip chains from school are shown by 2-year age groups (ages 5-6, 7-8, 9-10, 11-12, 13-14, and 15-17).

Until we created such reformulated datasets, it has not been feasible to describe the journey made by the vehicle driver dropping children off to or picking them up from school. However, due to the small sample size available for analysis, the results for driver trip chains must be regarded as indicative only. With respect to driver trip chains to school in the three main centres, we determined that:

- 27% had the sole purpose to drive a child/children to school and 56% ended at work or their own place of education.

1 Note that we are not suggesting that all driver tours of less than 4 km in total are walk- or cycle-able. Due to factors unknown to us, such as time constraints, having heavy loads to carry, catering to other passengers who may not be able to walk or cycle themselves, driving a company car, and so on, an individual's mode choice may (at a given point in time) be limited to car driver.

- 25% of the home to school segment of all chains (regardless of purpose) were less than 1.4 km – an easily walk-able distance; 50% were less than 2.5 km (i.e. walk- or cycle-able).

For driver trip chains from school, we established that:

- 59% start from home and 34% start from work.
- 69% do not have any other purpose than to pick up their child/children and either accompany them to a child-related activity or take them home.

This information highlights some reasonably obvious targets for efforts to change mode use, such as those who drive home immediately after dropping off or picking up their child at school and who thus have no other reason for being on the road at that time. Such drivers make up around a quarter (27%) of the total driving children to school and probably even more of those driving children from school. For many of these journeys, the distance between home and school is eminently "walk-able", suggesting that other factors may be causing these parents to drive.

It also highlights the fact that primary school children (5-12 year olds) are the ones who are most commonly driven to and from school, whereas 13-17 year old urban dwellers are commonly driven to school but use a different mode to travel home. This suggests that targeting for school travel initiatives should focus on primary schools for both journeys. With high schools, there is probably a need to be more selective as to where school travel initiatives are undertaken.

Potential for Further Research

The results presented here draw attention to the potential of the reformulated trip chains and tour datasets to improve understanding of New Zealanders' travel behaviour, particularly the nature and frequency of "short trips". It is essential to realise there are many other possible applications for the trip chain and trip tour datasets. Hence the most important outputs from the overall research project are the datasets and the associated programming rather than the initial reports.

Abstract

There has been increasing interest by governments in New Zealand in replacing short car trips (<5 km) with trips using other more environmentally friendly modes, such as passenger transport, walking and cycling. However, discussion of the *potential* for changing short trips often misuses the available data, with the potential cited being based on trip "segments" (or legs), which often differ from what most people would consider as a "trip" or what we define as a "trip chain".

The LTSA's 1997/98 New Zealand (Household) Travel Survey database during 2003-2004 has been reformulated to derive trip chains and tours (beginning and ending at home) to better understand New Zealanders' travel behaviour. Among other things, the research helps to:

- correct widespread misunderstandings about the nature and frequency of short trips,
- enable better quantification of potential for change from short car trips to other modes,
- provide inputs for developing policy and infrastructure programmes,
- enable new and improved performance measures.

1. Introduction

1.1 Background

Recently in New Zealand there has been an increasing interest by various Government agencies, Regional Councils and the general public in "short trips", particularly with respect to how to replace short car trips (<5 km) with trips using other more environmentally friendly modes, such as passenger transport, walking and cycling. This interest is, as yet, unaccompanied by any significant research focus on the extent or nature of short trips, unlike the situation in Europe where there has been considerable attention on both short trips and walking and cycling (e.g. ADONIS 1998; WalCyng 1997; Mackett & Robertson 2000).

Not only is there a lack of research on short trips in New Zealand, but also current discussions about short trips and the potential for changing them often misuses the available data. For example, the *New Zealand Transport Strategy* (Ministry of Transport 2002a), states as a "key fact" on transport and public health that "One third of vehicle trips were less than two kilometres and two-thirds were less than six kilometres" (p.39). This statement is merely an echo of various other prominent government documents and strategies.[2] The common interpretation is that these short trips can easily be converted to other more environmentally friendly and healthier modes such as walking and cycling.

Unfortunately, we found this statement to be materially exaggerated. The underlying data for such claims is the New Zealand (Household) Travel Survey (LTSA, 1997/98, established on a continuous basis in 2003). The results cited refer to "trip legs", which often differ from what most people would consider as a "trip", which is closer to what we define as "trip chain" in this paper. For example, if I drive home from work but stop briefly twice (e.g. to get a newspaper, and later to pick up children), that travel comprises **three trip legs** but only **one trip chain**. If the trip legs are each relatively short (i.e. < 2 km), then there might be a perception that some or all could be replaced by walking, when in fact, as part of the longer trip chain, the mode for each leg cannot be individually substituted. In fact, our earlier work on mode choice, using a stated choice experiment, revealed that morning peak car drivers were more resistant to changing mode if they were trip chaining on their way to or from work (O'Fallon et al. 2004).

We have reformulated the 1997/98 NZ (Household) Travel Survey database to derive trip chains and tours (round trips beginning and ending at home or work) to better understand New Zealanders' travel behaviour, particularly their use of the car. Among other things, our work helps to:

- correct widespread misunderstandings about the nature and frequency of short trips,

2 For example, the recent *Getting there – on foot, by cycle – a draft strategy to increase walking and cycling in New Zealand transport* (MOT October 2003), stated that "a significant proportion of our motor vehicle trips (around 30%) are for distances of under two kilometres" (p.7) while acknowledging that "trips" referred to a (trip) leg in a journey.

- enable better quantification of potential for change from short car trips to public transport and active modes (walking and cycling),
- establish generally accepted definitions and procedures for trip chains and tours,
- establish new performance indicators,
- provide inputs for the development of business cases for policy and infrastructure programmes,
- improve the knowledge about the complexity of travel behaviour (by enabling analysis of units of travel such as chains and tours that are more complex than segments/trip legs),
- provide inputs for the development of business cases for policy and infrastructure programmes,
- enable new and improved performance measures about short trips.

Our end users generally specified urban-based information as being most desirable, as this continues to be where the majority of projects addressing travel behaviour change and/or mode shift are focused. We also provide some examples of how the research output might be used. First, we show possible new performance indicators for walking and cycling mode share of short trips. Second, we demonstrate the analysis of trip chains involving the travel of children to and from school. This includes, for New Zealand's three main urban centres (Auckland, Wellington, Christchurch), some analysis of the nature of vehicle driver trip chains where the chain includes transporting children to or from school. These vehicle driver results relating to school travel are a relatively complex use of trip chains because they involve a linkage to a separate and complicated analysis of vehicle occupancy completed for the three main centres (Sullivan & O'Fallon 2003).

Note that this project can only illustrate a handful of the very large number of possible uses of trip chains and tours. There are many other possible applications for the trip chain and trip tour datasets. We believe the most important outputs from the overall research project are the aggregated datasets and the programming that goes with them rather than the small number of results presented in this report.

Examining tours and trip chains enables researchers, decision- and policy-makers to better understand some aspects of travel behaviour (e.g. the potential impact of multi-purpose journeys on the choice of travel modes), so that better policy tools can be developed to address issues such as traffic management and environmental degradation and creating a sustainable land transport system.

Encouraging individuals to change modes for **existing** short trips is only one way of increasing the mode share of public transport, walking and cycling. Other tactics might include:

- encouraging people to consider transport issues when making major life decisions (e.g. where they live/work/send their children to school), that is decisions that will impact on their ongoing daily transport choices,
- encouraging people to consider their choice of some destinations, in order to gain the benefits (e.g. increased fitness) that walking or cycling can provide,

- working toward land use that provides more destinations within shorter distances,
- providing a transport system and transport services that encourage the use of passenger transport, walking and cycling.

Finally, note that although the current NZ (Household) Travel Survey dataset is now reasonably "old" (being compiled in 1997/98), the survey was established as a continuous survey in 2003. As the continuous survey is using the same questions as the previous survey, it should be possible to apply our programming to the updated database and thus monitor trends in travel patterns.

1.2 Report Structure

- The remainder of the paper is structured as follows:
- Section 2 – outlines our project definitions, including the literature review findings.
- Section 3 – outlines our project methodology, namely the derivation of the reformulated trip chain and tour datasets from the original 1997/98 New Zealand (Household) Travel Survey database.
- Section 4 – outlines the fundamental trip chain results based on our reformulated trip chain dataset.
- Section 5 – outlines the fundamental tour results based on our reformulated tours dataset.
- Section 6 – demonstrates a potential use of the reformulated datasets to derive performance indicators.
- Section 7 – demonstrates another potential use of the reformulated trip chain dataset to enhance knowledge about travel to and from school, from the perspectives of children *and* those who drive the children.
- Section 8 – presents our conclusions.
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2. Definitions

2.1 Introduction

Axhausen (2000) points out the need for clear definitions to make sense of the observations and outcomes of survey-based research. Such clarity is important for others who wish to understand how and why the conclusions were reached, and for comparability with other research project output. Hence, in reformulating the NZ (Household) Travel Survey (NZHTS) database to create new datasets, we had indicated our intention to base our terminology and definitions of the linked segments of travel on precedents in the published international literature.

Although the idea of linking trip legs together seems reasonably straightforward, Krizek (2003) pointed out that "the concept is more difficult to operationalise". This became particularly evident when, on reviewing the material available, we found a lack of consistency in the terminology and definitions used with respect to trip chains, tours, segments, trips, main purpose and main mode. In fact, many authors did not define any of their terminology, or did so only in a loose way. While this could be construed as quite liberating (as we had increased scope to devise our own definitions), it was largely frustrating as this made it difficult to readily compare our work with previous research findings and, hence, build on the international knowledge base in a coherent fashion. McGuckin & Murakami (1999) provide a reasonable summary of the situation:

> *Although there is no formal agreement on the definition of a chained trip, many transportation professionals believe that they know a trip chain when they see one (p.80).*

The following section summarises what we found in the overseas literature (including that "published" electronically and as journal papers, conference proceedings, etc.) with respect to definitions and terminology for use in this research project and discusses the considerations we made in deriving our project definitions. In addition to reviewing the literature, we consulted with end users and our peer reviewers on their views as to what seemed sensible in a New Zealand context. Note that we have headed the sections with our preferred terminology.

2.2 Segment

In order to avoid confusion when discussing analysis based on the reformulated 1997/98 NZHTS datasets, we wanted to adopt an alternative to the term "trip leg" and to the more commonly used term "trip" (which variously means either a "trip leg" as presented in the NZHTS database or a "trip chain" or "tour" as we have defined them in this paper, depending on whose work you are referring to).

Several studies based on the US Nationwide Personal Transportation Survey (NPTS) use the term "trip" to refer to something akin to the NZHTS "trip leg" concept (see for example, McGuckin & Murakami 1999; Strathman & Dueker 1995; and Gordon et al. 1988). In these cases, a "trip" is articulated as a "one-way segment of travel between an origin and destination, by any means of travel" (McGuckin & Murakami

1999). On the other hand, Axhausen (2000) and Cirillo & Axhausen (2002) defined trip as "the movement between two meaningful and substantial activities" where there could be more than one mode used for travel between the two activities and additional (minor) stops could also be incorporated. This is quite different from the NPTS or NZHTS definition where either of these occurrences (changing modes or other stops) would be designated as a "stop" or end point, with a new trip or trip leg starting with the movement to the next location. Given such multiple definitions and inconsistencies around the term "trip" we chose to avoid it.

A wide variety of other terms have been used to describe a concept similar to our "segment", including trip link, activity stop, or stage. None of these terms is ever used to refer to trip chains and tours, but nor is there consensus on a preferred term. Hence, we chose to use "segment" both because this term appropriately suggests that it is part of a larger unit of travel (chains or tours) and because of the wish to avoid any previous misunderstandings arising locally from the treatment of "trip leg" and "trip" as synonymous.

2.3 Trip Chain

2.3.1 Definitions Based on Home and Work

McGuckin & Murakami (1999) noted that "different terms and expectations exist as to what types of trips should be considered part of a chain" (p. 80). They illustrated their point with a simple diagram (Figure 2.1), stating that what is shown could be described as:

- four separate trips ("segments" using our terms),
- two trip chains, one from home to work and one from work to home,
- one home-based tour.

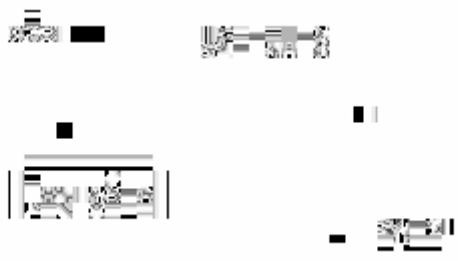


Figure 2.1 An illustration of trip types. (Source: McGuckin & Murakami 1999)

The variation in how the term "trip chain" is used and defined in the literature is exemplified by the following examples:

- Sometimes a "trip chain" is characterised as a series of travel that almost always begins and ends at home, thus being what we will define as a "tour" (see Section 2.4): Strathman & Dueker (1995), Nishii et al. (1988), Hensher & Reyes (2000), Lee et al. (2002) and Golob (1986) all adopt this formulation. Strathman & Dueker (1995) also define a series of work-based trip chains.

- Sometimes a trip chain is anchored at home or at work (i.e. when an individual is departing from home or departing from work, this begins a new chain). There may be one or more segments within the chain. This is the case with Wallace et al. (2000) and Rutherford et al. (1997). While the terms are not actually defined, it appears that Rosenbloom (1998) and Bianco & Lawson (1998) have adopted a similar meaning.
- Sometimes what is labelled as a "tour" could be better understood as a "trip chain". McGuckin & Murakami (1999) describe trip chains as a set of trips in a tour. However, they then define four types of "tour":

  1. beginning at home and ending at work,
  2. beginning at work and ending at home,
  3. beginning and ending at work,
  4. beginning and ending at home.

McGuckin & Murakami's (1999) use of the word "tour" to describe some of these linked segments of travel appears misleading given that the word implies "a going around" or "a journey in a circuit" (Webster's Revised Unabridged Dictionary 1998).

2.3.2 Introducing a Temporal Element to Chaining Definition

As can be seen, most definitions focus on either work (including education) or home as a reason for breaking a "trip chain". Given the considerable amount of non-work travel that occurs, we wanted to develop a definition for trip chain that meaningfully described non-work trips (e.g. shopping, recreational, personal business and leisure). Hence, we wanted to have an element of "stop duration" included in our definition of trip chaining. This would allow the chain of travel to be broken if a person spent a "reasonable" amount of time at a given location, generally thought to reflect the main purpose of their journey.

Other reasons for introducing the "stop duration" as a basis for breaking linked segments of travel include the desire to characterise the length, mode(s) used and purpose of such chains so that decision-makers have better information to identify potential populations for travel-behaviour-change programmes.

In the past decade, few researchers have used "time" to actively break a chain. We found Rutherford et al. (1997) and Wallace et al. (2000) broke a chain if a person stopped for >90 minutes at a single destination. They chose this figure based on earlier work done by Hodge (1991, cited in Rutherford et al. 1997). Rutherford et al. (1997) stated that:

> *Breaking a chain after a time threshold served as a mechanism to clearly delineate the importance of the home and work trip anchors in determining trip chains. In addition, Richardson and Young argued that the use of temporal constraint serves to reduce the number of unrealistically long chains and could make the process of exploring travel more tractable (1982, p.113).*

Note that the purpose of the break was to place more emphasis on the work and home trip anchors, rather than highlight non-work travel.

Krizek (2003) cites several earlier references[3] wherein 90 minutes or something similar was also used to break a chain, although he offers no explanation as to why this particular time period was chosen.

In addition to underscoring other purposes for travel, such a temporal break also allows analysis of environmental impact, as it reflects the increased probability of a "cold start" when a car is the mode of travel. Shiftan & Suhrbier (2002) assessed the probability of hot versus cold starts, albeit without "breaking" the tour. Instead, they determined whether a segment was part of the outbound or return portion of a tour, then whether it was the first or subsequent segment in that portion and, finally, if less than 2 hours had passed since the previous segment of travel, they assume the segment to be a "hot start".

In an attempt to provide ourselves with a more informed basis for introducing a temporal element to the chaining definition, we analysed research that addressed the mean activity duration for different activities.

Cirillo & Axhausen (2002) analysed the Mobidrive data collected in Karlsruhe and Halle, Germany, to develop an understanding of mode choice of complex tours. The Mobidrive data is based on 160 households, with 360 members, who completed travel diaries over a six-week period in 1999. Their analysis compared the spatial and duration characteristics of activity patterns of workers with non-workers. For non-workers, Cirillo & Axhausen (2002) identified the "principal activity" as the out-of-home activity with the maximum duration occurring during a 24-hour period. The "main activity" is the activity with the longest duration in travel patterns other than the "principal activity" or "work" activity pattern.

As illustrated in Table 2.1, Cirillo & Axhausen (2002) found that the mean duration of the main activity within an activity pattern varied significantly, depending on whether it was a worker or non-worker activity pattern and the time of day in which it occurred.

Table 2.1 Mean duration of activities within activity patterns of workers and non-workers. (Source: drawn from Cirillo & Axhausen 2002)

Timing of activity	Mean duration (min)	Timing of activity	Mean duration (minutes)
Workers		Non–workers	
Morning (before work)	37	Before principal activity	41
Home to work period (with activities on the way)	14		
Work duration	405	Principal activity	130
Work to home period (with activities on the way)	21		
Evening (post-arrival home)	87	After principal activity	45

3 These were published between 1967 and 1985. Unfortunately we have not been able to obtain these references to understand the rationale behind the authors' choice of time cut-offs.

Levinson & Krizek (2004) conducted a similar analysis based on data from the "Twin Cities" (Minneapolis / St Paul) metropolitan area and for the Washington DC metropolitan area. They compared the mean duration per day of various activities by gender for workers and non-workers. They found that, in 2000, in the Twin Cities, workers spent 10 to 15 minutes shopping compared with non-workers who spent 20-40 minutes, while in Washington DC, in 1994, workers spent around 10 minutes compared with 30 minutes (male) and 50 minutes (female) for non-workers. Time spent on other out-of-home activities ranged from 45 minutes for workers to around three hours for male non-workers in either metropolitan area.

Schwanen & Dijst (2001) used data from a sub-sample of workers in the 1998 Dutch National Travel Survey (based on a one-day travel diary) to identify "time windows" in their activity patterns (e.g. home to work, with or without stops along the way, or home-based evening travel to undertake further activities). While the "time windows" estimated the mean duration of the whole activity pattern, Schwanen & Dijst (2001) were also able to differentiate between those who had "long" work duration compared with short work duration, and to identify the primary activities occurring in the activity patterns.

Table 2.2 shows that a very narrow range of time is spent on travelling to and from work without any stops on the way, compared with those journeys which include activities on the way to and from work. In the home to work period, the mean number of minutes spent increases from 24 (with no stops) to 98 when activities occur; while in the work to home period, the mean time spent increases from 25 minutes to 159, although there is considerable variation in the duration.

Schwanen & Dijst (2001) report that Maintenance (personal business and shopping) is the primary purpose of the activities undertaken, with the purpose of "serve passenger" being an important feature for those with shorter work durations. Unfortunately they do not discuss how many activities occur in each time window, so we cannot compute an average time spent per individual activity.

Table 2.2 Mean number of minutes spent on travel and activity by time window time window length in minutes). (Source: drawn from Schwanen & Dijst 2001)

Time window	Range	Overall mean
Home to work period (no stops on the way)	18 – 38	24
Home to work period (with activities on the way)	38 – 155	98
During work period	23 – 150	50
Work to home period (no stops on the way)	19 – 34	25
Work to home period (with activities on the way)	60 – 305	159
Post-home arrival period	72 – 162	111

The main conclusion we can draw from the preceding analysis is that there is a wide variation in the time spent on any given activity, dependent on a range of factors, including:

- whether the person involved is a worker or non-worker and is male or female,

- the time of day (before or after work; on the way to or from work or during the work day),
- the purpose (shopping or leisure or personal business).

Clearly, there is no one "stop duration" value that will delineate the main activity of a travel pattern for all individuals or that can be said to accurately reflect how an individual thinks of their travel behaviour. Hence, as the time duration chosen to break a chain was unavoidably going to be arbitrary to some extent, we decided to adopt the 90 minute criterion used by Rutherford et al. (1997) and Wallace et al. (2000), as it permits analysis of additional energy consumption and pollutant emissions due to cold starts. In addition, Cirillo & Axhausen (2002) and Schwanen & Dijst (2001) both show that large portions of non-work activities have durations of at least 90 minutes but often longer.

Applying the 90-minute criterion to the NZHTS reduced the 124,000 usable segments of travel in the database to around 65,000 trip chains. Of these, about 15,000 chains are generated because the stop time is greater than 90 minutes. (The rest were generated because they were the start of the travel day or starting from home or work.)

We also explored using stop durations of ≥30 minutes and ≥10 minutes as generators of new trip chains. Using ≥30 minutes increased the number of trip chains by approximately 16,000, to around 81,000 trip chains (compared with 65,000 using >90 minutes), while using stop duration of ≥10 minutes increased the total number of chains to around 92,000 trip chains. This exploration confirmed that the 90 minutes criterion produces a distinctive new unit quite different from trip segments (trip legs).

If we were to choose a chain breaking point of ≥10 minutes, the results might have been very similar to analysis by segments, raising the question of "why bother?" Using ≥30 minutes may have generated an interesting analysis, but we have not found any precedents for such a time break in the literature as there was for >90 minutes.[4]

2.3.3 Summary

As a result of the literature review (and consultation with end users and our peer reviewer), we defined a **trip chain** as a series of one or more segments defined by *starting* a new chain whenever:

1. The segment is the first one recorded in the respondent's travel diary (any segments by plane were excluded because our focus is on land transport).
2. The starting point of the segment is home or their workplace.
3. The origin of the trip is neither home nor work, but the respondent has been at that location for more than 90 minutes (and the purpose of the immediately preceding segment was not *Change mode*).

[4] Of course, should analysis using a chain breaking point of ≥30 minutes be of particular interest for applied work, the programming completed in our project now provides the foundation for doing such analysis reliably and cost effectively.

4. Plane was the mode used for the previous segment (and plane is not the mode for the current segment).

Thus, the current trip chain *ends* when the person arrives at home or at their workplace, or when they stay at one location for longer than 90 minutes (or, in a very few cases, begin to travel by plane).

2.4 Tour

Greater consensus is apparent with respect to defining tours than trip chains. In most of the work we examined, the definition adopted for the term "tour" reflects that first provided by Adler & Ben-Akiva (1979), namely a "set of consecutive trip links which begin and end at an individual's home". This is true of: Bhat et al. (2001); Kitamura (1984); Nishii et al. (1988); Shiftan & Suhrbier (2002); Cirillo & Axhausen (2002); Festa et al. (2002); Ben-Akiva & Bowman (1999) and Golob (1986). Axhausen (2000) takes a slightly differing perspective, suggesting that tours begin and end "at the same location", thus including the possibility that a tour could begin and end at the workplace or a place of study as well as at home.

To go beyond analysing the number of stops within a tour (i.e. whether it is "simple", consisting of only two segments, or "complex", having more than two segments), it is necessary to develop other tour-type classifications. Krizek (2003) observes that classification is a useful tool that "allows many variables to be considered simultaneously", such as the timing and purpose of the tour or the purpose and number of segments comprising the tour. Several means of classifying tours are discussed in the literature:

- by the number of stops within a tour,
- by the main activity or purpose of the tour,
- by the time of day in which the tour occurs (morning, evening, pre- and post-commute tour, work-based tours),
- a combination of two or more of the above.

Some researchers develop very comprehensive classifications of tour types, such as Golob (1986) who derived 20 tour types based on the sequence and nature of activities within the tour.

2.4.1 Classification Schemes

We chose to develop two classification schemes for tours in this study, primarily to demonstrate the potential for the different types of analysis that are available with the reformulated dataset.

One classification scheme is quite simple, being based solely on purpose, with the purpose assigned on a hierarchical basis. Our "trip chain" analysis also uses this classification (described in Section 2.6).

Given the New Zealand Government's funding priority to reduce severe congestion on the roading network along with increasing walking, cycling and passenger transport use (Ministry of Transport 2002b), we wanted to adopt a classification scheme that recognised the complexity of tours and incorporated both time of day

and tour purpose. Because the most severe congestion occurs during morning and afternoon commuting periods, we drew on the classification scheme of Strathman & Dueker (1995), which categorises tour purpose into "work" and "non-work" and accommodates different levels of tour complexity (see Table 2.3).

Table 2.3 Strathman & Dueker (1995) tour classification scheme.

Description	Sequence
Simple work	h - w (-w-) -h
Complex to work	h - nw (-nw/w-) - w - h
Complex from work	h - w (-nw/w-) - nw -h
Complex to and from work	h - nw - (-nw/w-) –w- (-nw/w-) -nw- h
Complex at work	h - w - (-nw/w-) –nw- (-nw/w-) -w- h
Simple non-work	h - nw –-h
Complex non-work	h - nw -(-nw-) - h

h = home, w = work, nw = non work (including education, personal business, shopping, and leisure / recreational purposes). The bracketed terms represent additional trips that may be in the tour.

However, the work v non-work focus of this classification means that it is most useful for describing the travel patterns of the adult population, as the education-based tours (of which a huge proportion are carried out by those under 18 years old) are subsumed into the "non-work" category. We considered two possibilities to address this issue:

- Include "education" in the "work" category, effectively creating Subsistence (see discussion below) v "other" tour purposes.
- Create a new series of tour types based on the purpose "education", recognising that, for the most part, a population segment distinct from that undertaking work tours will complete these tours.

As there is significant interest in understanding school travel patterns (as part of the overall congestion issue) in New Zealand, we decided to add a new series of tour types to the initial classification scheme.

Based on our preliminary work with Strathman & Dueker's (1995) classification scheme, we found that it would also be useful to make a further distinction in the *structure* of tours, in terms of whether they were:

- "Multi-part" tours – consisting of two or more segments (e.g. several work-related segments), all for the same purpose,
- "Composite" tours – comprising segments with differing purposes (e.g. a work-related segment with one or more non-work segments).

As it stood, Strathman & Dueker's (1995) categorisation permitted "simple work tours" to be composed of one or more work-related segments (whereas "simple non-work tours" could only consist of a single non-work segment before a return trip home). We found that this grouping obscured a significant amount of tour-making complexity, particularly as "multi-part non-work tours" comprise nearly one-quarter of all tours within the reformulated dataset. In addition, their categorisation potentially confuses by using "simple" to mean two different things. For work tours,

simple indicated that the tour was not composite; for non-work tours, simple indicated that the tour was not multi-part.

As a result of these adjustments, we devised a tour classification scheme, comprising 10 tour types (see Table 2.4).

Table 2.4 Classification of tours by complexity and purpose.

Tour description	Sequence
Simple work	h - w - h
Multi-part work	h - w - (-w-) - w - h
Composite to work	h - nw/e - (-nw/w/e-) - w - h
Composite from work	h - w (-nw/w/e-) - nw/e - h
Composite to and from work	h - nw/e - (-nw/w/e-) -w- (-nw/w/e-) - nw/e- h
Composite at work	h - w - (-nw/w/e-) - nw/e- (-nw/w/e-) - w - h
Simple / multi-part education*	h - e - (e) - h
Composite education and non-work	h - nw - e - (-nw-) - h **and** h - (-nw-) - e - nw - h
Simple non-work/non-education	h - nw/ne - h
Multi-part non-work/non-education	h - nw/ne - nw/ne - (-nw/ne-) - h

h = home, w = work, e = education, ne = non-education, nw = non-work (including, personal business, shopping, and leisure / recreational purposes). The bracketed terms represent one or more additional segments that may be in the tour.

*Multi-part education tours form less than 0.5% of all tours within the dataset, hence they are combined with the "simple education" tour category.

2.4.2 Summary

Thus, for our research, we defined a **tour** as a series of segments that starts from home and ends at home. We classified these tours into 10 different types, depending on the range of activities/purposes contained within the tour itself.

Note that this definition leaves some segments not classified into any tour (e.g. segments recorded at the start of the travel diary where the respondent is not starting from home). In contrast, all valid segments in the NZHTS trip database are classified into a chain.

2.5 Main Mode

In trip chains where only one mode is used throughout the whole journey (about 90% of all trip chains and 85% of all tours in the reformulated NZHTS datasets), it is easy to determine what the main mode is for that chain or tour. However, to simplify the analysis of trip chains and tours where at least two modes were used, we wanted to determine the main mode.

Axhausen (2000) asserted that the main mode should be determined based on pre-determined rules, which are clearly laid out. He also outlined several "typical" rules, including identifying main mode as the mode with:

- the largest share of distance travel within a tour (or trip chain),
- the longest duration,
- the highest speed.

Alternatively, Axhausen (2000) suggested that hierarchies could be created based on the assumed strength of the mode to shape the movement (e.g. aeroplane-train-coach-underground-LRT-bus-car-bike-walk).

Despite Axhausen's (2000) assertion that clearly stated rules are required, we found only three articles that *explicitly* stated their main mode rule:

- Cirillo & Axhausen (2002) took the mode used for the longest duration (note that 86% of tours only used one mode). The main modes identified were: car driver, car passenger, passenger transport, walk and cycle.
- Kitamura (1984) adopted the rule "work trip mode" is identified as car, if the car was used (as car passenger, driver, car pool) in at least one trip between the home and work place.
- Strathman & Dueker (1995) used car and passenger transport, and excluded walking, in determining their main mode classification.

Other authors identify their category modes, but not how they determined them.

Given the lack of a "dominant" rule in the literature regarding the identification of main mode, we gave some thought to each of Axhausen's (2000) suggested classification rules. We considered adopting a time-based rule but discovered, when we tried to impute distances for walking journeys in the NZHTS database, that people tend to approximate the time spent on each mode (rather than accurately documenting it), often rounding it off (e.g. to the nearest 5 or 10 minutes). These approximations would also reduce the reliability of speed estimates.

Adopting the rule that the main mode is the one used for the greatest distance in the trip chain or tour appeared more sensible, because the distance (except for walking) is computed using geo-coding (as opposed to the respondent's best estimate). Hence, for example, if a trip chain consisted of driving 1 km and then walking 300 m, the main mode would be vehicle driver. Conversely, a very small proportion of trip chains that have the main mode as "walk" will include other modes such as "vehicle driver" or "vehicle passenger".

Furthermore, if a person walks 15 minutes to the train station and then travels 15 minutes by train, they have probably travelled much further by train than by foot and it seems reasonable to describe the "main" mode of travel as train rather than walking. Such a distance-based approach does potentially exaggerate the importance of faster modes over slower ones (particularly walking). Hence, it is important to remember that the main mode variable only affects 10% of all trip chains and 16% of all tours, and that the vast majority of trip chains and tours only use a single mode.

Where the distance was missing (106 cases only in the original NZHTS database), we took a hierarchical approach to assigning the mode.[5]

2.6 Main Purpose

Axhausen (2000) also discussed the need to have pre-determined rules for selecting the main or primary purpose of a trip chain (or tour). Typical rules include categorising the **main purpose** of the chain or tour by:

- identifying the activity with the longest duration,
- creating hierarchies based on the assumed strength of the activity to shape the individual's movement.

Our review of international experience indicated that many studies use a combination of the two to determine the primary purpose. Initially, we adopted a hierarchy of activities (or purposes) ranked by priority, as introduced by Reichman (1976, in Krizek 2003, p.396), and subsequently used by many others including Bianco & Lawson (1998), Ben-Akiva & Bowman (1999) and Shiftan & Suhrbier (2002):

- Subsistence – work or education,
- Maintenance – personal business, social welfare, shopping,
- Discretionary (labelled "Leisure" in several reports e.g. Ben-Akiva & Bowman 1999) – social and recreational.

However, we found a number of chains whose main purpose did not fit into these three categories. Thus, we adopted these categories originally used in the LTSA 1997/98 NZHTS:

- Accompanying someone else – this delineates situations where an individual is travelling somewhere for a purpose other than their own: for example, a child is accompanying a parent/caregiver to do the family shopping or for the parent's visit to the doctor; a parent is accompanying a child on a trip to or from school (including walking them to school) or to take their child to an activity that the child is participating in; someone taking their mum to the doctor, and so on. If an individual drives to work but goes out of their way to drop off a partner at their workplace, the first segment will be coded to "Accompanying someone else".
- Home – where the purpose, usually of a single segment chain, was to return home.
- Change mode – where the only purpose of the chain/tour appeared to be changing from one mode to another.
- These reasons are used hierarchically; that is, a chain or tour with any segment having the purpose "work" is classified as Subsistence, regardless of the other purposes found within the chain or tour

5 We used the following hierarchy: ferry, train, bus, vehicle driver, vehicle passenger, taxi, bicycle, other, walk. That is, in such a case, if a trip chain involves a train and walking, main mode will be *Train*. This process was applied to tours as well.

3. Methodology

3.1 Introduction

The research project involved reformulating the original 1997/98 LTSA NZHTS database into three quite distinct datasets, namely:

- Trip chain dataset (nationwide).
- Tour dataset (nationwide).
- A merged occupancy database and trip chain dataset (to establish passenger-driver links) for the purpose of studying the trip chains of those driving children to and from school (Auckland, Wellington and Christchurch only).

All four of the datasets (including the original NZHTS database), and the approach to reformulation where appropriate, are described below.

3.2 1997/98 New Zealand (Household) Travel Survey Trips Database

The primary source of data for this study is the 1997/98 New Zealand (Household) Travel Survey (NZHTS), which involved interviews with approximately 14,000 people in 7,000 randomly sampled households from all over New Zealand over the period of one year from June 1997 to July 1998 and during April and May 1999 (some Auckland households only). Each respondent answered questions concerning two consecutive travel days, including the purpose, mode, timing, and duration of any travel. The resultant "trips" database comprised over 129,000 separate rows, one for each "trip leg" or segment. As indicated in Section 2.2, a trip leg (often reported simply as a "trip") is recorded each time travel is interrupted, whether it is to drop off/pick up someone, buy a newspaper, change modes, etc.

Although the current NZHTS dataset is now reasonably old (being compiled in 1997/98), note that the survey was established as a continuous survey from 2003. Hence the analysis in this project will provide a useful reference point for future monitoring of travel pattern trends. In addition, the structure of the new continuous survey is very similar to its predecessor; hence the programming defining chains and tours can be transferred readily. The trip chain and tours datasets together with the programming creating them are being given to the LTSA for further use as they see fit.

3.3 Trip Chain Dataset

As highlighted in the introduction, this report is part of a larger project, the purpose of which was to reformulate the NZHTS trips database into trip chains and tours (or round trips).

To avoid the inherent difficulties in trying to establish what any one individual regarded as their "day" (as opposed to how a "day" was defined within the NZHTS database), we simply applied our definition for trip chains across both travel days recorded by the respondent.

Reformulating the NZHTS database to account for trip chains required the following steps:

1. "Tidying up" the database, which originally comprised 129,414 segments, including such things as:
   - excluding 3,672 segments where respondents had not completed all interview forms (who are generally excluded from the statistical weights provided by the LTSA) and, hence, had a significant amount of missing information,
   - excluding 70 segments where the mode was "plane", as we are focused on land transport,
   - excluding 1,583 segments where times seemed inconsistent or potentially unreliable (this is particularly important for trip chains because correct times are important for determining the 90 minute chain breaking point). This included excluding all other trip legs on that person's same travel day because we could not confidently create trip chains (or tours) for that day.
   - After the exclusions, there were 124,089 segments suitable for translation into chains and tours.
2. Creating two new variables applying to every trip segment (and hence every line) in the database: Chain90 and Seg90.
3. Defining the first segment included for each respondent as
   - Chain90 = 1, Seg90 = 1.
4. If the next segment for that person started after a stay of 90 minutes or less and did not start from home or work, that segment would be labelled as Chain90 = 1, Seg90 = 2.

   or

   If the next segment for that person started from either home, main workplace[6] or after a stay of longer than 90 minutes, it would be coded as Chain90 = 2, Seg90 = 1. (This was also done for the few cases where "plane" was the mode for the previous segment.) Exception: a new chain does not start because of the time limit rule if the reason for the previous segment (by the same person on the same day) is *Change mode*.
5. This process was continued until the next respondent occurred.

The resulting dataset aggregated 124,089 segments into 65,077 trip chains.

3.4 Tour Dataset

For consistency, the very same exclusions of trip segments and preliminary processing were done as for trip chains (described in Section 3.3).

Preliminary creation of trip "sequences" was a necessary step in creating tours and enabled all segments analysed as trip chains to be included in either a tour or a sequence. Preliminary creation of trip "sequences" was a necessary step in creating tours and enabled all segments analysed as trip chains to be included in either a tour or a sequence.

6 A second address location was also allowed to start a new chain for respondents with a second job.

Most such sequences form part of a valid trip "tour", but several sequences were not complete valid tours (because they did not start or end at home). Key steps in reformulating the database into tours were:

1. Creating two new variables applying to every trip segment (and hence every line) in the database: Tour and SegTu.

2. Defining the first segment recorded for each respondent as Tour = 1, SegTu = 1, unless the travel mode for the first segment was "plane", as our study focused on land transport. Usually people started from home, and hence were potentially starting new tours.

3. If the next segment for that person did not start from home, that segment would be labelled as Tour = 1, SegTu = 2.

   or

- If the next segment for that person started from home, it would be coded as Tour = 2, SegTu = 1.

  This process was continued until the next respondent occurred. This aggregated 124,089 segments into 39,253 sequences.

4. Following the establishment of the above tour sequences, we categorised all sequences of trip segments into:
   - valid tours beginning and ending at home (10 types – these are defined in Section 2.4), or
   - sequences which are not valid tours (3 types), that is the sequences neither begin at home, end at home, nor begin or end at home, or
   - a few anomalous sequences, which we chose not to define as tours (2 types).

Sequences that were not valid tours formed a small proportion (4.4%) of the total sequences, and are generally ignored in the analysis. As a result, we had a total of 37,565 valid tours in the reformulated NZHTS tours dataset.

3.5 Independent Check on Creation of Chains and Tours

This project always planned an independent check on translation of the database into trip chains and tours. Fortunately, the LTSA Research and Statistics group agreed to work on this. This enabled a broader contribution than the narrow consistency checks originally envisaged (that non-LTSA researchers could have completed). Because of their uniquely detailed knowledge of the NZHTS and database, the LTSA could provide extra information to deal with possible inconsistencies found and more critically assess the logic we originally used to create chains and tours.

Key tasks they completed (for both trip chains and trip tours) included:

- reviewing conceptual definitions,
- checking logic of computational definitions,
- manually checking computation of trip chain and tour variables for randomly chosen records,
- manually checking computation of trip chain and tour variables for selected "problem" records.

This work led to substantial improvements in the way we created chains and tours.

3.6 Approximating Distances Walked from Durations

In addition, the LTSA contributed a substantial amount of work to provide a solid basis for imputing distances walked.

In contrast to other modes, segments walked do not have distances recorded in the original database. The usual geo-coding procedures estimating distance by the shortest driving distance between points cannot simply be applied to segments walked because of the many off-road shortcuts open to pedestrians, etc.

To avoid this resulting in a very large number of missing distance values for tours and chains, we approximated distances walked from the **durations** of the segments walked. There are precedents for this. For example, the draft walking and cycling strategy (Ministry of Transport 2003) approximated walking distances in the NZHTS assuming a speed of 5 km/h.

Rather than simply making such an assumption, we examined 145 segments walked in a stratified random sample from the NZHTS (over sampling those aged 60+ years). The LTSA sampled these from one urban area only (Wellington), for ease of assessing shortcuts, etc. They flagged segments where shortcuts seemed likely and provided distance estimates based on the shortest driving route. This data provides evidence that an implied speed slightly lower than 5 km/h is better to impute distances walked. Even with this data, it was surprisingly awkward to settle on a policy for imputing distances from times. We used a single value, 4.4 km/h, to impute distances walked from the times recorded. Others wishing to impute distances for purposes different from ours might choose different approaches e.g. a different implied speed for segments of long duration compared with segments lasting only five minutes.

Note that we are not claiming that 4.4 km/h is necessarily a good estimate of people's unimpeded walking speed. Rather, this number is a useful means to translate respondents' walking durations as recorded in this survey into estimates of distance (recorded durations probably include substantial errors from rounding times to the nearest 5 minutes, not to mention unrecorded stops, e.g. to chat). Nor do we suggest that this single value is the best for all analyses (e.g. different values might be appropriate for analyses specific to the very old or the very young, or for analyses limited to short trips only, etc.).

3.7 Linking Passenger Trip Chains with Driver Trip Chains

Our examination of children's travel to and from school as *vehicle passengers*, involves a rather complex linkage to a separate and complicated analysis of vehicle occupancy (Sullivan & O'Fallon 2003). The work matching vehicle passenger trip chains with driver trip chains revealed that the final number of trip chains relevant for travel to or from school is somewhat fewer than hoped for. This unfortunately restricted possibilities for more in-depth analysis of the characteristics of such trip chains. In order to understand how we came to have such a restricted dataset, the following sections outline the process of linking passengers and drivers, together with the effects on sample size at each step.

3.7.1 Travel to School

The process to link passengers with drivers for the journey to school can be described as follows:

1. Using the complete (reformulated) NZHTS trip chain dataset, identified segments where respondents aged 5-17 were travelling with purpose "education" (by any mode) before 10 am.
   - There were 3625 such segments.

2. Identified segments in trip chains where respondents aged 5-17 were travelling with purpose "education" before 10 am as a "vehicle passenger" (this mode is separate from train, bus, ferry, or taxi)[7]. We could not discriminate precisely between schools and university, allowing that, in a small number of cases, ages up to 17 may be including travel to university or polytechnic.
   - There were 1452 such segments.

3. Marked other segments in the same trip chains by the children as relevant also. For example, if a parent drove two children to two separate schools, the child dropped off last would report the purpose of the first trip segment to their sibling's school as "Accompanying someone else". The purpose of the second segment, to go to their own school, would be recorded as "own education".
   - There were 1742 such segments. It is reasonable to assume that the main overall purpose of travel for these segments (from the child's perspective) is school; hence we refer to these as "passenger2school segments".

4. Restricted the dataset consistent with the occupancy dataset. First, this required restriction to Auckland, Wellington, and Christchurch only. "Auckland" includes all four cities in the urban area, and "Wellington" similarly includes Lower Hutt, Upper Hutt, and Porirua as well as Wellington City.
   - Restriction to the three main centres more than halved the number of passenger2school segments, down to 633.
   - In order to facilitate as accurate matching of passengers with vehicle drivers as possible, further exclusions were made as follows:
     a. Around 17% of the segments were as a "vehicle passenger" in a non-household vehicle (e.g. car of family friend, car pooling children to school). We cannot fully describe the driving involved for most such cases because we do not have questionnaires for people outside the household of the respondents.
     b. 10% of the segments were using other modes (mainly walking as part of the chain, which could be as little as a child being dropped on the opposite side of the road from school and crossing the road).
     c. 8% of the segments belonged to passengers who were in households from which full responses from all eligible people were not received. Such households were excluded from the occupancy analysis because the

7 The age range has been changed since our preliminary Topline report from 5-18 to 5-17, so as to more closely correspond to secondary school age groups.

incompleteness threatened the validity of matching passengers to drivers within the household.

- These exclusions reduced the number of relevant passenger2school segments to 469.

5. The occupancy dataset was then used to identify the driver for each of the passenger segments.
   - A driver within the household was successfully identified for 451 of the 469 segments (96%).
   - The actual number of drivers involved is fewer than 451, of course. For example, a single driver's trip chain could account for three of the passenger2school segments if the driver takes two children to primary school in the car (equivalent to two passenger2school segments, one for each child), and then one child to a secondary school in a different location (one further passenger2school segment).
   - In total, 272 driver trip chains included passenger2school segments.[8]

3.7.2 Travel from school

The process of linking passengers with drivers for the journey from school was similar to that employed for the journey to school. It can be described as follows:

1. Identified segments where respondents aged 5-17 departed (at 1:45 pm or later up to and including 6 pm) from the address location of the "school or educational institution" they attend. This starting point is not precisely comparable to the starting point for travel to school where we can make convenient use of the recorded purpose of travel being (to get to) *Education* rather than relying on the school address code.
   - There were 2884 such segments (excluding cases where the school address location was also the point of arrival, e.g. where going to another part of the school involves crossing a street).

2. Marked later segments in the same trip chains by children as relevant also.
   - There were 4196 segments in such after-school trip chains. This excludes 24 trip chains eliminated because they were for the same child on the same day (typically, this reflected child going home and later returning to school).

3. Marked the segments in after-school trip chains where the respondent was a "vehicle passenger" (this mode is separate from train, bus, ferry, or taxi) for some of the travel.
   - Initially, there were 2024 such segments.

4. Restricted the dataset consistent with the occupancy data set.
   - First, this required restriction to Auckland, Wellington, Christchurch urban areas only (eliminating around two thirds of the relevant segments), leaving 707 segments.

8 Strictly, there were 274 trip chains from the perspective of the drivers. But one driver on two days first drove a child to the driver's main workplace at around 8 a.m. Arrival at their main workplace ended the chain from the driver's perspective. But from the child's perspective the chain was not finished until completion of the drive to school shortly afterwards.

- In order to facilitate as accurate matching of passengers with vehicle drivers as possible, further exclusions were made as follows:
  a. As with travel to school, around one fifth of the segments involved passengers being driven in a non-household vehicle (e.g. car of family friend or car pooling).
  b. Another fifth of the segments used modes other than passenger (particularly walking).
  c. Nearly 10% of cases did not have complete questionnaires from everyone in the responding household.
- These exclusions reduced the number of relevant segments to 398.

5. The occupancy dataset was then used to identify the driver for each of the passenger segments.
   - A driver within the household was successfully identified for 382 segments (96%).
   - The number of drivers involved is smaller than 382, of course, because a single driver's trip chain can account for several passengers or one passenger travelling several segments.
   - In total, 209 driver trip chains were associated with these 382 segments of travel by children from school.

3.8 Precision of Results

Given the relatively modest base sample sizes and the complications involved in the processes outlined above, it is best to regard the results with respect to driver trip chains to and from school as indicative only, rather than being as reliable as published results from the NZHTS usually are. The complexity of the linkage process, on top of the fact that some of the driver trip chains are by the same driver on the following day rather than being independent, means that we have not attempted to estimate margins of error.

Sampling error is less of a problem for the analysis of children's travel overall because of the large number of relevant trip chains in the trip chain dataset. Precisely quantifying margins of error to take account of the relationships between trip chains (because some of the trip chains are by children to school from the same child on two separate days, or from other children in the same household) and also the complex sampling design and statistical weighting is outside the scope of this project. But note that even if we double the usual margin of error calculation (assuming a simple random sample), with around 3000 trip chains the margin of error for overall results would be only ±3.6%.

Margins of error for the main results in this report (concerning all trip chains and tours) will also be distinctly larger than conventional calculations that assume simple random sampling. But given the large base sample sizes of around 65,000 trip chains and over 37,000 tours from around 14,000 respondents, lacking precise calculations of margins of error is not a major problem for using the main results.

For future work analysing trip chains and tours, particularly if subgroups involving smaller sample sizes are a focus, we suggest that a useful preliminary step would be to commission a statistician to estimate some key margins of error.

4. Fundamental Trip Chain Results

4.1 Overview

Once the 1997/98 NZHTS database was reformulated based on trip chains, we had 65,077 valid trip chains on which to base our analysis. These were derived from 124,089 segments.

All of the values given in the following sections have been weighted in terms of "millions of chains per year", using weights derived by the LTSA for the NZHTS. We have not adjusted the weighting to take account of the fact that around 1% of segments (with weights) in the original database were not translated into chains.

4.2 Number of Segments within a Trip Chain

As explained in Section 3.3, we applied our definition for trip chains across **both** travel days recorded by the respondent. Hence, the range was from 0 (where a person stayed home both travel days) to 39 trip chains. On average, respondents completed 2.3 chains per day (compared with 4.4 segments per day[9]). This average incorporates the effect of those who did not travel at all during the two days of the survey (and hence recorded 0 chains). It also takes account of the handful of cases where chains spanned two travel days[10].

Table 4.1 shows that nearly one-half (48%) of all trip chains consist of one "segment", such as a simple "home to work" or "home to school" journey. One-third (33%) of the chains have two segments (e.g. home, stop to drop a child at school, then on to work). Around 5% of trip chains comprise five or more segments. On average, a trip chain comprises 1.9 segments.

Table 4.1 Number of segments within a trip chain.

Number of segments	Millions of trip chains	%
1	1537	48.3
2	1037	32.6
3	321	10.1
4	138	4.3
5 or more	149	4.7
Total	**3182**	**100.0**

9 This average may differ by about 0.1 from that calculated on the original LTSA database. This is because, in the interests of comparability, our average is restricted to those segments used for our analysis of chains and tours (that is, segments travelled by air are excluded, as are some excluded because inconsistencies in recorded times precluded translating them into chains).

10 This was done by subtracting one from the number of chains recorded for the respondent, because chains spanning two travel days are an indicator of the frequency with which sequences at the start and end of the two-day travel diary form part of longer chains rather than being two separate chains.

We found that there was no simple relationship between the total number of chains a respondent undertook over two days and the number of segments within each chain. That is, it was about equally likely for a person making six or more trip chains in two days to have a one or a five segment trip chain as it was for a person who made only one or two trip chains.

4.3 Travel Modes within a Trip Chain

Along with the number of segments comprising a chain, the variety of travel modes used within a chain provides an insight into the complexity of some people's day-to-day travel patterns. Table 4.2 illustrates the range of combinations of travel modes.

Note, however, that 90% of all trip chains used a single mode. "Vehicle driver" is the most frequent mode used by New Zealanders in a trip chain (48%), with "vehicle passenger" taking a distant second place (25%). "Walk only" trip chains form about 13% of all trip chains undertaken in New Zealand, although considerably more chains have some walking within them (over 20%, including walk only).

Table 4.2 Modes used within a chain (regardless of relative distance).

Chain mode(s) used	Millions of Trip chains	%
Vehicle driver	1528	48.0
Vehicle driver & walk	102	3.2
Vehicle passenger	805	25.3
Vehicle passenger & walk	70	2.2
Cycle	73	2.3
Cycle & walk	2	0.1
Train	0	0.0
Train & walk	5	0.2
Bus	27	0.9
Bus & walk	65	2.1
Ferry & walk	0	0.0
Taxi	15	0.5
Taxi & walk	3	0.1
Other modes (not plane) only	6	0.2
Walk only	404	12.7
Vehicle driver + Vehicle passenger (& walk)	37	1.2
Vehicle driver + bus/train/ferry (& walk)	8	0.2
Vehicle passenger + bus/train/ferry (& walk)	17	0.5
Other combinations	14	0.4
Total	**3182**	**100.0**

Hence, if we consider the main mode for a trip chain, that is the mode used for the greatest distance within the chain, we find that Table 4.3 shows a distinctly lower main mode share for walking, which reflects the extent to which walking is often done in conjunction with "faster" modes (typically used to cover more of the distance in the trip chain).

Table 4.3 Main mode share for trip chains versus mode share by segment.

Chain Mode	Main mode (chains) %	Mode (segments) %
Unweighted count	*65,076*	*124,088*
Vehicle driver	51.9	50.0
Vehicle passenger	28.1	26.4
Walk	13.0	18.7
Cycle	2.4	1.8
Passenger transport	3.8	2.5
Other	0.8	0.7
Total	100.0	100.0

4.4 Total Length of Trip Chains

Approximately one-half (51%) of trip chains (by all modes) were less than 6 km in total length and 22% were less than 2 km in total (Table 4.4).

As could be expected, we found that when the number of segments in a trip chain increased, the overall length of the chain was likely to increase as well. Thus, Table 4.4 reveals that 7% of trip chains with five or more segments were less than 5 km in total length, the vast majority (78%) were 10 or more km long. By contrast, 55% of trip chains with only one segment and 48% of chains with two segments were less than 5 km long.

Table 4.4 Total length of trip chain (walk distance imputed) compared with the number of segments per chain.

Total chain length (km) (walk dist imputed)	All trip chains %	Number of segments per chain %				
		1	2	3	4	5 or more
Unweighted Count	*N=64877*	*N=31735*	*N=21121*	*N=6309*	*N=2743*	*N=2969*
Up to 0.99	9.7	13.2	9.7	1.1	0.5	0.1
1.00 - 1.99	11.8	15.4	11.5	4.3	3.1	0.7
2.00 - 2.99	9.8	11.2	11.0	5.6	3.5	1.4
3.00 - 3.99	7.5	8.5	7.8	5.6	3.9	2.8
4.00 - 4.99	6.5	6.2	7.8	6.6	4.1	2.2
5.00 - 5.99	5.2	4.8	5.8	5.8	4.3	3.2
6.00 - 9.99	14.0	11.9	15.2	20.3	15.7	11.3
10.00 - 19.99	17.2	14.9	16.5	23.7	27.1	23.9
20.00 or more	18.3	13.6	14.7	27.0	37.9	54.4
Total	100.0	100.0	100.0	100.0	100.0	100.0

4.5 Complexity and Length of Trip Chain by Main Mode

As discussed in Section 2.5, to simplify our analysis we determined the main mode for each trip chain where more than one mode was used, based on the mode used for the greatest distance within the chain.

Table 4.5 shows that around 48% of all trip chains are composed of only one segment, with just over half of trip chains having two or more segments. This is true for individual modes, including walking, vehicle passenger and vehicle driver. Unsurprisingly, passenger transport is clearly different: only 21% of trip chains having passenger transport as the main mode are one segment.

Table 4.5 Main travel mode by number of segments within a chain.

Number of segments in chain	All modes %	Main mode %					
		Vehicle driver	Vehicle passenger	Walk	Cycle	Passenger transport	Other (incl taxi; not plane)
Unweighted Count	*N=65076*	*N=33661*	*N=18794*	*N=8314*	*N=1696*	*N=2144*	*N=467*
1	48.3	47.4	52.0	47.6	66.6	20.6	66.9
2	32.6	32.8	28.3	43.2	26.5	31.6	20.9
3	10.1	10.3	9.3	5.7	3.3	31.7	6.3
4	4.3	4.4	4.9	1.9	2.3	8.2	2.2
5 or more	4.7	5.0	5.4	1.7	1.3	7.8	3.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

In addition to identifying the number of segments in the chain, we have also calculated the lengths of trip chains as part of the reformulated dataset. This is particularly relevant where there is more than one segment in the chain. Leaving aside any other factors that could affect the choice of travel mode, knowing the length of the chain allows us to refine our expectations of the volume of "short trips" currently made by private car that are potentially suitable for encouraging travel behaviour change.

Thus, with respect to *vehicle driver* trip chains, Table 4.6 shows that 13% of driver trip chains are less than 2 km long, 21% are under 3 km, and 42% are less than 6 km in total length. This is a major difference from the analysis of trip segments (or trip legs), which emphasised that approximately 33% of vehicle trips were less than 2 km and 66% were less than 6 km long (Ministry of Transport 2002a). The implications are that there are fewer vehicle driver "short trips" (13% of driver trip chains, rather than 33% of driver segments) available for targeting travel behaviour change,[11] such as walking. We contend that the chain-based result is more relevant for quantifying the potential for mode shift away from short car driver trips.

11 It should be noted, however, that this analysis cannot take into account what proportion of longer driver trips could be replaced with more local destinations and, *ipso facto*, have their trip chain length reduced.

Table 4.6 Main travel mode by length of trip chain.

Total chain length (walk distance imputed) (km)	All modes %	Main mode %					
		Vehicle driver	Vehicle passenger	Walk	Cycle	Passenger transport	Other (incl. taxi; not plane)
Unweighted Count	*N=64877*	*N=33613*	*N=18747*	*N=8293*	*N=1695*	*N=2075*	*N=454*
Up to 0.99	9.7	4.0	4.5	46.0	15.1	0.0	4.1
1.00 - 1.99	11.8	8.5	10.8	27.7	25.3	1.1	16.1
2.00 - 2.99	9.8	8.6	10.0	13.7	18.7	4.9	17.9
3.00 - 3.99	7.5	8.0	8.1	4.6	11.2	4.6	11.6
4.00 - 4.99	6.5	7.0	6.9	3.5	10.5	4.3	6.1
5.00 - 5.99	5.2	5.4	5.5	1.5	6.1	10.0	8.4
6.00 - 9.99	14.0	16.4	14.5	2.2	7.9	20.3	12.8
10.00 - 19.99	17.2	20.8	18.2	0.7	3.9	28.0	13.1
20.00 or more	18.3	21.3	21.6	0.1	1.2	26.8	10.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 4.6 also reveals that 74% of walking trip chains are less than 2 km (with a further 14% between 2 and 3 km long), while around 80% of cycling trip chains are under 5 km in length. Unlike the vehicle driver trip chains, these proportions are not overly different from those from an analysis of trip segments, largely because walking and cycling segments are typically much shorter than vehicle driver segments. In addition, most walking and cycling trip chains (90% and 92% respectively) comprise one or two segments (hence they are not a lot different from a single trip segment).

4.6 Purpose of Trip Chains

Although (going) Home is a significant purpose category (23%), this merely reflects the fact that after completing other activity chains, people return to their residence. It is more interesting, therefore to consider the Subsistence, Maintenance and Discretionary (leisure) categories in Table 4.7. Fairly equal numbers of chains have each of these main purposes (24%, 21%, and 24%, respectively). Note that the Subsistence category includes both work and education (or school) travel purposes. In the analysis of "tours" we have separated these categories in recognition of the fact that many education-related journeys will be completed by children, often as car passengers, as opposed to work-related journeys taken by adults.

Table 4.7 Main mode by main purpose of trip chain.

Activity/purpose in hierarchical order	All modes %	Main mode %					
		Vehicle driver	Vehicle passenger	Walk	Cycle	Passenger transport	Other (incl taxi; not plane)
Unweighted Count	*N=65054*	*N=33649*	*N=18792*	*N=8313*	*N=1696*	*N=2137*	*N=467*
Subsistence	24.1	28.4	15.0	20.0	33.1	43.9	24.0
Maintenance	21.1	24.2	18.5	20.5	11.9	7.6	12.2
Discretionary	23.6	17.3	32.0	33.2	24.0	10.1	27.6
Accompanying someone else	7.6	7.8	10.6	4.0	0.6	0.8	1.1
Home	23.3	22.2	23.5	21.8	30.4	36.5	32.1
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Of further interest in considering the main purpose of the trip chain is to examine the main mode used. We found that the most common purpose for vehicle driver and passenger transport trip chains was Subsistence (28% and 44% respectively). A high proportion of cycling trips (44%) were undertaken for Subsistence purposes, perhaps reflecting cycling to school. Discretionary activities are more commonly the purpose of walking and vehicle passenger trip chains (33% and 32% respectively).

Forcing a trip chain to end when a person arrived at home or at their workplace (whereas a trip chain with the purpose Maintenance, Discretionary or Accompanying someone else would only terminate if the individual stayed in one location for longer than 90 minutes) means that, by definition, trip chains with the main purpose Subsistence or Home are generally going to have fewer segments than trip chains for other purposes. This is indeed what Table 4.8 shows.

Table 4.8 Main purpose of trip chain by number of segments within a chain.

Number of segments	All purposes %	Main purpose %					
		Subsistence	Maintenance	Discretionary	Accompany someone else	Home	Change mode
Unweighted Count	*N=65055*	*N=15665*	*N=13731*	*N=15342*	*N=4971*	*N=15129*	*N=178*
1	48.3	60.1	6.6	43.3	7.5	91.9	49.1
2	32.6	23.6	48.3	41.9	73.2	5.3	42.2
3	10.1	8.7	21.2	8.1	13.6	2.3	4.6
4	4.3	3.1	10.5	4.2	3.8	0.3	3.0
5 or more	4.7	4.4	13.4	2.6	1.9	0.1	1.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

This is further confounded by the fact that, of the three main purpose chain types (Subsistence, Maintenance and Discretionary), individual Maintenance activities are far more likely than the others to last for 90 minutes or less, thus resulting in multi-segment trip chains which include the "returning Home" trip segment. Trip chains with the purpose of Accompanying someone else are also more likely to be shorter in duration and thus include a "returning Home" trip segment.

By comparison, only a small proportion of Subsistence and Discretionary trip chains are round trips (home–activity–home): first because arriving at their work or their own education forces a person's trip chain to end, and second because many recreational and leisure activities last longer than 90 minutes, also ending the chain.

5. Fundamental Tour Results

5.1 Background

As discussed in Section 2.4, tours are based on the notion of a complete round trip, beginning and ending at home. We have also made provision for work-based "sub-tours", which begin and end at a person's place of employment. By examining the complete tour/round-trip as a single entity, we aim to further improve understanding of how different travel modes are used and how travel patterns may constrain mode choice decisions.

All of the values given in the following sections have been weighted statistically to correct for sample imbalance, using weights derived by the LTSA for the NZHTS. Where all of the 37,565 valid tours are included in the analysis, the weighted total is 1829 million tours per year. We have not adjusted weighting to take account of the fact that some segments (with weights) in the original database were not translated into tours.

5.2 Number of Segments within a Tour

As indicated in Section 3.4, we applied our definition for tours across **both** travel days recorded by the respondent. Hence, there was a range from 0 (where a person stayed home both travel days) to 13 tours undertaken by any one respondent. On average, respondents completed 1.3 tours per day. This average includes those who did not travel at all during the two days of the survey (and hence recorded 0 tours). It also takes account of the cases where tours spanned two travel days[12].

Table 5.1 shows that over one-half (56%) of all tours consist of two segments, such as a simple "home to work and return to home" or "home to school and return to home" journey. A further 17% of the tours have three segments (e.g. home, stop to drop a child at school, then on to work and return home). Around 6% of tours comprise seven or more segments. On average, a tour comprises 3.1 segments.

We investigated whether the number of segments in a tour varied by age or gender, but found that there were no distinctive differences.

12 This was done by adding one to the number of valid tours recorded for the respondent, because tours spanning two travel days are an indicator of the frequency with which sequences at the start and end of the two-day travel diary form part of longer valid tours (but which were not counted as such because the start or end of the tour fell outside the two days specified for the travel diary).

Table 5.1 Number of segments within a tour.

Number of segments in each tour	Tours per year (M)	%
2	1027	56.1
3	303	16.6
4	208	11.4
5	105	5.7
6	74	4.1
7-8	65	3.5
10 or more	48	2.6
Total	**1829**	**100.0**

5.3 Type and Complexity of Tours

Most (66%) tours made by New Zealanders are non-work/non-education tours (see Table 5.2). These may be either "simple" (two-segment) tours or "multi-part" tours, comprising three or more segments.

Table 5.2 Type and complexity of tours.

Tour type	Tours per year (M)	%
Simple non-work/ non-education tour	756	41.3
Multi-part non-work/non-education tour	455	24.9
Simple work tour	193	10.5
Multi-part work tour	59	3.2
Composite to work tour	37	2.0
Composite from work tour	72	4.0
Composite to & from work tour	31	1.7
Composite at work tour (includes sub-tour at work)	36	2.0
Simple/multi-part own-education tour	124	6.8
Composite own-education & non-work tour	65	3.6
Total	**1829**	**100.0**

Work-related tours are the next most frequent tour types, forming 23% of all tours. Most prominent is the "simple work tour" (11%), going from home to work and back home again. Note that it is more common to include non-work activities on the return journey to home than on the journey to work. "Composite at work tours" are only a small portion (2%) of all tours. They may include going out at lunchtime to purchase lunch or undertake other personal business. By definition, "multi-part work tours" would include work-based "subtours" where someone leaves work to conduct employer-related business (such as go to a meeting with clients, on-site visits, purchase office stationery, etc.).

Education-related tours are only 10% of all tours made. The vast majority of these are "simple own-education tours" (6.6% - multi-part education tours are only 0.2% of all tours), meaning that the person travels from home to their place of study and home again. Not surprisingly, 3 to 17-year olds (going to kindergarten and school) embark on 86% of the simple/multi-part education tours and 77% of the composite education tours.

5.4 Main Purpose of Tour

The tour classification described in the preceding section is helpful for considering the complexity of journeys New Zealanders make, but the categories only reveal the reasons or purposes for the work- and education-based tours, which are approximately one-third (34%) of all tours. Hence, we also categorised tours using the same hierarchical purpose classification (Table 5.3) we adopted for trip chains (Subsistence, Maintenance, Discretionary, etc).

Table 5.3 Main purpose of tour (hierarchical categorisation).

Tour type	Tours per year (M)	%
Subsistence	618	33.8
Maintenance	527	28.8
Discretionary	508	27.8
Accompanying someone else	175	9.5
Total (includes other minor purposes)	**1829**	**100.0**

Here it is possible to determine some of the broader "drivers" for people's non-work/non-education related tours, which are 66% of all tours made. Table 5.3 shows that (ignoring tours made mainly to accompany others) such tours are fairly evenly split between Maintenance (shopping, social welfare, personal business – 29% of all tours) and Discretionary (leisure, social, recreational – 28% of all tours) activities. Whereas women undertake more than one-half (57%) of Maintenance tours, there is a 50/50 split between men and women for Discretionary tours (see Table 5.4).

Table 5.4 Tour purpose by gender.

Gender	All purposes %	Main purpose %			
		Subsistence	Maintenance	Discretionary	Accompanying someone else
Unweighted Count	*N=37539*	*N=12514*	*N=10743*	*N=10683*	*N=3597*
F	50.5	42.8	57.2	50.0	59.2
M	49.5	57.2	42.8	50.0	40.8
Total	100.0	100.0	100.0	100.0	100.0

Approximately one in ten tours (9.5%) has the purpose of Accompanying someone else, such as a driver taking a parent to the doctor and returning them home (the tour of the passenger going to the doctor would be denoted as Maintenance, while the driver would have the purpose Accompanying someone else). In 54% of the Accompanying tours, the main mode is vehicle driver and for a further 38%, the main mode is vehicle passenger. Unsurprisingly, 89% of the vehicle passengers in Accompanying tours are children under the age of 18. Women (61%) are more likely than men (39%) to be the *vehicle driver* for tours with the purpose Accompanying someone else.

5.5 Travel Modes within a Tour

In addition to the number of segments comprising a tour and the tour type, the variety of travel modes used within a tour provides further insight into the complexity of some people's day-to-day travel patterns. Table 5.5 illustrates the range of combinations of travel modes.

Note, however, that 84% of all tours used a single mode. This is lower than the 90% of trip chains that used one mode. Vehicle driver is the most frequent mode used by New Zealanders for tours (47%), with vehicle passenger taking a distant second place (23%). "Walk only" tours form about 12% of all tours undertaken in New Zealand, although about as many more tours again include walking segments.

Table 5.5 Modes used within a tour (regardless of distance).

Modes used in tour	Millions of tours	%
Vehicle driver	854	46.7
Vehicle driver & walk	84	4.6
Vehicle passenger	411	22.5
Vehicle passenger & walk	73	4.0
Cycle	40	2.2
Cycle & walk	3	0.2
Train & walk	2	0.1
Bus	9	0.5
Bus & walk	26	1.4
Taxi	4	0.2
Taxi & walk	2	0.1
Other modes (not plane) only	3	0.2
Walk only	217	11.8
Vehicle driver + Vehicle passenger (& occasionally walk)	49	2.7
Vehicle driver + bus/train/ferry (& usually walk)	5	0.3
Vehicle passenger + bus/train/ferry (& usually walk)	29	1.6
Other combinations	19	1.1
Total	**1829**	**100.0**

5.5.1 Relationship between Main Mode and Tour Type

As is the case with trip chains, we determined the main mode for each tour where more than one mode was used, based on the mode used for the greatest distance within the tour, in order to simplify our analysis. About 16% of all tours used more than one mode and hence will be affected by this simplification.

Because vehicle driver is the main mode for the majority of all tours (53%), it is not surprising to find that it is the main mode for a number of different tour types, such as simple and multi-part non-work/non-education tours (49% and 52% respectively). However, Table 5.6 reveals that vehicle driver is *overwhelmingly* the mode of choice for all types of work tours: simple (75%), multi-part (85%) and composite work tours (80%).

Table 5.6 Type of tour by main mode.

Main mode used	All tours %	Type of tour %						
		Simple work tour	Multi-part work tour	Composite work tours (all types)	Simple/ multi-part own-education tour	Composite own-education & nw tour	Simple nw/ne tour	Multi-part nw/ne tour
Unweighted Count	*N=37564*	*N=4028*	*N=1158*	*N=3465*	*N=2583*	*N=1276*	*N=15612*	*N=9442*
Vehicle driver	53.1	75.2	84.6	80.2	9.9	15.9	49.4	52.2
Vehicle passenger	27.9	10.9	7.3	10.7	33.6	57.1	28.3	38.0
Walk	13.0	6.8	2.2	3.3	27.9	12.4	18.7	7.2
Cycle	2.4	2.8	3.1	1.6	7.2	4.2	2.4	.9
Passenger transport	3.1	3.1	2.0	3.8	20.7	10.2	0.7	1.2
Other (+ taxi; not plane)	0.6	1.2	0.8	0.5	0.7	0.2	0.5	0.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Simple (and multi-part) education tours have more balanced mix of modes: vehicle passenger is the most common (34%), walking is a close second (28%), followed by passenger transport (21%). However, as soon as another activity type (Maintenance, Discretionary or Accompanying someone else) is incorporated into the tour, the vehicle passenger mode dominates (57%).

After vehicle driver, vehicle passenger is the next most common mode for simple and multi-part non-work/non-educational tours (28% and 38%, respectively).

5.5.2 Relationship between Age, Gender and Mode Use

There are some (expected) differences in mode use between different age groups. For example, most tours by vehicle drivers (84%) are 18 to 59 year olds, whereas most vehicle passengers (59%) and cyclists (53%) are under 18. This is despite the fact that under 18 year olds undertake only 25% of all tours. Table 5.7 also shows that 55% of passenger transport (including school buses) users are less than 18 years old as well.

Table 5.7 Main tour mode use by age group.

Age in 4 categories	All modes %	Main mode %					
		Vehicle driver	Vehicle passenger	Walk	Cycle	Passenger transport	Other (incl taxi; not plane)
Unweighted Count	*N=37549*	*N=19797*	*N=10733*	*N=4824*	*N=983*	*N=1004*	*N=208*
0-4	6.8	0.0	21.1	6.5	0.3	1.1	4.9
5-17	18.6	2.0	37.6	30.6	52.8	54.1	15.3
18-59	62.5	84.3	33.1	46.3	38.9	39.9	69.8
60+	12.1	13.7	8.2	16.6	8.0	4.9	10.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

With respect to gender (Table 5.8), we found that men are more likely than women to complete tours as a vehicle driver (54% compared with 46%), and females are more likely to be vehicle passengers (60% compared with 40%). Similarly, females are more likely to complete walking or passenger transport tours (54% compared with 46% in each case). The greatest gender difference in mode use is found in cycling, where males completed 78% of such tours.

Table 5.8 Main tour mode use by gender.

Gender	All modes %	Main mode %					
		Vehicle driver	Vehicle passenger	Walk	Cycle	Passenger transport	Other (incl taxi; not plane)
Unweighted Count	*N=37564*	*N=19807*	*N=10733*	*N=4829*	*N=983*	*N=1004*	*N=208*
Female	50.6	46.3	59.6	53.4	22.3	53.5	44.0
Male	49.4	53.7	40.4	46.6	77.7	46.5	56.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

5.6 Total Length of Tour

Table 5.9 shows that more than a quarter (28%) of all tours are less than 4 km in length, that is, the equivalent of two 2-km one-way trips each "walkable" in under 30 minutes. About half (53%) of all tours are less than 10 km in length. One in five tours (20%) is 30 km or longer.

There is no notable difference between males and females in terms of the total length of their tours. There is also very little difference between age groups in terms of overall tour length, although 18 to 59 year olds are somewhat less likely to complete tours of less than 10 km, and are more likely to complete tours of longer than 30 km, than either children aged under 18 or adults aged 60 or over.

Table 5.9 Main mode by tour length.

Total tour length (walk dist imputed) (km)	Main Mode %						
	All modes	Vehicle driver	Vehicle passenger	Walk	Cycle	Passenger transport	Other (incl taxi; not plane)
Unweighted Count	*N=37428*	*N=19766*	*N=10700*	*N=4814*	*N=982*	*N=962*	*N=204*
Up to 1.99	13.0	6.9	5.6	55.3	24.1	0.2	6.5
2.00 - 3.99	14.5	12.0	13.4	27.3	24.6	1.2	27.6
4.00 - 5.99	11.2	10.8	12.1	10.7	18.0	5.9	15.5
6.00 - 9.99	14.3	15.8	16.5	4.8	15.6	8.1	11.6
10.00 - 19.99	18.5	20.7	21.2	1.6	14.0	30.5	20.3
20.00 - 29.99	9.0	10.4	9.8	0.2	2.3	20.0	4.7
30.00 or more	19.6	23.4	21.5	0.1	1.3	34.1	13.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 5.9 also reveals that 55% of walking tours are less than 2 km in length, with a further 27% between 2-4 km long. As the tour length increases, it is less likely that walk will be the preferred single mode for a tour. By contrast, more than half (51%) of cycling tours are 4 km or longer, and a third are between 4 to 10 km long.

In terms of the existing vehicle driver tours that are walk- and cycle-able distances, 19% of vehicle driver tours are under 4 km (i.e. less than 2 km each way), while 46% are less than 10 km.

The majority (nearly 85%) of passenger transport tours are more than 10 km long.

5.6.1 Relationship between Tour Length and Tour Type

Another informative comparison is that of the total tour length by the tour type as illustrated in Table 5.10. While 28% of all tours are less than 4 km long, and just over half are under 10 km, there are quite different patterns in tour lengths for work- and education-based tours. Simple work tours have a very similar pattern of tour lengths to all tours types combined, in that 24% are less than 4 km and 51% are under 10 km. Multi-part work tours (involving at least two work-related segments) are quite different in nature, as only 20% of these are less than 10 km in total – 54% are more than 30 km. Similarly, composite work tours have a tendency to be longer – only 20% of these are less than 10 km, although fewer of them (42%) are greater than 30 km, suggesting that the additional non-work stops are not directly on the route between home and work.

Table 5.10 Type of tour by length.

Total tour length (walk dist imputed) (km)	All tours %	Tour type %						
		Simple work tour	Multi-part work tour	Composite work tours (all types)	Simple/ multi-part own-education tour	Composite own-education & non-work tour	Simple nw/ne tour	Multi-part nw/ne tour
Unweighted Count	*N=37428*	*N=4022*	*N=1150*	*N=3442*	*N=2568*	*N=1268*	*N=15585*	*N=9393*
Up to 1.99	13.0	10.0	2.0	1.0	19.8	3.5	23.0	3.2
2.00 - 3.99	14.5	13.8	4.3	3.4	22.3	14.0	20.0	8.9
4.00 - 5.99	11.2	10.5	5.3	4.9	14.2	13.3	13.9	9.0
6.00 - 9.99	14.3	16.5	7.8	11.0	10.6	17.4	14.7	15.3
10.00 - 19.99	18.5	18.5	16.6	23.3	14.3	20.1	14.1	25.1
20.00 - 29.99	9.0	9.9	10.2	14.8	7.9	10.4	5.6	12.0
30.00 or more	19.6	20.8	53.7	41.5	10.9	21.3	8.6	26.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Education-based tours, 86% of which are undertaken by 3 to 17-year olds, provide a significant contrast to work related tours. Nearly 20% of simple education tours are less than 2 km long, and a total of 42% are below 4 km. Only 33% are greater than 10 km. Composite education tours, including non-education stops, have a different pattern, insofar as 18% of them are 4 km or less, again suggesting that the non-education component of the tour is not directly on the route between home and their place of study.

Like work-related tours, non-work/non-education (nw/ne) tours also tend to vary depending on whether they are simple or complex in nature. Simple nw/ne tours are more likely to cover quite short distances, with 43% being less than 4 km long and over one-half of these (23%) being under 2 km. Approximately 72% of these tours are less than 10 km, compared with 51% of simple work tours. Multi-part nw/ne tours (having at least two non-work/non-education segments) have a tendency to be much longer, with only 12% being less than 4 km in total and 64% being 10 km or longer.

With non-work/non-education tours, there is not much difference between the proportions of Maintenance, Discretionary and Accompanying tours that are less than 4 km in length (around 30% each). Overall, "Accompanying someone else" tours are more likely to be shorter than 10 km in length than are Maintenance or Discretionary tours (69% compared with 56% and 57%, respectively).

5.6.2 Relationship between Vehicle Driver Tour Length and Tour Type

Given the interest in reducing congestion on our transport networks and in encouraging the use of environmentally friendly modes, it is useful to examine in more detail the nature of the vehicle driver tours.

As noted in Section 5.6, nearly one in five (19%) of all vehicle driver tours are less than 4 km in length. From Table 5.11, it would appear that simple work tours (19%), simple education tours (16%) and simple non-work / non-education tours (33%) are more likely to be under 4 km than are multi-part or composite tours of any type.

Table 5.11 Type of vehicle driver tour by tour length.

Total tour length (walk dist imputed) (km)	Vehicle driver tour type %							
	All vehicle driver tours	**Simple work tour**	**Multi-part work tour**	**Composite work tours (all types)**	**Simple/ multi-part own-education tour**	**Composite own-education & nw tour**	**Simple nw/ne tour**	**Multi-part nw/ne tour**
Unweighted Count	*N=19766*	*N=3056*	*N=1003*	*N=2844*	*N=202*	*N=178*	*N=7648*	*N=4835*
Up to 1.99	6.9	6.4	0.7	0.5	6.3	0.8	13.9	1.5
2.00 – 3.99	12.0	12.6	2.3	2.4	9.8	2.7	19.9	7.5
4.00 - 5.99	10.8	10.1	4.2	4.1	9.5	3.6	15.8	9.0
6.00 - 9.99	15.8	17.3	8.4	10.4	14.6	12.7	18.1	16.1
10.00-19.99	20.7	19.7	16.1	22.9	18.2	18.5	16.9	27.2
20.00-29.99	10.4	11.0	10.8	15.2	10.2	16.0	6.7	12.9
30.00 or more	23.4	22.9	57.5	44.5	31.5	45.8	8.7	25.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

The trend of simple tours being shorter than multi-part and composite tours is continued when we consider the proportion of vehicle driver tours that are less than 10 km in length. Nearly 68% of all simple nw/ne vehicle driver tours are less than 10 km, compared with 46% of simple work tours and 40% of simple education tours. Thirty-four per cent (34%) of multi-part nw/ne tours are also less than 10 km, whereas between 16 and 20% of multi-part work, composite work, and composite education tours are less than this length.

5.7 Comparison of Tour Characteristics by Major City

We briefly analysed the tours dataset to determine if any notable differences in tour-making patterns were obvious between Auckland (the four cities of North Shore, Waitakere, Auckland and Manukau), Wellington (the four cities of Porirua, Upper Hutt, Lower Hutt and Wellington), and Christchurch. We found no discernible differences in the type or purposes of tours, apart from a slight propensity for Christchurch respondents to make fewer Subsistence tours and more Discretionary ones compared with Auckland and Wellington respondents.

There was not as much divergence in mode share between the three major cities as one might have expected given, for example, the far greater amount of cycling that occurs in Christchurch and the high level of passenger transport use for work journeys in Wellington. As could be expected, Wellingtonians do use their cars less often as a mode for tours (see Table 5.12) than either Aucklanders or Christchurch respondents; Christchurch has slightly more cycling tours than do the other two

cities; and walking is a more common mode for tours in Wellington and Christchurch than in Auckland. Note that in none of these instances are the differences greater than 5 percentage points in absolute terms.

Table 5.12 Comparison of tour modes in the three major cities.

Mode of tours (regardless of distance)	All 3 cities %	Auckland %	Christchurch %	Wellington %
Unweighted Count	*N=12165*	*N=6332*	*N=3544*	*N=2289*
Vehicle driver	44.5	45.8	44.2	40.5
Vehicle driver & walk	5.8	5.9	6.1	5.2
Vehicle passenger	22.0	23.4	20.8	18.8
Vehicle passenger & walk	4.6	5.0	3.9	4.4
Cycle (incl. cycle & walk)	2.1	1.3	3.8	2.7
Passenger transport (incl. PT & walk)	2.2	1.9	1.8	3.2
Walk	12.1	10.7	14.2	14.4
Vehicle driver & vehicle passenger (& sometimes walk)	2.4	2.4	2.2	2.7
Vehicle passenger & PT (& sometimes walk)	2.2	2.2	1.1	3.2
Other combinations (incl. taxi; not plane)	2.2	1.4	1.9	5.0
Total	100.0	100.0	100.0	100.0

With respect to total tour length (see Table 5.13), we found that Christchurch respondents made somewhat more very short tours (up to 1.99 km) than did Aucklanders (15% compared with 11%). Christchurch respondents made fewer really long tours (greater than 30 km) than did Aucklanders or Wellingtonians (12% compared with 22% and 21% of all tours, respectively). Instead, more of their tours tended to be in the 10-29.99 km range (38%, compared with 28% in Wellington and 29% in Auckland).

Table 5.13 Comparison of tour length in the three major cities.

Total tour length (walk dist imputed) (km)	Total %	Auckland %	Christchurch %	Wellington %
Unweighted Count	*N=12116*	*N=6321*	*N=3536*	*N=2259*
Up to 1.99	12.1	10.9	14.7	12.9
2.00 - 3.99	13.5	13.6	13.6	13.0
4.00 - 5.99	10.7	11.3	9.3	10.0
6.00 - 9.99	13.6	13.3	12.5	15.7
10.00 - 19.99	19.8	18.2	24.7	19.6
20.00 - 29.99	10.7	10.6	13.5	7.9
30.00 or more	19.8	22.1	11.6	21.0
Total	100.0	100.0	100.0	100.0

6. Potential New Performance Indicators

A first demonstration of one of the many potential uses of the NZHTS database reformulation into trip chains and tours is the creation of new performance indicators. Several government organisations have specified walking or cycling indicators in their strategies, for example:

- *A step in the right direction:* Pedestrian strategy for Christchurch City: (Christchurch City Council 2001) lists as a desired indicator: "Change in the proportion of walking trips compared to other modes for distances under 2km.... Data sources need to be developed" (p.24).
- The draft *"Getting there - on foot, by cycle: A draft strategy to increase walking and cycling in New Zealand transport"* (Ministry of Transport 2003) states that a first step in implementing the strategy will be to establish "more detailed performance indicators." "Outcome indicators" will be related to the strategy's overall goals; an example given is the "levels of increase sought in walking and cycling trips undertaken for transport" (p.48).

Recent Greater Wellington Regional Council draft pedestrian and cycling strategies have identified the use of "system wide indicators" to monitor strategy implementation. Given the current lack of specification in the draft national pedestrian and cycling strategy, we decided to delineate the baseline performance indicator for walking trips less than 2 km long in the three major cities, as this would appear to meet Christchurch City Council monitoring requirements. Note that a basis for more general *national* performance indicators of increasing cycling and walking mode share are found in Table 4.6 (on p.36), which shows main mode by trip chain length.

The use of trip chains to develop such indicators is preferable to "trip legs" or segments, because trip chains identify a complete sequence of segments (ending when the person arrives at home or work, or stays in one location for longer than 90 minutes). We believe this more accurately reflects what the general population think of as describing their travel.

In Table 6.1, we calculated the mode share for *walking only* and *cycling only* trip chains less than 2 km long for the three main cities.

Table 6.1 Trip chains less than 2 km long: % walked or cycled (three main cities).

City	*Base number of chains (unweighted)*	% of trip chains <2km walked	% of trip chains <2km cycled
Auckland cities	*2032*	48.8	3.7
Wellington/Hutt/Porirua	*853*	57.9	3.6
Christchurch	*1237*	52.1	5.6

Wellington has the highest proportion of walking only trip chains less than 2 km (58%), and Auckland the lowest (49%). Between 25% (Auckland and Wellington) and 36% (Christchurch) of these trip chains were round trips, in that the individual left home, completed their trip purpose, and returned home again, walking less than 2 km for the entire journey. Cycling only trip chains less than 2 km were, by contrast with walking, an infrequent occurrence, forming about 4% of such chains in Auckland and Wellington and 6% in Christchurch.

Vehicle driver-related trip chains (whether this is "vehicle driver only" or a combination of vehicle driver and another mode such as walking or car passenger) form about 20–25% of the trip chains less than 2 km long.

There are other approaches to calculating and refining these performance indicators, depending on what purpose the indicator is to be used for. For example, it is possible to use the variable "main mode", which determines the main mode based on the greatest distance within the chain as explained in Section 2.5, instead of identifying single mode trip chains, if the focus was on increasing physical activity, rather than reducing vehicle kilometres travelled. In some cases, it may be desirable to base an indicator on "tours" rather than "trip chains", recognising that the mode chosen for the outward portion of the journey commonly pre-determines the mode used on the return journey. Different trip chain (or tour) lengths could be used, as could the purpose of the trip chain or time of day. The variations are seemingly infinite.

7. School Travel: Characteristics of Children's and Drivers' Trip Chains

7.1 Children's Trip Chains to and from School

In contrast to results for drivers reported in Section 7.2, we provide results for children on a nationwide, major city and rural basis, because we were not restricted to the cases in main centres where we have drivers matched. This meant we had a larger pool of trip chains to work with (3044 "to school" trip chains and 2849 "from school" trip chains in the reformulated trip chain dataset).

7.1.1 Trends in Children's Travel to School 1989-1998

Between 1989/90 and 1997/98, the absolute number of children being driven to school in "main urban areas"[13] nearly doubled, partly because the total number of school-aged (5-17 years old) children in cities also increased during that period. At the same time, however, there was only a relatively small increase in the absolute number of walking trips to school. Thus, in terms of *mode share* (as opposed to number of *trips*), the share of "walk only" trips to school dropped from 36% of all school journeys to 26% during that period, while the journeys to school as a "car passenger" rose from 27% to 43% (National Pedestrian Project 2000).

Mode share is explored further in the following section.

7.1.2 Travel to School

This section describes the characteristics of New Zealand children's travel to school namely, the nature of their trip chain and their main mode of travel.

7.1.2.1 Trip chain characteristics

The mean number of segments in a child's trip chain going to school is 1.2 segments, and only 15% of all children's chains going to school have more than one segment. This indicates that most children leave home and go straight to school.

Table 7.1 Number of segments in child's (age 5-17) trip chain going to school before 10:00 (am).

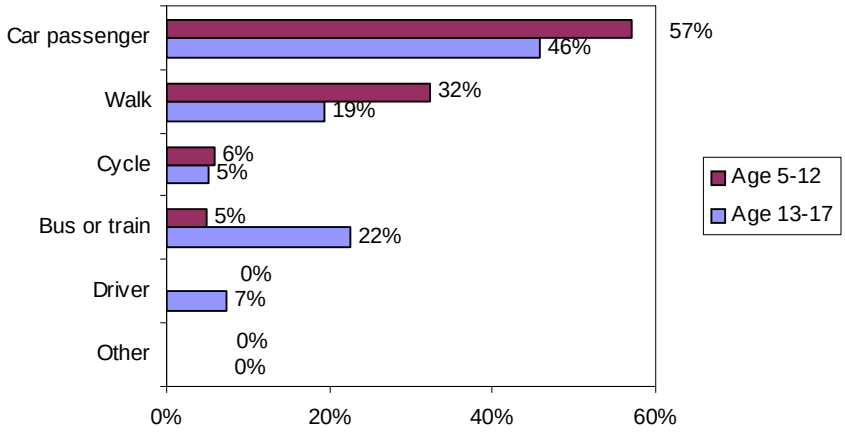
Number of segments	Millions of trip chains	%
1	122	84.6
2	19	13.2
3	3	2.0
4	0	0.2
Total	**144**	**100.0**

[13] At the time, the Statistics New Zealand definition of main urban areas included places at least as large as Gisborne and Upper Hutt (with 1996 populations of 31,000 and 36,000 respectively).

7.1.2.2 Main mode of travel

As mentioned in Section 7.1.1, in 1997/98 about 43% of all school-aged children in "main" urban areas of New Zealand arrived at school as car passengers. We get a similar result to that LTSA analysis using trip chains. However, this overall figure hides some important differences between children of primary school age (5-12 years) and secondary school age (13-17 years).[14] For example, nationally, 51% of 5-12 years have car passenger as their main mode for trip chains to school, compared with 36% of 13-17 year olds. Secondary school students are far more likely to use passenger transport (bus or train) to get to school (28%), compared with primary school students (14%), while the reverse is true for walking (28% of 5-12 year olds compared with 19% of 13-17 year olds walk as their main mode).

Figure 7.1 Main mode for trip chain to school (Auckland/Wellington/Christchurch n = 972 trip chains).

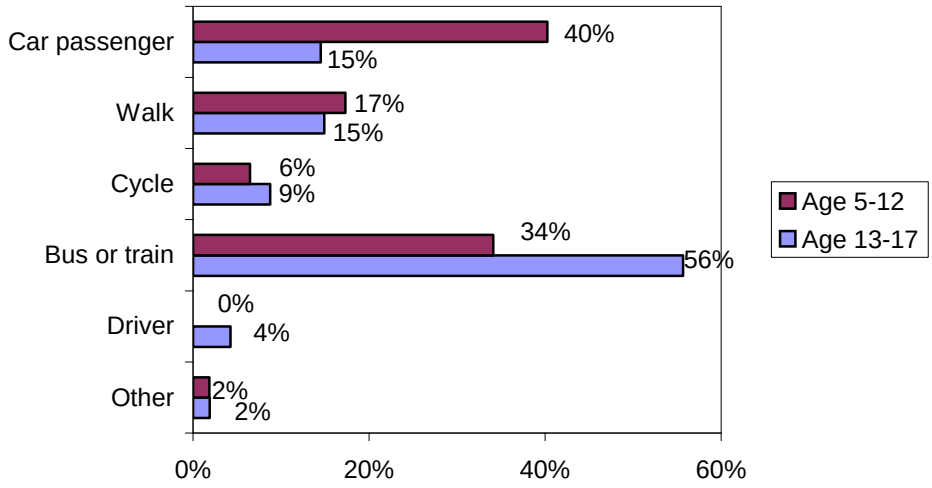


If we compare the main mode for trip chains to school in Auckland (including the four cities of North Shore, Waitakere, Manukau and Auckland), Wellington (including the four cities of Upper Hutt, Lower Hutt, Porirua and Wellington) and Christchurch with "rural" areas (defined as small towns of fewer than 10,000 population and rural areas), we find further differences. Figure 7.1 shows that the national trends are generally mirrored in the three main centres, although the actual proportions vary somewhat: 57% of age 5-12 children travel to school as car passengers in the three main centres, compared with 46% of 13-17 year olds. This contrasts with the 51% and 36%, respectively, reported as the nationwide figures. Fewer primary school children travel by bus or train to school (5%) in the three main centres compared with the national average (14%).

[14] Note that we have chosen to use 17 as the cut-off point for age at secondary school for two reasons: (1) many New Zealand children are 17 years old for most of their final year at secondary school, and (2) many 18 year olds are attending tertiary study rather than secondary school and may have quite different travel patterns.

Rural areas show an even greater contrast in mode share, both when compared with the three main New Zealand cities and between the two age groups of children (see Figure 7.1). Car passenger is a far less common mode of travel for 13-17 year olds in rural areas (15% of their trip chains), while passenger transport (effectively bus only rather than train or ferry) forms 56%. Younger children (5-12 years) still commonly travel as a car passenger to school (40%), although this is much less than the situation in Auckland, Wellington, and Christchurch where it is 57%. Rural children aged 5-12 are much more likely to travel by bus or train than their urban-based counterparts (34% compared with 5% in the three main centres).

Figure 7.1 Main mode for trip chain to school (Rural areas n = 912 trip chains).



7.1.3 Travel from School

This section describes the characteristics of New Zealand children's travel from school, based on the reformulated 1997/98 NZHTS chains dataset. In addition to the number of segments and main mode information given for the to school trip chains, we also discuss the purpose of from school trip chains and highlight the differences in mode use for different 2-year age groups.

7.1.3.1 Trip chain characteristics

The mean number of segments in a child's trip chain from school is 1.5 segments. By contrast with the morning trip to school, where only 15% of trip chains for 5-17 year old children going to school had more than one segment, Table 7.2 reveals that 34% of children travelling from school have trip chains of two or more segments. Some children were found to have trip chains of up to ten segments, compared with the morning school trip, where the maximum number of segments was four on any one chain.

Table 7.2 Number of segments in child's (age 5-17) trip chain leaving school between 13:45-18:00 (pm).

Number of segments	Millions of trip chains	Percent
1	90	66.0
2	33	24.0
3	9	6.4
4	3	1.9
5-10	2	1.6
Total	**136**	**100.0**

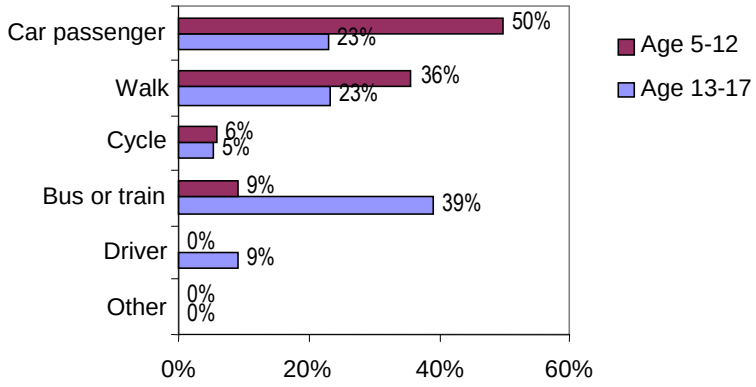
7.1.3.2 Main mode of travel

As with the morning "to school" trip chains, some significant differences are seen between children of primary school age (5-12 years) and secondary school age (13-17 years), and between children in the three main centres (Auckland, Wellington and Christchurch) and in rural areas. In addition, there are notable differences between the morning and afternoon school-based trip chains of children of the same age group and geographical location.

On a national basis, 46% of 5-12 year olds travel as car passenger from school, compared with 21% of 13-17 year olds. Secondary school students are much more likely to use passenger transport (bus or train) to travel from school (36%), compared with primary school students (16%). Walking as a main mode is quite high amongst both age groups (31% of 5-12 year olds and 25% of 13-17 year olds).

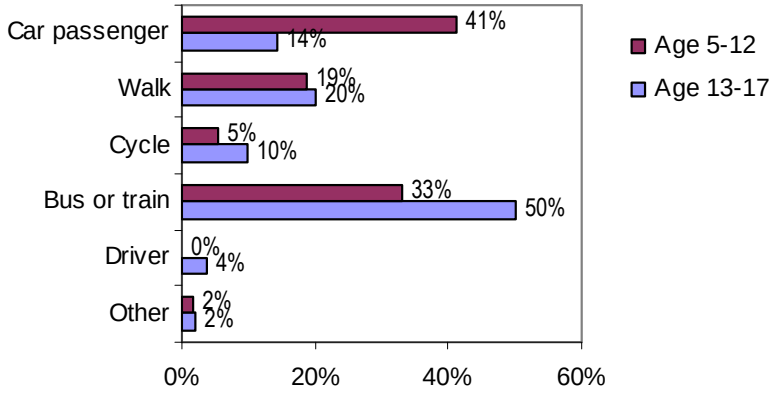
As with the morning journey to school, substantial differences are recorded in mode use relating to degree of urbanisation. Figure 7.3 shows the main mode used for the 899 trip chains from school in Auckland, Wellington, and Christchurch. Travelling as a car passenger, from school, was the main mode for one-half (50%) of the children aged 5-12 in the three main centres. Car passenger was much less common (23%) among the 13-17 age group, where 39% had bus or train as the main mode and a further 9% drove themselves.

Figure 7.3 Main mode for trip chain from school (Auckland/Wellington/Christchurch n = 899 trip chains).



By contrast, Figure 7.4 shows that being driven from school is still very common for those aged 5-12 (main mode for 41%) in rural areas. Bus travel was more common than in the three main centres. Bus was the main mode for 33% of the 5-12 year olds in rural areas compared with only 9% in Auckland, Wellington, and Christchurch. Walking was a much less common mode for the trip chain from school for 5-12 year olds in rural areas compared with the three main centres (19% compared with 36%).

Figure 7.4 Main mode for trip chain from school (rural areas n = 867 trip chains).



The differences of mode use for the morning "to school" trip chain and the afternoon "from school" trip chain, between the same age groups living in the same areas, are quite marked in some respects. Fewer children in Auckland, Wellington and Christchurch are driven as car passengers from school in the afternoon, than are driven to school in the morning. The contrast is greatest with respect to the 13-17 year old age group, where 46% travel as car passengers to school and only 23% do the same from school. In the 5-12 year old group, the difference is only 7 percentage points (57% in the morning and 50% in the afternoon). It appears that quite a few of these 13-17 year olds shift to bus or train: passenger transport use nearly doubles from the morning trip chain (22%) to the afternoon one (39%).

Children in rural areas are more likely to use the same mode for both travel to and travel from school.

7.1.3.3 Main mode usage by specific age groups

When implementing possible interventions in school travel such as walking school buses or supervised cycling groups, targeting the appropriate age groups can be useful in the planning stages. But, until now, accurate quantification of the relationship between age and mode use has generally not been available as background for such decisions.

By using all trip chains nationwide (n = 2849) the sample size is enough to accurately show variations in the modes used for travel from school by 2-year age groups. (Note that it is also possible to illustrate this for the journey to school but, while the actual percentages may differ, we expect that the overall trend will be the same as for the afternoon journey.) For the sake of clarity in the graphs, the main motorised modes for trip chains from school by age group are illustrated in Figure 7.5, while active modes (walking and cycling) are shown separately in Figure 7.6.

With respect to motorised mode use, some of the changes are surprisingly dramatic. For example, the use of the car passenger mode declines steadily from a high of 62% of all trip chains from school for 5-6 year olds, to a low of 16% for 13-14 year olds. Passenger transport use shows a reversed trend, increasing from a low of 12% at age 5-6 years to a high of 42% for 13-14 years, and then declining in the 15-17 year old age group, where the ability to hold a driver's licence clearly has an effect on how they travel [to and] from school.

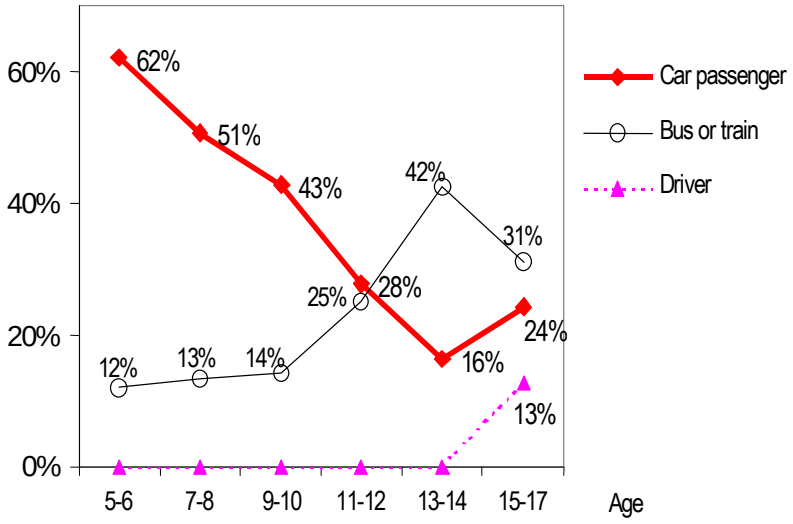


Figure 7.5 Main mode for trip chain from school by age-group (nationwide, motorised modes only).

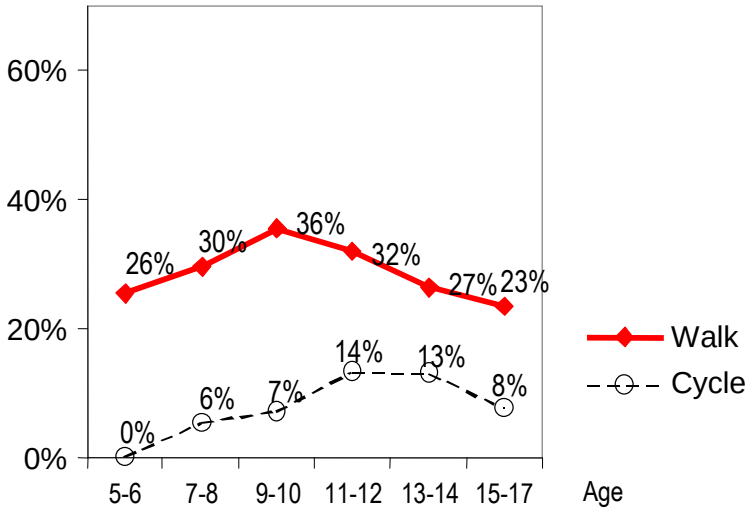


Figure 7.6 Main mode for trip chain from school by age-group (nationwide, active modes only).

Active mode use does not demonstrate such dramatic changes. It appears that walking from school peaks around the age of 9-10 and then slowly declines. Similarly, cycling peaks around the age of intermediate school (ages 11-12), with hardly any 5-6 year olds cycling from school.

7.1.3.4 Purpose of trip chain

Although the purpose of a child's trip chain to school is fairly obvious, the purpose of their from-school trip chain is less so. Indeed, this very issue hampered analysis of after-school travel until our creation of trip chains. (Travel to school was already identifiable by the purpose code *Education*, but no convenient code like this existed to identify travel from school let alone to link together the relevant segments.) For most children being driven from school (91%), the ultimate destination of their trip chain from school is home. Only 8% of children had *Social/Recreation* as the main activity or purpose for the last segment of their trip chain from school. This indicates that most of the 34% of children with 2 or more segments to their trip chain from school did not have stops of >90 minutes that would cause a break in their trip chain.

With respect to the *purpose* (as opposed to the *destination)* of the trip chain from school, Table 7.3 shows that 72% of trip chains by any mode after school involved no activity or purpose other than travelling Home (apart from occasionally changing mode of transport). A further 5% of trip chains by any mode only had "Accompanying someone else" as an activity/purpose in addition to Home. If we examine chains where the main mode for the child is "car passenger" separately, we can see slightly different travel behaviour. There is an increase in Accompanying someone else as a reason for a particular segment (e.g. being driven somewhere to pick up or drop off a sibling at their activity or to help with the family shopping) (12% when main mode is passenger compared with 5% for all modes). It is also more common for the purpose of a trip chain from school to be Discretionary (social/recreational) when travelling as a car passenger (21%) as compared with all modes (15%).

Table 7.3 Activity/purpose of child's trip in hierarchical order for after-school trip chain (nationwide).

Activity/purpose of child's trip	All modes %	Main mode is car passenger %
Subsistence (work, education)	3.0	2.4
Maintenance (shopping, personal business, social welfare)	5.1	6.8
Discretionary (social, recreational)	14.9	21.3
Accompanying someone else	4.6	11.6
Home	71.8	57.8
Change mode	0.4	0.1
Total	100.0	100.0
Unweighted base (chains)	*n=2849*	*n=1102*

7.2 Characteristics of Drivers and their "School-Related" Trip Chains

Until now, it has been impossible to describe the nature of the journey made by the *vehicle driver* responsible for dropping children off to (or picking them up from) school using the original NZHTS database. First, this is because the link between passengers and drivers had not been made prior to our work on vehicle occupancy in 2003 (Sullivan & O'Fallon 2003) and second, because the analysis linking segments into trip chains had not been undertaken. Unfortunately, as discussed in Section 3.5, after matching passenger and driver trip segments for Auckland, Wellington and Christchurch, in the NZHTS reformulated dataset, we had 272 driver trip chains including a "passenger2school" segment and 209 driver trip chains including taking a child passenger from school segment. This relatively small number of chains severely limits the potential for in-depth analysis.

Hence, as indicated in Section 3.8, the complications involved in the linkage process means that it is best to regard the following results as indicative only.

7.2.1 Demographic Characteristics

The driver trip chains found were predominantly in Auckland (70%), which is not unexpected, given that most New Zealanders live in or around Auckland. Perhaps unsurprisingly, Table 7.4 shows that a clear majority (70%) of the drivers were women in the mornings, with this proportion probably rising to 81% for the after school "pick up". Around half (55% in the morning and 60% in the afternoon) of the drivers were aged 35 to 44 years.

Table 7.4 City, gender, and age group of those driving children to school.

Demographic Characteristic	Driver trip chains			
	To school		From school	
	% weighted	Unweighted base number	% weighted	Unweighted base number
Total	100	*272*	100	*209*
City				
Auckland	70	*171*	74	*143*
Wellington	16	*42*	14	*28*
Christchurch	13	*59*	12	*38*
Gender				
Female	71	*197*	81	*164*
Male	29	*75*	19	*45*
Age				
<34 years	22	*61*	27	*53*
35-44	55	*167*	60	*126*
45+	23	*44*	13	*30*

7.2.2 The Morning Trip Chain

The following sections describe various characteristics of the driver's trip chain, including the purpose (other than dropping a child to school), its composition and length.

7.2.2.1 Trip chain purpose

Although the main purpose of the trip chain is clear from the child's perspective (i.e. to go to school), the purpose of the trip chain from the driver's perspective is less obvious. However, as described in Section 2.6, our reformulation of the LTSA database included establishing the main purpose of trip chains. Table 7.5 shows that the sole purpose of 27% of the drivers' trip chains was to drive their child to school (denoted as A*ccompanying someone else* in the LTSA database)[15]. As can be seen in Table 7.5, most drivers have another reason to travel on the same trip chain. Over one-half of them (56%) are on their way to work or their own place of education. Most of the Maintenance, Discretionary and Accompanying trip chains (39%) finish when the driver arrives at home.

Table 7.5 Activity/purpose of driver (in hierarchical order) for before-school trip chain with passengers (Auckland/Wellington/Christchurch only).

Activity/Purpose	%
Subsistence (work, education)	55.8
Maintenance (shopping, personal business, social welfare)	14.0
Discretionary (social, recreational)	3.3
Accompanying someone else	26.7
Total	100.0
Unweighted base (chains)	*n=272*

7.2.2.2 Composition and length of trip chains

The mean number of segments in a trip chain, where the chain involves a passenger aged 5-17 going to school, is 2.7 segments and the mean distance driven (regardless of trip chain purpose) in the driver's trip chain is 10.5 km. By contrast, children's trip chains to school average 1.2 segments, approximately one-half the number of segments in their parent/caregiver trip chain. This is not surprising, given that dropping a child off counts as one segment, with the onward journey counting as another. However, over 40% of drivers had more than 2 segments to their trip chain, indicating that they made a further stop on their chain before reaching their final destination.

The distances children were driven ranged up to 28 km, with a median of 2.5 (that is, around half of the chains were shorter than 2.5 km). Fully one-quarter of the home-to-school portion of the trip chains was less than 1.4 km, a reasonable distance to walk (including walking school buses for younger children).

[15] It is also possible that some of these drivers are dropping other adults off at work, but the sample size used was too small to discern this type of behaviour.

In terms of potential for totally eliminating trips (and gaining the resultant reduction in energy use, etc.), the trip chains where the driver returns home immediately rather than continuing on for other purposes are of particular interest. Because only 27% of the chains were of this type, the small sample available (unweighted base number of 79 chains) means that we cannot provide detailed description of these chains. We can report that the median distance to school for this type of chain was 2.1 km (i.e. half of the relevant distances were less than 2.1 km) and the longest distance was only 6.5 km.

7.2.3 The Afternoon Trip Chain

The basic demographics of drivers picking up children from school were described in Section 7.2.1. The following sections describe other characteristics of the driver's trip chain, including where it started from, the purpose, composition and length.

7.2.3.1 Starting point for driver picking up children from school

One factor that may affect whether or not children are driven from school is the location of the driver beforehand. In particular, it might be interesting to consider what proportions of drivers are coming from work as opposed to home.

To describe the starting point of the driver trip chain, we examined the activity/purpose at the end of the previous trip chain by the driver. As Table 7.6 shows, most drivers (59%) started their trip chain from home. A further one-third (34%) began their trip chain from work, while the remaining 6% came from other activities or locations.

Table 7.6 Activity/purpose at end of the trip chain before driver starts a chain picking up from school.

Activity/Purpose	%
Home	59
Work or own education	34
Maintenance (shopping, personal business, social welfare)	1
Discretionary (social, recreational)	1
Accompanying someone else	2
Unknown	2
Total	100
Unweighted base (chains)	*n=209*

Note: Components may not always add to 100% exactly because of rounding.

7.2.3.2 Purpose of trip chain from school

Clearly, it is considerably easier to assess the purpose of the morning journey to school from the child's perspective and a little more demanding when the adult driver's perspective is accounted for. However, ascertaining the purpose of the trip chain from school presents a challenge from the perspectives of both the adults and the children involved. Describing the activity or purpose of a trip chain from the

driver's perspective is complicated because we must assess activities both before and after the school pickup.

The hierarchical ordering of activity/purpose described in Section 2.6 summarises the different activities and purposes of a trip chain. The hierarchical approach allows any other trip activities/purposes recorded within the trip chain to take priority over Home.

Around two thirds of chains (69%) shown in Table 7.7 did not have a reason other than Home or Accompanying someone else (this would, in most if not all cases, be the child or children the driver was picking up from school). This suggests that the primary or sole reason for the driver's trip chain is to pick up their child/children, and then to either accompany them home or to a child-focused after-school activity.

The most common other purposes incorporated into the trip chain were clearly more family- or possibly adult-oriented Maintenance activities, such as shopping, social welfare, and personal business.

Table 7.7 Activity/purpose of driver for after-school trip chain with passenger (Auckland/Wellington/Christchurch only).

Activity/Purpose	%
Subsistence	5.4
Maintenance	21.3
Discretionary	3.2
Accompanying someone else	61.5
Home	7.5
Change mode or unspecified	1.0
Total	100.0
Unweighted base (chains)	*N=209*

7.2.3.3 Composition and length of trip chains

The mean number of segments in a trip chain, where the chain involves a passenger aged 5-17 from school is 2.8 segments and the mean distance driven (regardless of trip chain purpose) in the driver's trip chain is 11.0 km. This is similar to the morning trip chain where the mean number of segments was 2.7 and the mean distance driven was 10.5 km.

8. Conclusions

The purpose of this research report has been to describe the recent reformulation of the New Zealand (Household) Travel Survey (LTSA 1997/98) trips database into trip chains and tours and to provide some preliminary analysis using the reformulated datasets. The reformulation required us to create definitions and programming sequences for the key elements of the new datasets (segments, trip chains, tours, main mode and main purpose) as well as a new tour classification scheme, which acknowledges the distinctive travel patterns for different tour purposes.

When considering results from different units (segments, chains, tours), it is often useful to keep in mind just how many of each unit is typical.

- On average, respondents completed **4.4 segments (trip legs) per day**.
- Tours are a distinctly broader unit of measurement, and people often complete only one in a day. The average was **1.3 tours per day**.
- Trip chains, as we defined them using a 90 minute cut-off, provide an alternative unit that is usefully intermediate in scope between segments and tours. Respondents averaged **2.3 trip chains per day**.

8.1 The Nature of Short Trips

The results presented here draw attention to the potential of the reformulated trip chains and tours datasets to assist in better understanding New Zealanders' travel behaviour, particularly the nature and frequency of "short trips". Short trips are of particular interest for sustainable transport planning because, other things being equal, environmentally friendly modes such as walking and cycling are more likely to be satisfactory substitutes.

Trip chains describe how New Zealanders link their travel between "significant" locations, namely home, work or education, and other activities where they remain for >90 minutes. A trip from home, stopping to pick up the newspaper and travelling on to work is an example of a trip chain. Highlights of our trip chain analysis include:

- 48% (of all trip chains) are only one segment and a further 33% are two segments.
- 22% are less than 2 km in length and 51% are less than 6 km.
- As the number of segments in a chain increases, so does the length on average.
- 90% use only one mode of transport, of which
  - 48% are vehicle driver trip chains;
  - 25% are vehicle passenger and
  - 13% are walking.
- Of the chains with vehicle driver as the main mode, 13% are less than 2 km long and 42% are less than 6 km in total length.

  This result of 13% from analysis of trip chains provides a very different perspective on the potential for switching vehicle travel to walking from the result of 33% for segments less than 2 km.

- Fairly equal numbers of trip chains have the purposes of Subsistence (work or education) (24%), Maintenance (personal business, shopping, etc.) (21%), and Discretionary (social, recreational, leisure) (24%).
- Subsistence activities are the most common purpose for vehicle driver (28%), cycling (44%) and passenger transport (44%) trip chains.
- Discretionary activities are the most common purpose for walking (33%) and vehicle passenger trip chains (32%).

Tours describe how New Zealanders link their trip segments in a round trip that begins and ends at home. A simple tour could consist of leaving home, travelling to work and returning home again at the end of the working day. Tours may consist of multiple segments, either for the same purpose (e.g. a "multi-part" work tour) or for a mix of purposes (e.g. a "composite" work tour, containing non-work segments). Key fundamentals from our tours analysis include:

- 56% (of all tours) are simple, two segment tours (e.g. home–activity–home); a further 17% are three segment tours.
- 28% are less than 4 km in total and 53% are less than 10 km.
- 84% use one mode of transport (47% are vehicle driver tours; 23% are vehicle passenger and 12% are walking).
- 66% have a main purpose other than work or education, namely:

  Maintenance (29%)

  Discretionary (28%)

  Accompany someone else (10%)
- 23% are for work purposes – nearly half of these are simple two segment tours.
- 10% are for education purposes – 86% of these are completed by 3–17 year olds.
- Work tours have vehicle driver as the main mode more often: 75% of simple, 85% of multi-part, and 80% of composite (all types) work tours use vehicle driver as the main mode.
- Simple education tours are more likely to be completed as vehicle passenger (37%), walking (28%), or passenger transport (21%). In contrast, composite education tours (e.g. involving a non-education activity) are more predominantly as vehicle passenger (57%).

Vehicle driver tours and their relationship in terms of their length and the type of tour was examined in order to identify what the potential is for encouraging environmentally friendly mode use, particularly walking and cycling. Nearly all walking tours (98%) in New Zealand are less than 10 km in total; 83% are less than 4 km. With respect to cycling tours, nearly one-half (48%) are less than 4 km, while 82% are under 10 km. This suggests that targeting vehicle driver tours of less than 10 km is a reasonable proposition.

We found that 19% of vehicle driver tours are less than 4 km and 46% are less than 10 km in total length. When examined by type of tour, we established that "simple" vehicle driver tours of all types were far more likely than composite or multi-part vehicle driver tours to be less than 4 km long: 33% of simple nw/ne tours, 19% of

simple work tours, and 16% of simple education tours fit in this group, compared with approximately 3% of the composite or multi-part work and education tours and 9% of multi-part nw/ne tours.

Nearly 68% of all simple nw/ne vehicle driver tours are less than 10 km, compared with 46% of simple work tours and 40% of simple education tours. Of multi-part nw/ne tours, 34% are also less than 10 km, whereas between 16 and 20% of multi-part work, composite work, and composite education tours are less than this length.

Examining vehicle driver tours that are under 4 km in length (i.e. averaging less than 2 km "each way") seems reasonably comparable in principle to the New Zealand Transport Strategy emphasis on vehicle driver trips (segments) less than 2 km. The results are markedly different however: 33% of vehicle driver segments are less than 2 km, but only 19% of tours with vehicle driver as the main mode average less than 2 km each way.[16] Such differences have important implications for analysis of sustainable transport. As noted earlier, the alternative of considering trip chains up to 2 km also delivers a result markedly lower than 33%; only 13% of chains with vehicle driver as the main mode are less than 2 km.

8.2 Potential New Performance Indicators

We have demonstrated the potential development of new performance indicators using the trip chain and tour datasets. We presented baseline performance indicators for walking only and cycling only trip chains less than 2 km long in the three major cities. For example, in Wellington 58% of trip chains less than 2 km long are walked, and in Christchurch 6% of trip chains less than 2 km long are cycled. More general *national* performance indicators of increasing cycling and walking mode share, based on main mode, could be derived from Table 4.5 (on p.35).

8.3 School Travel

Our analysis here focused on trip chains involving the travel of children to and from school, both from the perspective of the children going to school and – in the cases where the children were passengers in a vehicle – the vehicle driver. Only the driver trip chains from the three main centres (Auckland, Wellington, and Christchurch) were analysed.

The general trend of increasing numbers of children being driven to school (and decreasing numbers walking) had been established prior to our research (using trip segments), together with some disaggregation by age and degree of urbanisation. But we believe this to be the first assessment of mode share or purpose of children's travel from school, either nationally or by disaggregated groups. Our reformulated trip chain dataset permits this type of information to be drawn out.

16 Note that we are not suggesting that all driver tours of less than 4 km in total are walk- or cycle-able. Due to factors unknown to us, such as time constraints, having heavy loads to carry, catering to other passengers who may not be able to walk or cycle themselves, driving a company car, and so on, an individual's mode choice may (at a given point in time) be limited to car driver.

With respect to children's (aged 5-17) travel to and from school, we found that:

- 85% leave home and go straight to school (no interim stops are made on the way).
- The main mode used varies by age and residential location.
- Trip chains from school are more complex than those going to school; 34% of children had two or more segments in their afternoon trip chain compared with only 15% in the morning.
- In the three main centres, there is a significant contrast between how some age groups travel to school and from school:

  For 13-17 year olds, car passenger (46%) is their main mode of transport to school, while it is only 23% of from school trip chains.

  Passenger transport is a more common mode for from school than to school trip chains for 13-17 year olds (39% compared with 22%).
- In rural areas, children generally use the same mode to travel to and from school.
- There are dramatic differences in mode use for trip chains from school by 2-year age groups (5-6, 7-8, 9-10, 11-12, 13-14, and 15-17). For example, from a national perspective, "vehicle passenger" declines from a high of 62% of all trip chains for 5-6 year olds to a low of 16% for 13-14 year olds, climbing to 24% for 15-17 year olds.

Until now, it has been impossible to describe in any way the nature of the journey made by the *vehicle driver* responsible for dropping children off to (or picking them up from) school. However, due to the small sample size available for analysis, the results for driver trip chains must be regarded as indicative only.

Where driver trip chains involve either dropping off or picking up children from school, they are inevitably going to be more complex than those of the children they are transporting, given the scope to combine school trips with other travel purposes. With respect to driver trip chains to school, we determined that:

- 27% had the sole purpose to drive a child/children to school and 56% ended at work or their own place of education.
- 25% of the home to school segment of all chains (regardless of purpose) were less than 1.4 km – an easily walk-able distance, 50% were less than 2.5 km (i.e. walk- or cycle-able).

For driver trip chains from school, we established that:

- 59% start from home and 34% start from work.
- 69% do not have any other purpose than to pick up their child/children and either accompany them to a child-related activity or take them home.

This information highlights some reasonably obvious targets for efforts to change mode use, such as those who drive home immediately after dropping off or picking up their child at school and who thus have no other reason for being on the road at that time. Such drivers make up around a quarter (27%) of the total driving children to school and probably even more of those driving children from school. For many of these journeys, the distance between home and school is eminently "walk-able", suggesting that other factors may be causing these parents to drive. However, it

should not be forgotten that parents' obligations to get their children to school might be restricting their choice of transport mode for their journey to work. For example, some may feel that public transport is not practical for their travel from home to work because they "need" to get into their car to drive children to school anyway.

It also highlights the fact that primary school children (5-12 year olds), whether urban- or rural-based, are the ones who are most commonly driven to and from school, while 13-17 year old urban children are commonly driven to school but use a different mode to travel home. This suggests that the primary targeting for school travel initiatives should be primary schools for both journeys. With respect to high schools, probably the need is to be more selective as to where school travel initiatives are undertaken.

8.4 Potential for Further Research

Finally, it is essential to realise there are many other possible applications for the reformulated NZHTS trip chain and trip tour datasets. Hence the most important outputs from the overall research project are the datasets and the programming that goes with these rather than the initial reports.

9. References

Adler, T., Ben-Akiva, M. 1979. A theoretical and empirical model of trip chaining behaviour. Transportation Research Part B, 13B: 243-257.

ADONIS. 1998. Analysis and development of new insight into substitution of short car trips by cycling and walking. Transport Research Fourth Framework Programme Urban Transport VII – 56.

Axhausen, K.W. 2000. Definition of movement and activity for transport modelling. D.A.Hensher & K.Button (Eds.) Handbooks in Transport: Transport Modelling. Elsevier, Oxford.

Ben-Akiva, M.E., Bowman, J.L. 1999. Activity-based disaggregate travel demand model system with activity schedules. Pre-publication draft.
Later published in: Transportation Research Part A, 35 (2001): 1-28.

Bhat, C., Srinivasan, S., Guo, J. 2001. Activity-based travel demand modeling for metropolitan areas in Texas: model components and mathematical formulations. Center for Transportation Research, The University of Texas at Austin. Accessed from: *www.utexas.edu/depts/ctr/program/ctr_pubs_2002.html (June 2003).*

Bianco, M., Lawson, C. 1998. Trip-chaining, childcare, and personal safety – critical issues in women's travel behaviour. Pp. 123-143 in *Proceedings: Second National Conference on Women's Travel Issues*, October 1996. *Report FHWA-PL-97-024*, FHWA, US Department of Transportation.

Christchurch City Council. 2001. *A step in the right direction:* Pedestrian strategy for Christchurch City.

Cirillo, C., Axhausen, K.W. 2002. *Mode choice in complex tours: A panel analysis.* Arbeitsbericht Verkehrs und Raumplanung, 142, Institut für Verkehrsplanung und Transportsysteme (IVT), ETH Zürich, Zürich. Accessed from: http://www.ivt.baug.ethz.ch/vrp/arbeitsberichte_d.html (November 2003).

Festa, C., Condino, C., Mazzulla, G. 2002. Experimental Tour-based Travel Demand Models. Paper presented at *Handling Uncertainty in the Analysis of Traffic and Transportation Systems*, 13th Mini-EURO Conference and 9th Meeting of the Euro Working Group on Transportation, Bari, Italy, June 10-13, 2002. Accessed from: *www.iasi.rm.cnr.it/ewgt/13conference/103_festa.pdf* (October 2003).

Golob, T.F. 1986. A nonlinear canonical correlation analysis of weekly trip chaining behaviour. *Transportation Research (A), 20A:* 385-399.

Gordon, P., Kumar, A., Richardson, H.W. 1988. Beyond the journey to work. *Transportation Research Part A, 22A:* 416-426.

Hensher, D.H., Reyes, A.J. 2000. Trip chaining as a barrier to the propensity to use public transport. *Transportation 27(4):* 341-361.

Kitamura, R. 1984. A model of daily time allocation to discretionary out-of-home activities and trips. *Transportation Research (B*), *18B:* 255-266.

Krizek, K. 2003. Neighborhood services, trip purpose and tour-based travel. *Transportation 30:* 387-410.

Lee, M.S., Chung, J-H., McNally, M.G. 2002. *An empirical investigation of the underlying behavioural processes of trip chaining.* Institution of Transport Studies (University of California, Irvine) working paper UCI-ITS-AS-WP-02-6. Accessed from: *www.its.uci.edu/its/publications/papers/AS-WP-02-6.pdf* (August 2003).

Levinson, D., Krizek, K. 2004. Chapter 6: Individuals, short term. Place and Plexus (lecture notes for PA8202). University of Minnesota. Accessed from: *www.ce.umn.edu/~levinson/pa8202/PP-Chapter06.pdf (June 2004).*

Mackett, R.L., Robertson, S.A. 2000. *Potential for mode transfer of short trips: Review of existing data and literature sources*. Report prepared for the Department of the Environment, Transport and the Regions (UK) by the Centre for Transport Studies, University College London. Accessed from *www.cts.ucl.ac.uk/publications/publica/shtsvr.pdf* (December 2002).

McGuckin, N., Murakami, E. 1999. Examining trip-chaining behaviour: comparison of travel by men and women. *Transportation Research Record 1693:* 79-85.

Ministry of Transport. 2002a. *Moving Forward*. Ministry of Transport: Wellington, New Zealand.

Ministry of Transport. 2002b. *New Zealand Transport Strategy*. Ministry of Transport: Wellington, New Zealand.

Ministry of Transport. October 2003. *Getting there - on foot, by cycle – a draft strategy to increase walking and cycling in New Zealand transport*. Ministry of Transport: Wellington, New Zealand.

National Pedestrian Project. 2000. *New Zealand Pedestrian Profile.* Wellington, New Zealand.

Nishii, K., Kando, K., Kitamura, R. 1988. Empirical analysis of trip chaining behaviour. *Transportation Research Record 1203:* 48-59.

O'Fallon, C., Sullivan, C., Hensher, D. 2004. Constraints affecting choices by morning car commuters. *Transport Policy 11(1):* 17-29. (Further details available from *www.pinnaclereasearch.co.nz*).

Rosenbloom, S. 1998. Meeting the challenge of change: Developing transportation policies that avoid easy answers and actually work. Pp. 293-299 in *Proceedings of the 9th REAAA Conference,* Wellington, New Zealand, 3-8 May 1998.

Rutherford, G.S., McCormack, E., Wilkinson, M. 1997. Travel Impacts of Urban Form: Implications from an analysis of Seattle area travel diaries. *Final Report from Urban Design, Telecommuting and Travel Forecasting Conference: Summary, Recommendations and Compendium of papers.* Re-accessed from: *http://tmip.fhwa.dot.gov/clearinghouse/docs/udes/mccormack.pdf* May 2005.

Schwanen, T., Dijst, M. 2001. Time windows in workers' activity patterns: empirical evidence from the Netherlands. Presented at the NECTAR Conference, May 16-18, 2001, Espoo, Finland. Accessed from: *www.vtt.fi/rte/projects/nectar/schwanen_dijst_paper.doc* (June 2004)

Shiftan, Y., Suhrbier, J. 2002. The analysis of travel and emissions impacts of travel demand management strategies using activity-based models. *Transportation 29:* 145-168.

Strathman, J.G., Dueker, K.J. 1995. Understanding trip chaining. *Special Reports on Trip and Vehicle Attributes*, 1990 Report Series, US Department of Transportation, Federal Highway Administration.

Sullivan, C., O'Fallon, C. 2003. Vehicle occupancy in NZ's three largest urban areas. *Papers of the 26th Australasian Transportation Research Forum*, October 2003, Wellington, New Zealand. Also available from *www.pinnacleresearch.co.nz*

WalCyng (how to enhance WALking and CYcliNG instead of short car trips and to make these mode safer). 1997. Another European Union project, with 11 "work packages", and partners from several different countries.

Wallace, B., Barnes, J., Rutherford, G.S. 2000. Evaluating the effects of traveller and trip characteristics on trip chaining, with implications for Transportation Demand Management Strategies. *Transportation Research Record 1718:* 97-106.

Webster. 1998. *Webster's Revised Unabridged Dictionary.* Accessed from: *www.dictionary.com* (June 2004).