Driver Characteristics and Speeding Behaviour

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Abstract

Despite significant efforts to counteract the problem, excessive speed remains the number one causal factor associated with serious accidents in New South Wales. Part of the problem is that other than when motorists are actually caught speeding (typically through targeted enforcement) we actually have little information on the prevalence and magnitude of speeding as part of normal driving routines. This paper presents an analysis of speeding captured through a study of 133 motorists in Sydney in which driving patterns (including speeds and speeding) were captured for several weeks using Global Positioning System (GPS) technology. Results show that overall twenty percent of the moving distance travelled was above the posted speed limit, with a small but significant number of drivers regularly travelling more than 10 km/h above the speed limit. Exploratory analysis shows that speeding is more prevalent in high (100-110 km/h) and low (40-50 km/h) speed zones, and tends to be higher on weekday mornings and weekend nights. Overall, males speed more than females but there are only marginal differences by age. Speeding is more prevalent on weekends than weekdays but weekday speeding is higher in the mornings whilst weekend speeding is higher at night.

1. Introduction

Despite campaigns and strategies to the contrary, speeding and its consequences remain a major problem on Australia's roads. In 2007, evidence from the most populous state, New South Wales (NSW Centre for Road Safety, 2008) and South Australia (Wundersitz *et al.*, 2009) showed that almost one-third of licensed drivers were caught speeding in that year. The consequences of speeding in terms of increasing both the risk and severity of a crash are well documented. For instance, in 2007, speeding in New South Wales was a contributory factor in 32 percent of fatal crashes and 16 percent of all crashes resulting in injuries (NSW Centre for Road Safety, 2008). Despite this, many motorists still do not consider speeding to be dangerous (Lieb and Wiseman, 2001) with the majority of drivers admitting to exceeding the speed limit at least occasionally by 10 km/h or more (Fleiter and Watson, 2005).

Efforts to understand the characteristics of speeding (who, where, when, why, by how much) have uncovered a range of contributory factors pertaining to the driver, vehicle, trip, street environment and weather (Harrison *et al.*, 1998, Brundell-Freij and Ericsson, 2005, Ogle, 2005, Liu, 2007). Analyses have generally relied on speeding enforcement records or self-reported speeding behaviour, both of which have serious limitations when it comes to understanding the magnitude and prevalence of speeding for drivers over space and time. An alternative is to capture data while motorists are driving through instrumentation of the vehicle using Global Positioning System (GPS) technology (Ogle, 2005). The advantage here is that motorists are monitored while driving around as per their normal daily routines, providing the opportunity to study the factors impacting speeding in more depth. Clearly, the potential disadvantages are the sample sizes and the impacts of the monitoring itself on driver behaviour.

With this in mind, the current paper presents an analysis of speeding captured from 133 motorists in Sydney, in which driving patterns (including speeds and speeding) were recorded over several weeks using Global Positioning System (GPS) technology (Greaves *et al.*, 2010). Motorists also completed a detailed demographic and psychological survey, providing a wealth of information for analysing speeding. Following a review of recent literature on the causal factors behind speeding, the paper details the methods used for this study. We then present an overview of speeding behaviour for identifying the factors influencing speeding. Identifying these factors is helpful when developing and assessing education initiatives, policies, legislation and infrastructure intended to improve road safety.

2. Literature Review

The act of speeding can be defined in numerous ways. In some studies, speeding is defined as excessive speed for the driving conditions at any point in time (Giles, 2004). In others, speeding is defined in terms of a specific level above the posted speed limit, generally referred to as 'tolerance', mainly to account for the accuracy of vehicle speedometers, radar and speed cameras (Johnston, 2004). Tolerances vary markedly by jurisdiction. For instance, New South Wales currently has a zero tolerance for speeding (RTA, 2010), Victoria has a 3 km/h tolerance (Delaney *et al.*, 2005) and New Zealand a 10 km/h tolerance (Johnston, 2004). For our purposes, we adopted the New South Wales definition of speeding that is relative to the posted speed limit, given this was where the study was conducted.

2.1 Measurement Approaches

Previous investigations into the factors influencing speeding have largely relied on manual or automated speeding enforcement records, self-reported speeding behaviour and to a far lesser extent on-road investigations. Manual enforcement records are believed to understate the extent and magnitude of speeding and are restricted to the particular location/time for which enforcement takes place (Schafer and Mastrofski, 2005). Automated enforcement has the benefit of large sample sizes, but suffers from the ability to identify the driver, thereby hampering the collection of driver demographics (Delaney *et al.*, 2005). The additional caveat with automated enforcement in particular is that motorists have become increasingly aware of where cameras are, providing the opportunity to adjust behaviour so as not to get caught. Self-reported speeding behaviour has the clear advantage of being able to collect information about the participant and (depending on the selected sample) be more representative of the general population than those caught in enforcement records. However, evidence suggests that motorists significantly misreport speeding behaviour, with a tendency for motorists to understate their speed the faster they drive (Corbett, 2001, Hatfield *et al.*, 2008).

On-road investigations into speeding are few and far between. Várhelyi et al. (2004) used a GPS receiver to monitor speeds from 284 vehicles within the city of Lund in Sweden from November 2001 to January 2002 as part of an evaluation into the effects of the active accelerator pedal (AAP) which has been designed to enforce speed limits. More recently, Ogle (2005) used second-by-second GPS data collected from 172 vehicles in Atlanta over a two week period. They report (an astonishing) forty percent of driving time is spent over the posted speed limit, with 12 percent of driving time spent more than 10 mph (16 km/h) above the speed limit. Crucially, the study suggests that the fact driving was being monitored did not have a discernible impact on behaviour per se, supporting evidence elsewhere that once the novelty of the device has worn off, people revert back to their normal behaviour (Stopher and Greaves, 2009).

2.2. Speeding Measures

The caveats of definitions and measurement techniques aside, there is a wealth of literature on the prevalence of and factors behind speeding. In terms of prevalence, three separate Australian studies in New South Wales (New South Wales Centre for Road Safety, 2008), South Australia (Wundersitz et al., 2009) and Perth (Radalj, 2000) (all based on enforcement techniques) suggests that around one-third of licensed drivers get caught speeding each year. Based on self-reports, speeding is evidently more prevalent with both Australian (Fleiter and Watson, 2005) and U.S. studies (Sivak *et al.*, 2007) suggesting that two-thirds of motorists self-report breaking the speed limit at least occasionally. Most speeding (reported or observed) appears to be within 10 km/h, but evidently around 10-15 percent of motorists exceed the limit by more than this amount (Fleiter and Watson, 2005, Ogle, 2005).

2.2.1. Driver Demographics

Many studies have shown younger drivers (under 34 years) are more likely to be speeders, (Fildes *et al.*, 1991, Ogle, 2005, Williams *et al.*, 2006). In contrast, drivers over 55 years are less likely to be speeders (Fildes *et al.*, 1991, Ogle, 2005). The impact of gender is less clear with some studies showing gender to be significant with males more likely to speed than females (Laapotti *et al.*, 2003, Williams *et al.*, 2006), others showing gender to be significant only for certain speed limits (Fleiter and Watson, 2005) or for specific age groups (Ogle, 2005) and some finding that gender is not a significant factor at all (Fildes *et al.*, 1991, Goldenbeld and van Schagen, 2007). The uncertainty in the influence of gender on speeding behaviour is in contrast to clear evidence that males are involved in a disproportionate number of accidents, relative to their presence in the driver population, in which excessive speed is a contributory factor (Wundersitz et al., 2009).

The link between personality traits and speeding has attracted the attention of many researchers as being a more definitive indicator of speeding. Several researchers have shown that the 'sensation seeking' propensity of drivers is highly correlated with risky behaviours such as speeding (e.g. Jonah *et al.*, 2001, Greaves and Ellison, 2010). Others have focused on the 'classic' personality types, demonstrating Type-A personalities are more likely to speed (Tay et al., 2003). Conversely, characteristics such as altruism and aversion to risk have been shown to be negatively correlated with speeding (Machin and Sankey, 2008, Greaves and Ellison, 2010).

2.2.2. Vehicles

Drivers of vehicles less than five years old are more likely to speed (Fildes *et al.*, 1991, Williams *et al.*, 2006). These findings have been confirmed by Ogle (2005) who found vehicle age to be significant. On a more general level Horswill and Coster (2002) found several vehicle characteristics – particularly performance – to be related to risky driving behaviours (including speeding). Other vehicle characteristics such as vehicle ownership and vehicle size are less conclusive (Harrison *et al.*, 1998).

2.2.3. Trip Details

Fildes *et al.* (1991) found drivers travelling for work are more likely to speed but this finding was contradicted by a later study (Harrison *et al.*, 1998). However other more recent research has found trip purpose to be a factor in speeding (Fleiter and Watson, 2005). Although the presence of passengers in the car has been shown to have an impact on speeding (Fildes *et al.*, 1991, Harrison *et al.*, 1998, Fleiter *et al.*, 2006, Liu, 2007) the extent and direction of that influence varies based on other factors such as the age and gender of the driver and passengers (Fleiter *et al.*, 2006).

2.2.4. Road/Environmental Conditions

In addition to the speed limit of the road being a significant factor in speeding in itself, the extent of speeding and the factors that influence speeding appear to change from one speed limit to another (Fleiter and Watson, 2005, Ogle, 2005). However, the influence of the speed limit on driver behaviour may be partly a function of the street characteristics associated with a particular speed limit, as Brundell-Freij and Ericsson (2005) found that street characteristics have a significant impact on driver behaviour. Similarly, there is evidence that speeding in urban areas is different – in terms of magnitude and significant factors – from rural areas (Fildes *et al.*, 1991, Harrison *et al.*, 1998). In addition (Kyte *et al.*, 2001) suggests speeds reduce by around 10 km/h when the pavement is wet which indicates that weather appears to be a factor in *reducing* the likelihood of a driver speeding.

2.3. Gaps in existing research

Most previous research on speeding has relied on either self-reported speeding collected through surveys or using speed enforcement records. Both of these methods are limited by the inability to monitor the same drivers across time and the under and over reporting of speeding in self-reporting surveys (Corbett, 2001, Hatfield *et al.*, 2008).

Although Ogle (2005) used second-by-second GPS data to determine some of the possible factors which influence speeding, this study stopped short of including trip purpose, number of passengers and psychological variables which other studies have shown merit investigation.

3. Methods

3.1. Data sources

The primary source of data for this study was second-by-second GPS data collected from 133 motorists in Sydney over a period of five weeks as part of a wider investigation into driving behaviour (see Greaves *et al.* (2010) for details). Briefly, participants were recruited from across Sydney via an online panel according to strict criteria that reflected the main aims of the study as well as practicalities about using the GPS equipment. The original aim was to recruit 148 motorists (based on number of GPS devices) with roughly equal proportions of 17-30 year-old and 31-65 year-old drivers, although this criteria had to be relaxed as it proved particularly difficult to recruit drivers in the younger age cohort. It is important to stress that motorists were told the objectives of the study were to track vehicle usage of a number of drivers to help transport planning in Sydney. They were not told their speeds were being monitored because of the potential for artificially affecting their driving behaviour. This information was supplemented with the data summarised in Table 1.

Table 1: Summary of data sources

Second-by-second GPS data	Includes drivers' actual speed, speed limit, date, time, latitude and longitude for each second of driving.
Demographic and psychological data	Collected from participants and includes age, sex, vehicle information, self-reported psychological data collected from participants using a survey.
Trip details	Collected from participants using a web-based prompted-recall solution and includes trip-level variables including trip purpose, the actual driver and the number of passengers.[1]
Rainfall	Hourly rainfall data from 15 observation points across Sydney acquired from the Australian Bureau of Meteorology.
School zones	Was used to identify if a driver was travelling in a school zone (with a 40 km/h speed limit) at each point in time.

Given the focus on speeding, it is important to understand how speeding was identified. The GPS data were map-matched to a GIS-based street network of Sydney, which included accurate speed limits, collected by our partner in the project, Smart Car Technologies (SCT). The speed limit database was developed by driving all streets in Sydney and is kept updated through both notifications from the road authority and subscribers to SCT services when limits change. It must be acknowledged that during the course of the study (which ran in total for several months), we encountered only three cases where the limits were incorrect as identified by study participants and these were all in rural areas on remote highways. The speed limits also include temporal variations, which are particularly important for school zones that generally operate in Sydney from 8:00 a.m. – 9:30 a.m. and from 2:30 p.m. – 4:00 p.m. with a speed limit of 40 km/h.

The matching of GPS data to speed limits is non-trivial for two primary reasons. First is the GPS lag problem, which alludes to the fact that GPS (Doppler) speeds typically have a 1-2 second lag. This was overcome by matching GPS points to the speed segment 1-2 seconds upstream based on the assumed distance that would be covered. Second, is the more serious issue of incorrectly assigning GPS points to the wrong road, something that often happens when roads are in close proximity such as intersections, off-ramps, service roads etc. The reason this happens is because GPS points have an error of (typically) a few metres and map-matching algorithms work by 'snapping' the GPS point to the nearest line. This was overcome by building a much more detailed representation of the network and using the information (primarily speed) from previous GPS points, to maximise the probability that the point is snapped to the correct segment.

With reference to the previous discussion on tolerances in New South Wales, speeding was defined as any speed exceeding the speed limit.

3.2. Data processing

A custom data processing tool was developed to process and incorporate the supplementary driver, trip and environment data into the second-by-second GPS data. As output, the tool provided SPSS files containing all the relevant variables at a second-by-second level and a speed-limit-segment level (see Section 3.2.2.).

[1] Study participants were provided with access to a web-based prompted-recall interface. This was updated each day with a record of all trips displayed on a Google Map. Participants were asked to supply trip-level information and to confirm each trip. All 133 motorists included in the final analysis completed the prompted-recall for the full five weeks.

3.2.1. Excluded data

Although all valid data were included in the SPSS file created by the data processing tool, for the purposes of the analysis some types of records were excluded. Given it is impossible for a driver to be speeding when they are stopped, including points where the vehicle is stopped would understate the extent of speeding. Data for locations for which the speed limit was 10, 20 or 30 km/h and locations for which the speed limit is not available – identified in the database by a speed limit of 999 – were also excluded. Due to the lack of availability of demographic and psychological data, data from non-primary drivers[2] was excluded. Similarly, data for which the closest meteorological observation point was more than 50 km away was excluded due to the lack of reliable rainfall information. These rules resulted in the exclusion of 15 percent of otherwise valid data.

3.2.2. Speed limit segment-level

The second-by-second dataset (excluding observations where the actual speed is zero) included millions of records and was problematic to use and interpret at this level of disaggregation. Since an initial descriptive analysis of the second-by-second dataset showed that the speed limit appeared to be a significant factor, aggregating on the basis of speed limit segments seemed a logical choice with a new segment defined every time there was a change in speed limit; Figure 1 illustrates how this worked.

Each record in the segment-level dataset contains the total distance of the segment, the distance exceeding the speed limit by 1 km/h, 10 km/h and 20 km/h in addition to the total number of observations included in the segment. In total there were 160,000 segments in the final dataset. As can be seen in Table 2, there is a large variation in the distance of segments both within and between speed limits.

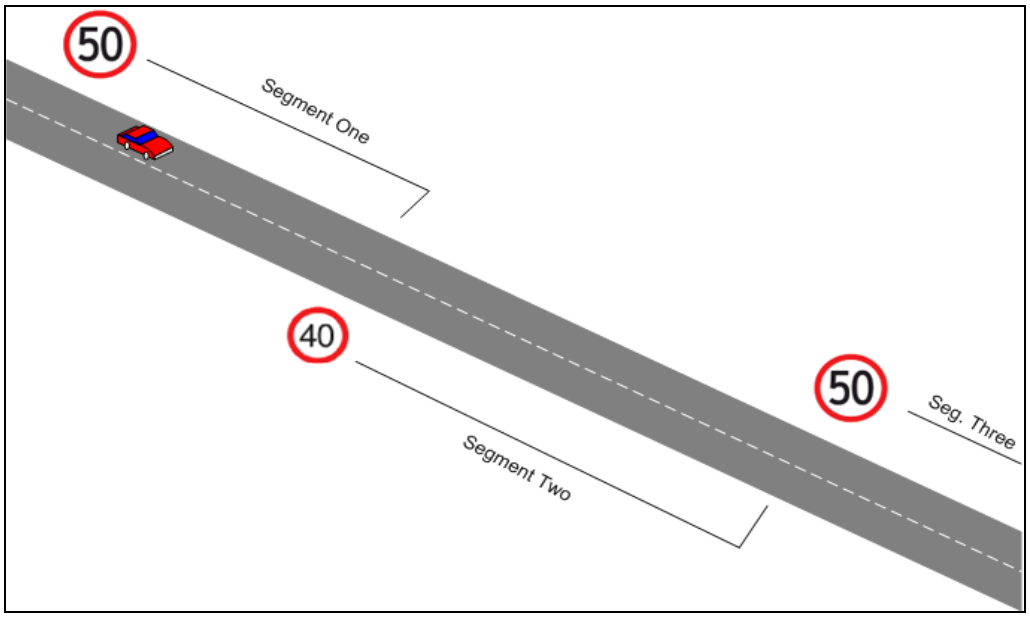

Figure 1: Speed limit segments

[2] The primary driver is the driver who completed the demographic and psychological survey. This classification is not related to how frequently the primary driver drove the car although in practice the primary driver was typically also the most frequent driver of the vehicle.

Table 2: Segment distance descriptive statistics

		Total Number of Segments	Segment Distance (km)			
			Maximum	Mean	Median	Standard Deviation
Speed Limit	40	16,029	4.36	.19	.13	.23
	50	40,646	26.76	.56	.22	.87
	60	41,672	23.30	1.05	.56	1.43
	70	13,925	19.69	1.32	.82	1.45
	80	7,835	26.35	1.59	.89	2.07
	90	4,101	11.33	2.06	1.15	2.15
	100	1,506	46.13	4.62	2.01	7.32
	110	612	152.46	12.48	6.08	19.42

3.2.3. Weighting

Given the heterogeneity in driver behaviour across the sample it was necessary to ensure that any analysis was not biased towards the driving behaviour of drivers that drove more frequently. This was addressed by weighting each segment so that each driver's total distance driven was the same. This was done using the formula in Equation 1.

Equation 1: Calculation of Weight Variable

$W = ((SD/TD_{driver})*1000)/SD$	W: Weight SD: Segment Distance TD_{driver}: Total Distance for this Driver

4. Analysis

4.1. Sample composition

The composition of the final sample is shown in Figure 2 along with a breakdown of total vehicle kilometres of travel (VKT) by speed limit and time of day. In common with many of these types of investigations (Ogle, 2005), it did prove difficult to recruit certain demographic segments, particularly young males, and clearly this must be borne in mind when interpreting results. Overall, although the sample included few (37) participants aged 30 and under, they represent 28 percent of the study sample which is broadly consistent with the proportion of drivers under 30 years of age in New South Wales (RTA 2010)[3].

[3] The number of drivers is sourced from data on drivers' licenses issued by the Road and Traffic Authority (RTA) in New South Wales in 2009.

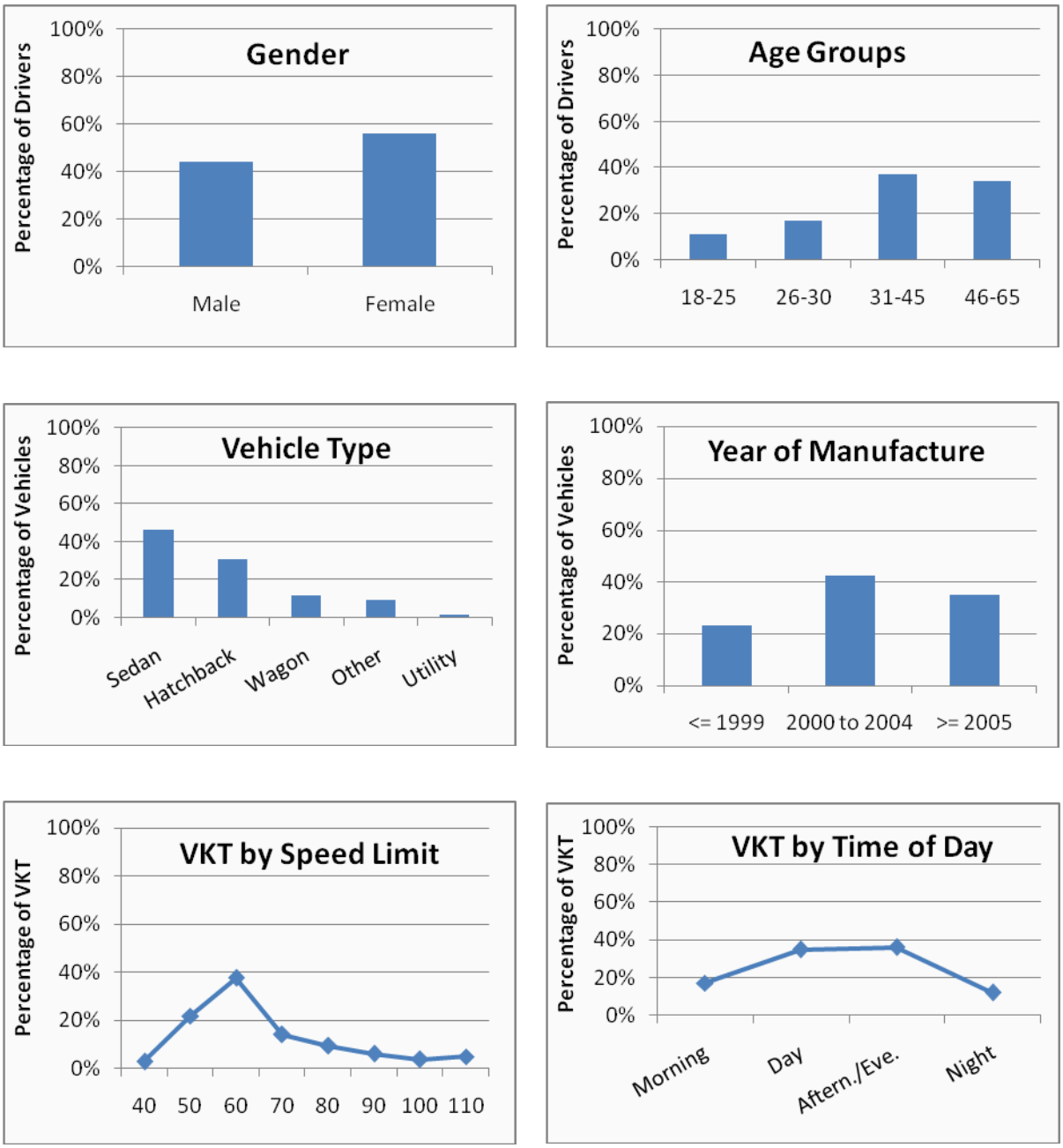

Figure 2: Participant sample composition

4.2. Overall measures of speeding

Figure 3 presents a summary of speeding behaviour by speed limit for the 133 motorists over the five-week sampling period. Overall 19 percent of the distance driven was spent above the speed limit, four percent of the distance was spent more than 10 km/h above the speed limit and one percent greater than 20 km/h above the speed limit. Evidently, speeding per se and higher magnitude speeding are most prevalent on 100-110 km/h roads (i.e., motorways) and more worryingly at the lower speed limits found in residential areas. The lowest levels of speeding occur in school zones at 10 percent of the distance driven exceeding the speed limit by 1 km/h or more.

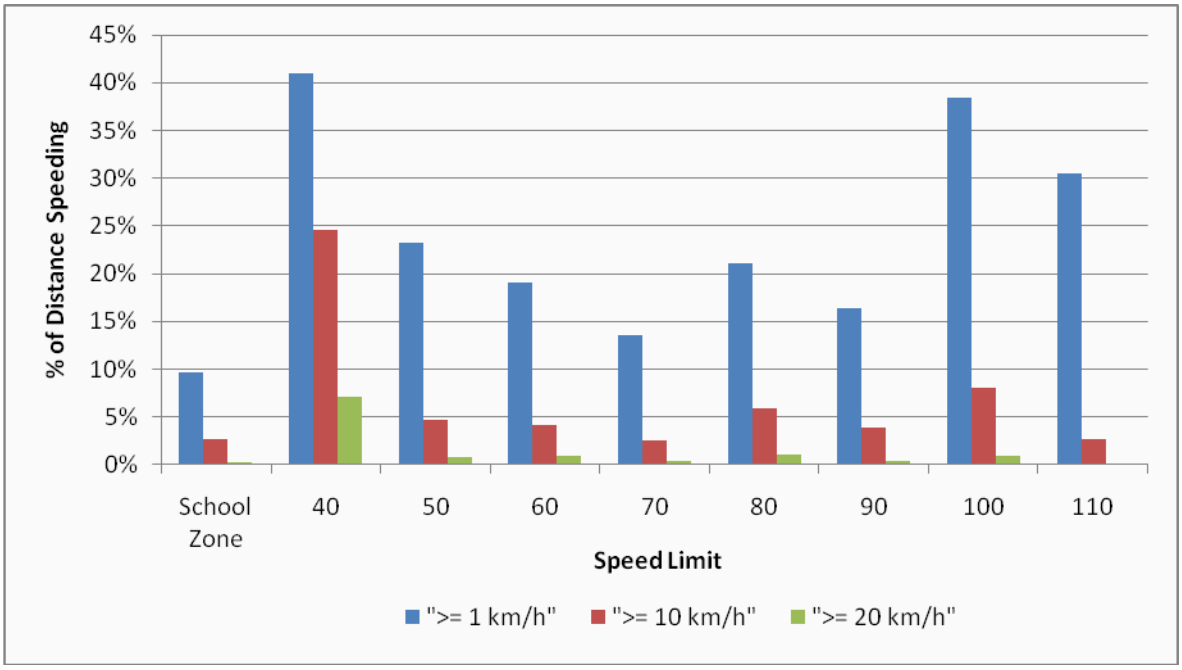

Figure 3: Percentage of speeding by speed limit (GPS Data)

It is clear that exceeding the speed limit is very common amongst drivers but as can be seen in Figure 4, the extent of speeding varies tremendously throughout the drivers in the sample. For example, although all 133 drivers exceeded the speed limit at some point during the study period – albeit a few for only a small proportion of their total driving distance – 14 drivers exceeded the speed limit for more than 30 percent of the distance including one driver who exceeded the speed limit for 61 percent of the distance driven. Furthermore, nearly half the drivers exceeded the speed limit for at least 20 percent of the distance. Although the extent of speeding at 10 km/h or more above the speed limit is lower, the same pattern emerges.

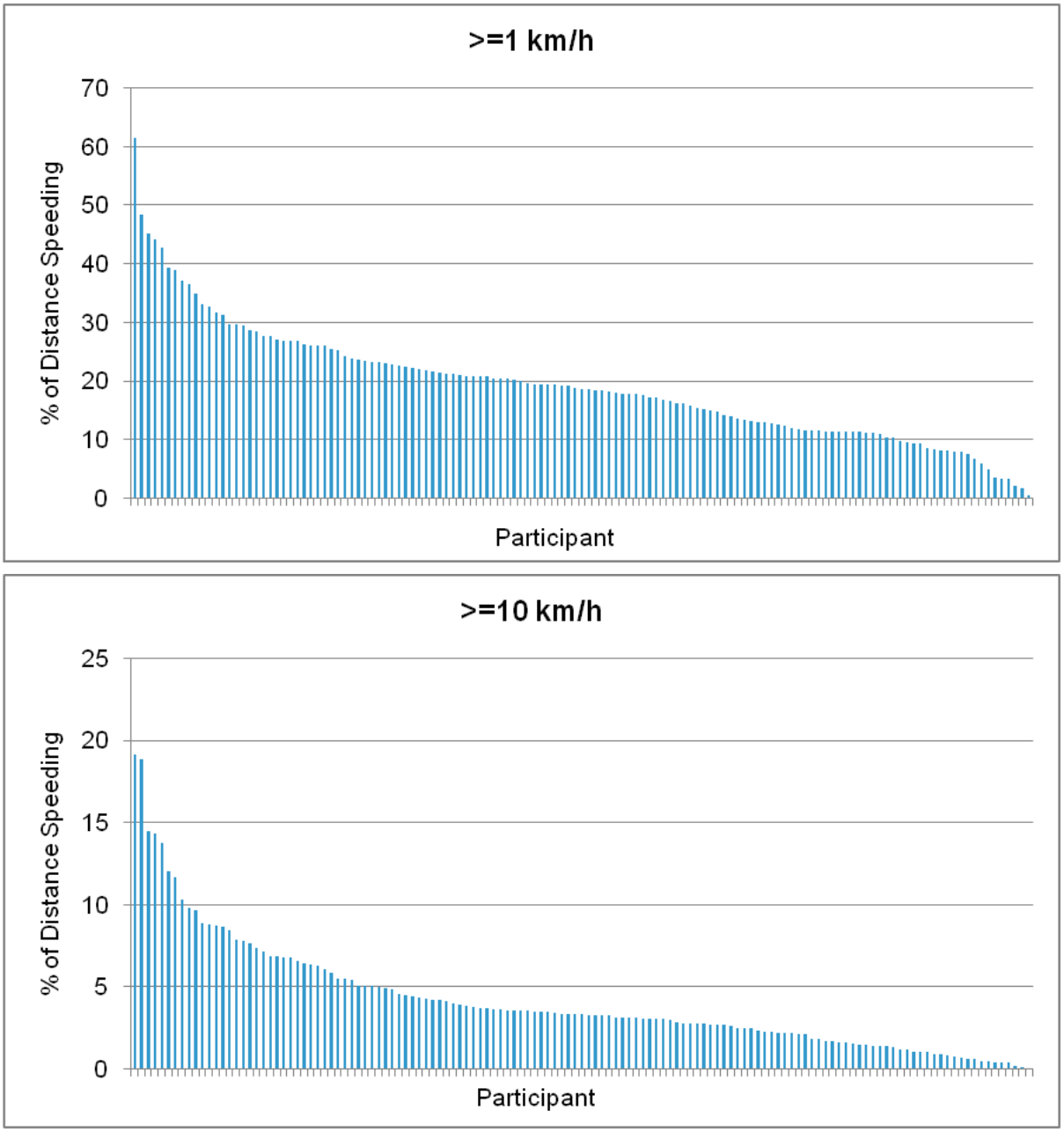

Figure 4: Speeding by participant

4.3. Demographics and Personality

In terms of demographics, overall males speed more than females of the same age group although the reverse is true for the 46-65 age group (Figure 5). Reasons for this (apparent) anomaly in the oldest age category are unknown. Caution must be taken over drawing too much from this because of the low representation, particularly of younger males, and self-selection bias for the study.

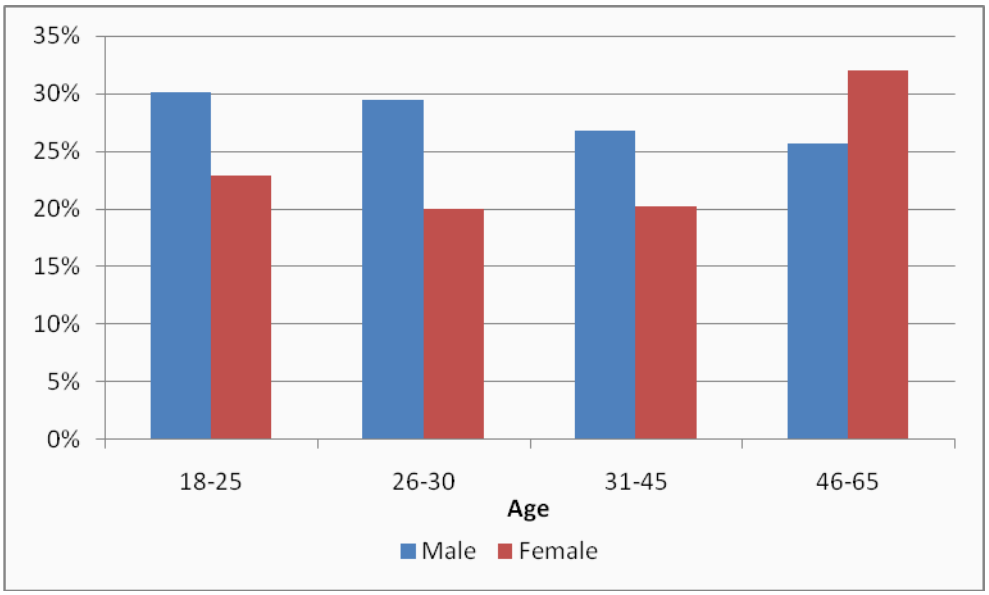

Figure 5: Percentage speeding by age and gender

As part of the study, a driver personality study was designed to capture facets of personality and risk perception. Figure 6 shows that, in general, the more risk averse a person is the less they speed. Interestingly, the opposite trend (albeit slightly) is true when plotting drivers likelihood of worrying against their driving (Figure 7). However, in both cases there is significant variation between drivers.

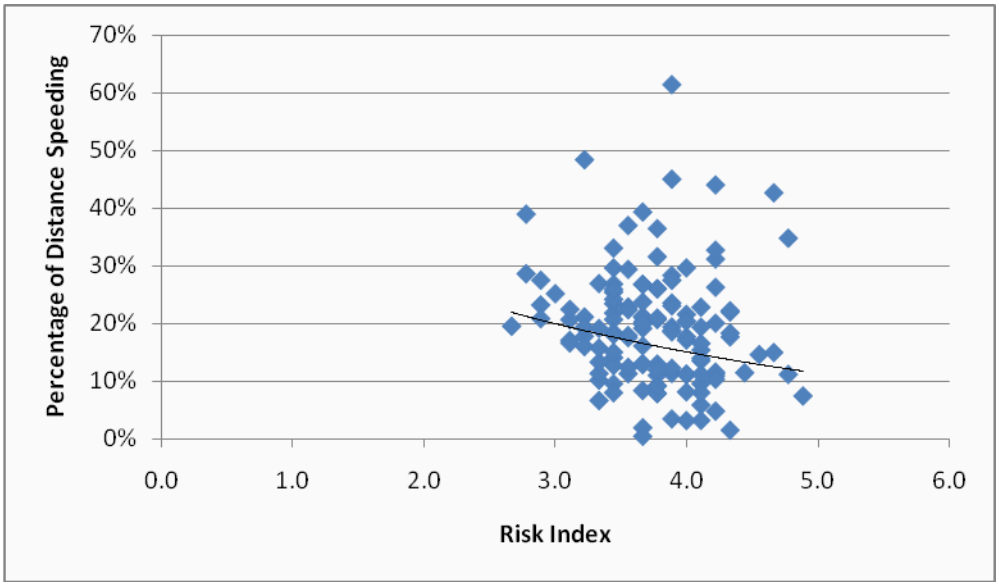

Figure 6: Percentage speeding by risk aversion[4]

[4] A higher number indicates greater risk aversion.

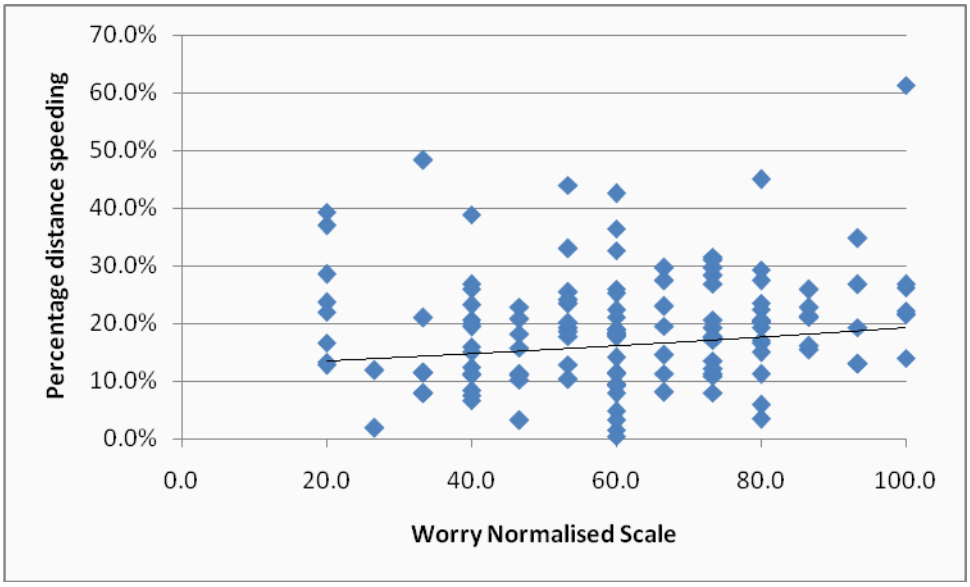

Figure 7: Percentage speeding by worry

4.4. Vehicles

Within the sample, drivers of BMWs had the highest levels of speeding exceeding the speed limit by 1 km/h followed by Holden, Ford and Subaru. Of the major vehicle manufacturers Mazda drivers sped the least. Drivers of the Mitsubishi Lancer had the highest levels of speeding followed by the Ford Falcon and the Toyota Corolla (the most common car in this study). The vehicle model appears to have a greater impact on the levels of speeding than the manufacturer. This is most likely due to the characteristics of drivers that buy certain models of car rather than something to do with the car itself. In terms of overall speeding, newer cars and cars with larger engines speed somewhat more than older cars and cars with smaller engines. There is little difference between them in the percentage of distance driven at 10 km/h and 20 km/h or more above the posted speed limit.

4.5. Temporal

In addition to the speed limit and driver demographics, the characteristics of each trip including the day of the week and time of day also appear to influence the extent of speeding. Figure 8 shows the temporal breakdown in speeding across the week. During the week, speeding was highest (27 percent), albeit marginally, during the morning, gradually falling throughout the day before stabilising at night. Speeding was systematically higher on weekends, peaking during the night-time period at 31 percent.

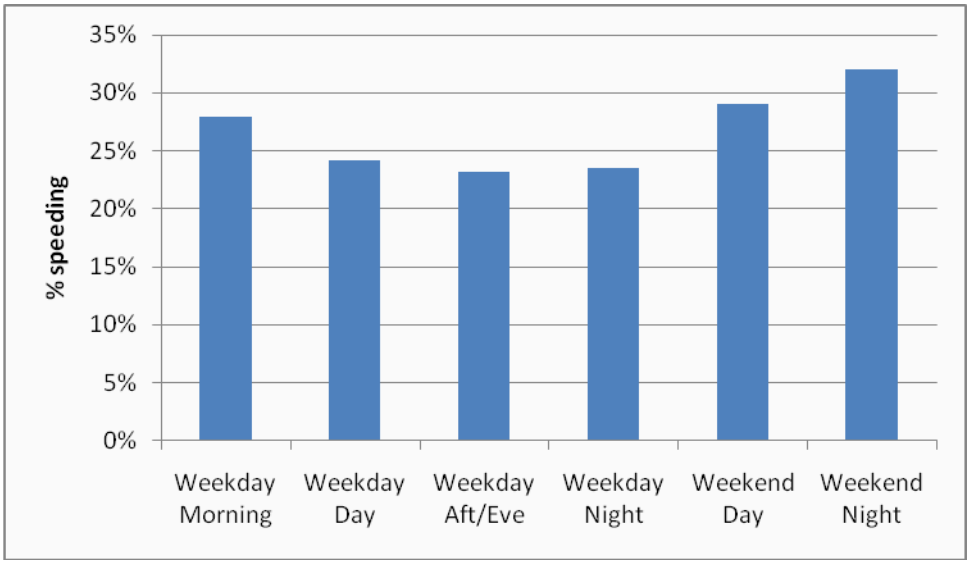

Figure 8: Percentage speeding by time of day and weekday/weekend[5]

Figure 9 shows that speeding during weekdays is highest on Monday and lowest on Friday. Speeding on weekends is slightly higher on Saturdays than on Sundays but both are higher than on any weekday. This may be partially a reflection of greater congestion during the week but as can be seen in Figure 8, speeding varies considerably during different time periods of the same weekday.

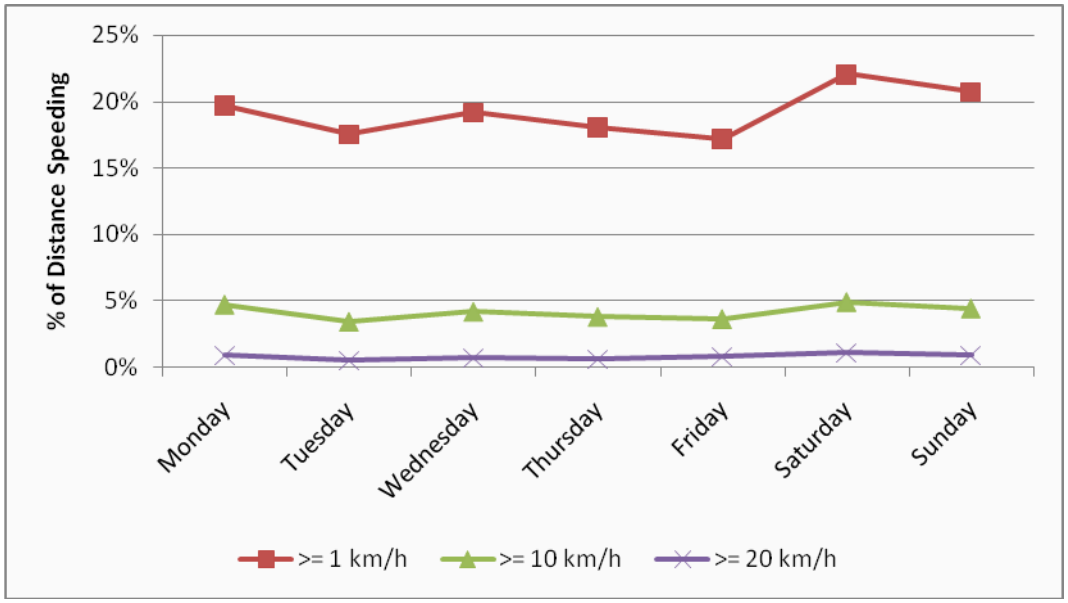

Figure 9: Percentage of distance speeding by day of the week

4.6. Trip-level

The impact of the purpose of the trip and the number of passengers (see Figure 10 and Figure 11 respectively) also has an effect on the extent of speeding. Speeding decreases

[5] The time periods are Weekday Morning (05-08:59), Weekday Day (09-14:59), Weekday Aft/Eve (15-19:59), Weekday Night (20-04:59), Weekend Day (05-19:59), Weekend Night (20-04:59).

as the number of passengers increases from the highest level (no passengers) to the lowest (two passengers), and begins increasing somewhat with three or more passengers. This is also reflected in that commuting trips to work have the highest level of speeding (21 percent), when there typically are no passengers, while education/childcare has the lowest at 16 percent.

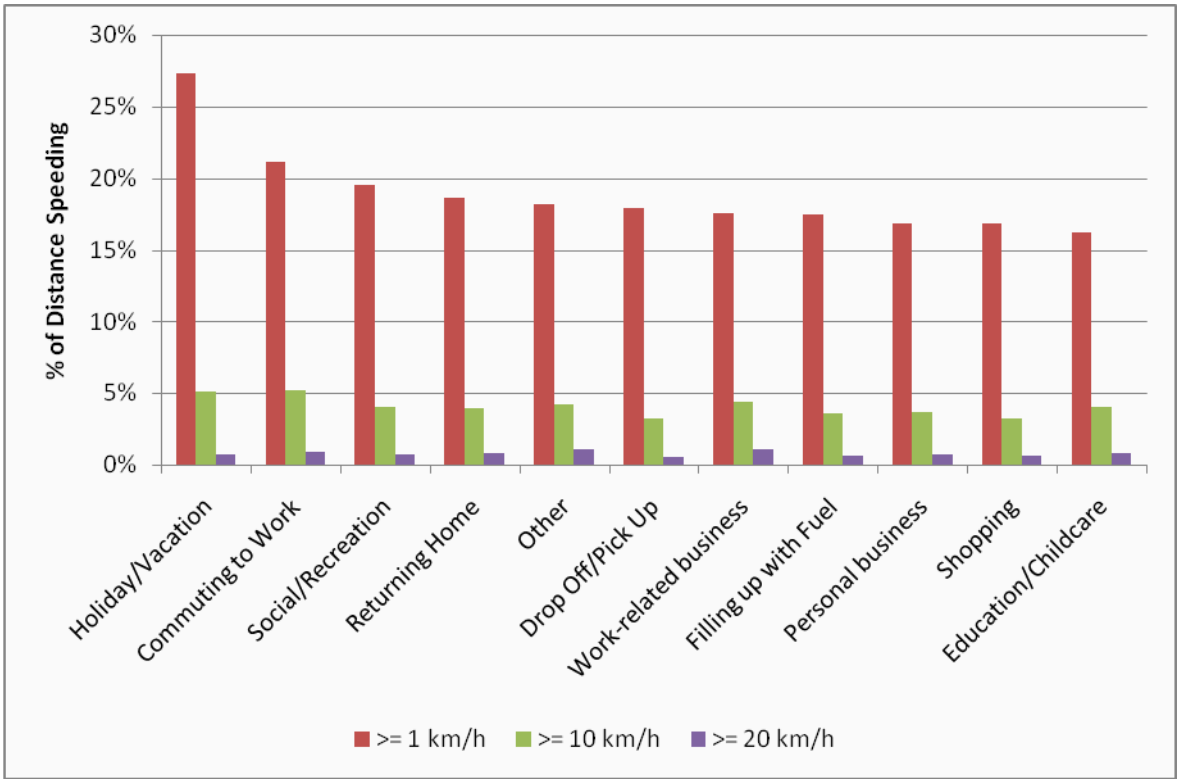

Figure 10: Percentage of distance speeding by trip purpose

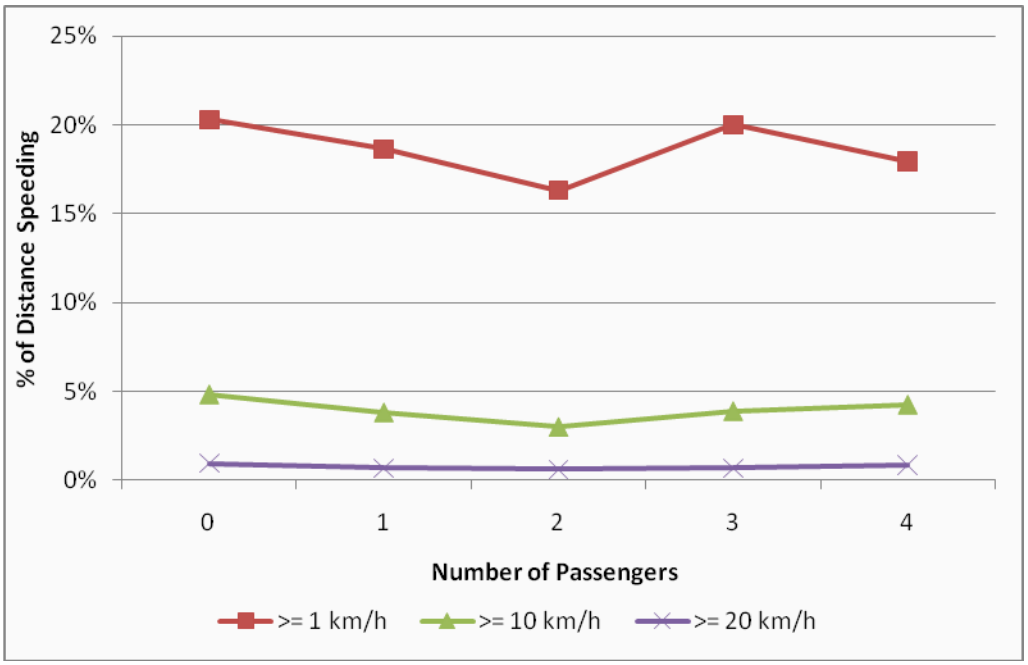

Figure 11: Percentage of distance speeding by number of passengers

6. Conclusions

While there have been many investigations into the factors impacting speeding, these have largely relied on enforcement/incident records and/or self-reporting of behaviour. These fail to fully capture the prevalence and magnitude of speeding as part of 'normal' driving routines. Presented here is an effort to address this issue by taking advantage of the technological capabilities offered by GPS and GIS technology to provide detailed driving (and speeding) behaviour over several weeks for a sample of motorists.

Among the most significant findings are the following. First, all drivers sped at some point over the five-week monitoring period, although there are a small (but significant) number who speed excessively, both in terms of the amount of distance speeding and the magnitude over the limit. Second, speeding varies markedly by speed zone, being most prevalent in 100-110 km/h zones and (we argue) more worryingly in 40-50 km/h zones typically found in residential areas. Third, speeding appears to be more prevalent among males than females overall, with marginal differences across the age categories – the high figure for females in the 46-65 age group appears counterintuitive. Speeding on weekends is more prevalent than on weekdays but weekday speeding is higher in the mornings whilst weekend speeding is higher at night. This is consistent with the findings of Ogle (2005) and Wundersitz *et al.* (2009).

On a more cautionary note, it must be stressed the results presented are specific to the sample of motorists in this study. One problem with any study in which participation is voluntary is self-selection bias and it is unquestionable that certain groups (e.g., middle-aged females) were much more willing to participate in this study than others (e.g., young, males). While we were able to gather information on why people chose to participate, we were not able to ascertain why people were unwilling and would be forced to speculate. Another issue of potential caution in this type of analysis is the accuracy of the GPS device in recording speeds. Prior to the data collection presented here, we conducted several months of testing involving numerous devices before selecting the device for the current study. Current work is focused on breaking out more clearly the different components behind speeding (interpersonal, trip, temporal, road/environment conditions) and their interactions.

References

Brundell-Freij, K. & Ericsson, E., 2005. Influence of street characteristics, driver category and car performance on urban driving patterns. *Transportation Research Part D,* 10**,** 213-229.

Corbett, C., 2001. Explanations for "understating" in self-reported speeding behaviour. *Transportation Research Part F,* 4**,** 133-150.

Delaney, A., Ward, H., Cameron, M. & Williams, A.F., 2005. Controversies and Speed Cameras: Lessons Learnt Internationally. *Journal of Public Health Policy,* 26**,** 404-415.

Fildes, B.N., Rumbold, G. & Leening, A., 1991. Speed Behaviour and Drivers' Attitude to Speeding. *Monash University Accident Research Centre*.

Fleiter, J. & Watson, B., 2005. The speed paradox: the misalignment between driver attitudes and speeding behaviour. *Journal of the Australasian College of Road Safety*.

Fleiter, J., Watson, B., Lennon, A. & Lewis, I., 2006. Significant others, who are they? - Examining normative influences on speeding, *Australasian Road Safety Research Policing Education Conference*, Gold Coast.

Giles, M.J., 2004. Driver speed compliance in Western Australia: a multivariate analysis. *Transport Policy,* 11**,** 227-235.

Goldenbeld, C. & Van Schagen, I., 2007. The credibility of speed limits on 80 km/h rural roads: The effect of road and person(ality) characteristics. *Accident Analysis & Prevention,* 39**,** 1121-1130.

Greaves, S.P. & Ellison, A.B., 2010. Personality, Risk Aversion and Speeding: An Empirical Investigation, *World Conference on Transport Research*, Lisbon, Portugal.

Greaves, S.P., Fifer, S., Ellison, R. & Germanos, G., 2010. Development of a GPS/Web-based Prompted-Recall Solution for Longitudinal Travel Surveys, *89th Annual Meeting of the Transportation Research Board*, Washington DC.

Harrison, W.A., Fitzgerald, E.S., Pronk, N.J. & Fildes, B., 1998. An investigation of characteristics associated with driving speed. *Monash University Accident Research Centre*.

Hatfield, J., Fernandes, R., Faunce, G. & Job, R.F.S., 2008. An implicit non-self-report measure of attitudes to speeding: Development and validation. *Accident Analysis & Prevention,* 40**,** 616-627.

Horswill, M.S. & Coster, M.E., 2002. The effect of vehicle characteristics on drivers' risk-taking behaviour. *Ergonomics,* 45**,** 85-104.

Johnston, I., 2004. Reducing injury from speed related road crashes. *Injury Prevention,* 10**,** 257-259.

Jonah, B., Thiessen, R. & Au-Yeun, E., 2001. Sensation seeking, risky driving and behavioural adaptation. *Accident Analysis & Prevention,* 33**,** 679-684.

Kyte, M., Khatib, Z., Shannon, P. & Kitchener, F., 2001. Effect of Weather on Free-Flow Speed. *Transportation Research Record,* 1776**,** 60-68.

Laapotti, S., Heskinen, E. & Rajalin, S., 2003. Comparison of young male and female drivers' attitude and self-reported traffic behaviour in Finland in 1978 and 2001. *Journal of Safety Research,* 34**,** 579-587.

Lieb, R. & Wiseman, F., 2001. Public Attitudes Toward Automobile Safety Issues. *Transportation Journal,* 40**,** 26-32.

Liu, B.-S., 2007. Association of intersection approach speed with driver characteristics, vehicle type and traffic conditions comparing urban and suburban areas. *Accident Analysis & Prevention,* 39**,** 216-223.

Machin, M.A. & Sankey, K.S., 2008. Relationships between young drivers' personality characteristics, risk perceptions, and driving behaviour. *Accident Analysis and prevention,* 40**,** 541-547.

Nsw Centre for Road Safety, 2008. *Road traffic crashes in New South Wales (2007)*.

Ogle, J.H., 2005. Quantitative Assessment of Driver Speeding Behavior Using Instrumented Vehicles. Georgia Institute of Technology.

Radalj, T., 2000. Pre-50 km/h Implementation Driver Speed Behaviours on Perth Metropolitan Local Roads. *Road Safety: Gearing Up for the Future***,** 1-19.

Roads and Traffic Authority, 2010. *2009 New South Wales Driver and Vehicle Statistics.* Sydney.

Schafer, J.A. & Mastrofski, S.D., 2005. Police leniency in traffic enforcement encounters: Exploratory findings from observations and interviews. *Journal of Criminal Justice,* 33**,** 225-238.

Sivak, M., Luoma, J., Flannagan, M.J., Bingham, C.R., Eby, D.W. & Shope, J.T., 2007. Traffic safety in the U.S.: Re-examining major opportunities. *Journal of Safety Research,* 38**,** 337-355.

Stopher, P.R. and S.P Greaves, 2009. Missing and Inaccurate Information from Travel Surveys – Pilot Results, *CD-ROM proceedings of the 32nd Australasian Transport Research Forum*, Auckland, New Zealand, September 2009.

Tay, R., Champness, P. & Watson, B., 2003. Personality and Speeding - some policy implications. *IATSS Research,* 27**,** 68-74.

Várhelyi, A., Hjälmdahl, M., Hydén, C. & Draskóczy, M., 2004. Effects of an active accelerator pedal on driver behaviour and traffic safety after long-term use in urban areas. *Accident Analysis & Prevention,* 36**,** 729-737.

Warner, H.W. & Åberg, L., 2008. Drivers' beliefs about exceeding the speed limits. *Transportation Research Part F,* 11**,** 376-389.

Williams, A.F., Kyrychenko, S.Y. & Retting, R.A., 2006. Characteristics of speeders. *Journal of Safety Research,* 37**,** 227-232.

Wundersitz, L., Hiranandani, K. & Baldock, M., 2009. Annual performance indicators of enforced driver behaviours in South Australia, 2007. *Centre for Automotive Safety Research*.