Trip chains and tours: definitional issues associated with household travel surveys

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1 Introduction

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." 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), there might be a perception that some or all could be replaced by walking, when in fact, as part of a longer trip chain or a tour, the mode for each leg cannot be individually substituted.

To improve the understanding of people's travel behaviour, we re-formulated the 1997/98 NZ (Household) Travel Survey database to link together the trip legs to derive two datasets, one based on "trip chains" and the other on "tours" (beginning and ending at home).

While this re-formulation appears straightforward, we encountered a number of difficulties in creating definitions and procedures for the treatment of trip chains, tours, main mode and main purpose as researchers use the same terms interchangeably or give them different meanings. This paper explores some of the issues we encountered while trying to derive coherent meanings for the terms "trip segment"; "trip chain"; "tour"; "main mode"; and "main purpose." It then goes on to demonstrate how the definitions are applied by highlighting some results from the re-formulated datasets.

2 Definitions

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 Travel (Household) 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 seem 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 that there was 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 only did so 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 and 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 by our preferred terminology.

2.1 Segment

In order to avoid confusion when discussing analysis based on the re-formulated 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 and Murakami 1999; Strathman and 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 and Murakami 1999). On the other hand, Axhausen (2000) and Cirillo and 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 are 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 also because the wish to clearly avoid any previous misunderstandings arising locally from the treatment of "trip leg" and " trip" as synonymous.

In collecting data for the NZHTS, a "trip" or "trip leg", both of which we call a segment, was defined as any movement on a public street, footpath, railway line, etc., of more than 100 metres. Walking segments less than 100 metres are included if a road is crossed or if there is a change of purpose from last segment. This only excludes segments when you walk from one shop to another (same purpose) for less than 100 metres (e.g., where a respondent went to the doctor, walked 50 metres to a shop, crossed the road to a second shop and then walked 80 metres to a third shop, it would be three segments by this definition. Only the last one doesn't count as a new segment).

All vehicle segments on public roads are included, regardless of length. Thus moving a car to the bottom of the driveway is not a segment, but driving to the bus stop is.

Segments were recorded continuously beginning at 4 a.m. on the first "travel day" until the end of the second travel day (3:59 a.m.). A segment began when the person left the location they were at on the beginning of their travel day (usually their place of residence), and ended

whenever they stopped to undertake an activity, be it to change from one mode to another (e.g. walking to the bus stop and then travelling on the bus constitutes two segments), to pick up a newspaper at the dairy, to drop a child off at school, or to arrive at their workplace. A new segment would be counted when the person left that location to move to another.

Of course, the precise definition of "segment" can vary substantially between surveys; but we simply had to accept the definition in the existing database.

2.2 Trip chain

A trip chain is a series of one or more segments. There are various ways of defining how segments can be grouped into chains, some of which we explore below.

2.2.1 Definitions based on home and work

McGuckin and Murakami (1999) noted that there are "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 (**Error! Reference source not found.**), 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.

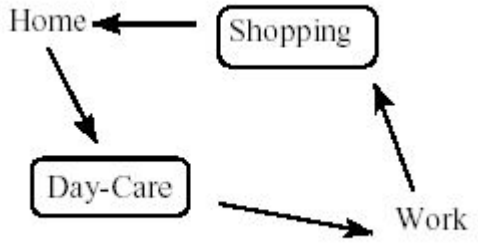

Figure 1 An illustration of trip types (source: McGuckin and Murakami 1999)

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 **Error! Reference source not found.**): Strathman and Dueker (1995), Nishii et al. (1988), Hensher and Reyes (2000), Lee et al. (2002) and Golob (1986) all adopt this formulation. Strathman and 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 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 and Lawson (1998) have adopted a similar meaning.

- Sometimes what is labelled as a "tour" could be better understood as a "trip chain." McGuckin and 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 and 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*).*

2.2.2 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 had 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). They 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. (Rutherford et al. 1997)

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[1] 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 and 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."

[1] 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.

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 and 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 and 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 **Error! Reference source not found.**, Cirillo and 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 1 Mean duration of activities within activity patterns of workers and non-workers (source: drawn from Cirillo and Axhausen 2002)

Timing of activity…	**Mean duration of main activity (in minutes)**	**Timing of activity…**	**Mean duration of main activity (in 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

Levinson and 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. Levinson and Krizek (2004) 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 and Dijst (2001) used data from a sub-sample of workers in the 1998 Dutch National Travel Survey (based on a 1-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 and Dijst (2001) were also able to differentiate between those who had "long" work durations compared with short work duration, and to identify the primary activities occurring in the activity patterns.
Error! Reference source not found. shows that there is a very narrow range of time 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 and 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 Schwanen and Dijst (2001) do not discuss how many activities occur in each time window, we cannot compute an average time spent per individual activity.

Table 2 Mean number of minutes spent on travel and activity by time window (time window length in minutes) (source: drawn from Schwanen and 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 or not 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 and Axhausen (2002) and Schwanen and Dijst 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.

2.2.3 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. 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).

3 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 provide by Adler and Ben-Akiva in 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 and Suhrbier 2002; Cirillo and Axhausen 2002; Festa et al. 2002; Ben-Akiva and Bowman 1999; 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 2 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.

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 re-formulated 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 **Error! Reference source not found.**).

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 (Minister of Transport 2002), 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 and Dueker (1995), which categorises tour purpose into "work" and "non-work" and accommodates different levels of tour complexity (see **Error! Reference source not found.**).

Table 3 Strathman and 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 and 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 and 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 ten tour types (see **Error! Reference source not found.**).

Table 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*

3.1.1 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.

4 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, trip chains and tours where at least 2 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 only found three articles that *explicitly* stated their main mode rule:

- Cirillo and Axhausen (2002) – 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 and Dueker (1995) used car and passenger transport, and excluded walking, in determining their main mode classification.

Other authors identify what their category modes are, 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 1km and then walking 300m, 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 them 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 – 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. 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.

5 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 and Lawson (1998), Ben-Akiva and Bowman (1999) and Shiftan and Suhrbier (2002):

- Subsistence – work or education

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

However, we found that there were 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'. In other studies, this type of segment has sometimes been denoted as "serve passenger".
- *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.

6 Some results

We present here some results of our analysis of the new datasets, simply to illustrate the potential output of the trip chain and tour datasets. In our full report on this project (O'Fallon and Sullivan, forthcoming), we provide much more detailed descriptions of New Zealanders' trip chain and tour characteristics, as well as demonstrating the potential use of the datasets to develop baseline and ongoing performance indicators to monitor (among other things) mode share for trips less than 2 km long. A separate analysis using the trip chain dataset to analyse school travel has also been prepared.

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**.[2] 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 cutoff, provide an alternative unit that is usefully intermediate in scope between segments and tours; respondents averaged **2.3 chains per day**.

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 traveling on to work is an example of a trip chain. Key fundamentals from our trip chain analysis include:

[2] Standard deviations or ranges are not provided because of the time-consuming extra data manipulations these minor additions would require, given that the NZHTS database and our current calculations concern two days of data, not one.

- 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)
- 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
- 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. For example, a simple tour could consist of leaving home, traveling 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:

- 84% use one mode of transport (47% are vehicle driver tours; 23% are vehicle passenger and 12% are walking)
- 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
- 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 – 18 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%).

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. Most 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 non-work/non-education 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 non-work/non-education tours.

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. Thirty-four per cent (34%) of multi-part non-work/non-education 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.

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 average less than 2km each way. 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 be limited to car driver. The point is that such discrepancies in measuring short "trips" have important implications for analysis of sustainable transport.

7 Conclusion

The primary purpose of our research was to re-formulate the New Zealand (Household) Travel Survey (LTSA, 1997/98) trips database into trip chains and tours datasets. The re-formulation 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 task of creating definitions was challenging, due largely to ambiguous and loose use of terminology in the international literature.

Originally, we explored using the well-known Strathman and Dueker (1995) tour classification scheme, but quickly found there were some shortcomings, insofar as the classification really only suited adult-based tours (work or non-work) – education tours were subsumed into the "non-work" category, and yet are fully 10% of all tours, with most (86%) made by 5-18 year olds; and the definitions of "simple" and "complex" were inconsistent within the classification scheme. As a result we devised a new 10-category classification scheme, recognizing four main purposes: education, work, non-work/non-education and (going) home; as well as whether or not the tour was "multi-part" (more than one segment had the same purpose, apart from going home) or "composite" (having mixed purposes). We found that this classification provided particularly useful insights into the nature of New Zealander's tour-making patterns.

The use of "main mode" as a means of identifying the mode used in a trip chain or tour results in some sizeable changes in results. For example, Table 5 shows that when all modes used in a tour are counted, "vehicle driver only" is the mode for 47% of all tours, while when *main mode* is reported; "vehicle driver" is the main mode for 53% of all tours. Vehicle passenger tours are affected similarly: "vehicle passenger only" tours are 23% of all tours, while "vehicle passenger (main mode)" tours are 28% of such tours. Much of the difference (around 5 percentage points in each case) is taken into account by the mode combinations "vehicle driver and walk" and "vehicle passenger and walk." The effect of the two definitions on active transport tours (walking, cycling and public transport) is much less pronounced, with around one percentage point difference in reported tour numbers, largely because these tours generally have fewer segments. However, the potential for distinctive differences suggests that definitions should be carefully laid out in any reporting.

Table 5 All modes used in a tour

Modes used in tour	Millions of tours	Percent
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	.2%
Train & walk	2	.1%
Bus	9	.5%
Bus & walk	26	1.4%
Taxi	4	.2%
Taxi & walk	2	.1%
Other modes (not plane) only	3	.2%
Walk only	217	11.8%
Vehicle driver + Vehicle passenger (& occasionally walk)	49	2.7%
Vehicle driver + bus/train/ferry (& usually walk)	5	.3%
Vehicle passenger + bus/train/ferry (& usually walk)	29	1.6%
Other combinations	19	1.1%
Total	1829	100.0%

In future work, it may be useful to consider the merit of keeping the categories of "subsistence", "maintenance" and "discretionary" when considering the purpose of trip chains and/or tours. These are quite technical terms that may confuse "lay" readers. The category "subsistence" incorporates both work and education, merging together the two quite distinctive demographic groups that make these types of chains and tours. While we considered discretionary chains and tours to be largely for the purpose of recreation and leisure (including social calls), some may argue that "shopping", which is currently included in the maintenance category, could in many cases be included in the discretionary one. Perhaps, given that generally it cannot be determined from a database whether any given shopping trip is "maintenance" or "discretionary", there might be merit in establishing shopping as a separate category.

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