

Speeding Behaviour in School Zones

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Abstract

Introduction: Speeding in school zones is a significant and sensitive safety issue. School zones have high levels of pedestrian activity that are particularly vulnerable in the event of a crash. Yet, other than from targeted police enforcement there is little information on day-to-day speeding in school zones.

Methods: Using GPS, spatial, demographic and psychological data we analyse the speeding behaviour in school zones of 147 motorists in Sydney over a period of several weeks. The focus is on both the duration and magnitude of speeding and whether this is related to particular driver, trip, and roadway characteristics, with a particular emphasis on the most prolific speeders.

Results: Overall, 23 percent of the distance travelled in school zones is above the speed limit, higher than for any speed limit other than motorways. Additionally, all drivers exceed the speed limit and there are a small but noteworthy number of drivers who consistently exceed the speed limit for as much as half the distance travelled.

Conclusions: Despite efforts at reducing speeding in school zones, these results show that speeding remains very common. The consequences of speeding in school zones make it particularly important that additional resources are put into reducing speeding. The results suggest that targeting the road environment such as transitions to school zones may be more effective than psychological/personality-based campaigns in changing drivers' speeding behaviour.

Keywords

Speeding, School Zones, GPS, Driver Profiling, Psychological Factors

Introduction

Despite the well-documented dangers associated with speeding behaviour, excessive speed continues to play a major role in serious road crashes. For instance, recent evidence suggests that speeding was a 'major factor' in one-third of fatal road crashes in Australia in 2006 (Bureau of Infrastructure Transport and Regional Economics, 2011). More worryingly, the prevalence of speeding as a major factor has increased from around one-fifth of fatal crashes in 1990 to the current levels (BITRE, 2011), suggesting that despite strategies and campaigns, the message simply is not getting through to motorists. The consequences of speeding are particularly acute in areas with high levels of vulnerable road users (Pedan et al., 2004) of which school zones are a prominent example (Roper et al., 2006). Although there have been an increasing number of studies on the effectiveness of school zones (Fitzpatrick et al., 2009; Tay, 2009; Kattan et al., 2011), there has been little research into the impact on speeding of drivers' demographics, personality and trip characteristics in this context. Previous research has been limited by the reliance on police enforcement records and occasional data collection using radar/laser speed guns and traffic/vehicle counting devices. These methods potentially understate the extent of speeding behaviour in school zones.

With this in mind, this paper presents the results of an analysis of speeding behaviour in school zones in the Sydney metropolitan area. The data used in the analysis represents several weeks of driving collected from 147 motorists using a Global Positioning System (GPS)

device as part of a broader study of driving behaviour (Greaves et al., 2010). Crucially, motorists were unaware that speeding was specifically being monitored and recorded because of the (obvious) potential for this in itself to impact behaviour and analysis. GPS data provides information into drivers' day-to-day speeding behaviour across time. The paper is structured as follows. First, the literature on speeding in school zones is reviewed, followed by an overview of the methodology. The most important results are presented and the paper concludes with a discussion of the results and policy considerations.

Literature review

School zones operate differently in each jurisdiction. In the state of New South Wales (where this study took place), a speed limit of 40 km/h is applied in school zones on weekdays from 08:00 to 09:30 and from 14:30 to 16:00 during the four school terms of ten weeks that operate over the calendar year (i.e., forty weeks total/annum). Various types of road markings and signage are used to indicate to drivers where school zones begin and end (Roads and Traffic Authority NSW, 2010). In Alberta, Canada, school zones maintain a 30 km/h speed limit from 08:00 to 16:30 on school days and some use speed displays (Kattan et al., 2011). In the United States, speed limits vary by state. However, most states use 15 miles/hr (24 km/h) or 20 miles/hr (32 km/h). California, Kentucky, Michigan and Oklahoma apply a *minimum* speed limit of 25 miles/hr (40 km/h). A number of other states do not have uniform school zone speed limits (Fitzpatrick et al., 2009). In New Zealand there is no national school zone speed limit, however 40 km/h variable speed limit zones (with signage) are increasingly common (Mackie, 2010). In many European countries a speed limit of 30 km/h applies in residential areas at all times (Garrard, 2009).

The need for drivers to abide by speed limits is particularly important in school zones given the high levels of child pedestrian activity and the consequences of a collision. Recent evidence suggests the likelihood of a fatality in the event of a pedestrian-vehicle collision is more than double with an impact speed of 50 km/h compared to 40 km/h (Pedan et al., 2004). At a speed of 30 km/h, the likelihood of a pedestrian fatality is 10 percent, significantly lower than 40 percent at a speed of 40 km/h (Pedan et al., 2004). Evidence from Sydney and South West New South Wales (covering one quarter of NSW school zones) shows the implementation of school zones resulted in a 45 percent reduction in pedestrian casualties (all ages, 46 percent for children) in school zones (Graham & Sparkes, 2010) but few crashes have resulted in child fatalities (Hanan et al., 2011) and even fewer (5% of reported crashes, 1% of reported school zone crashes involving 5-16 year old pedestrians) were due to speeding (Graham & Sparkes, 2010). Nonetheless, the danger and perception of danger posed by speeding motorists is a significant barrier to more active transport (walking and cycling) which has declined markedly over the last twenty years (Garrard, 2009). It is possible that the reductions in school zone crashes and fatalities reflect this modal shift from walking and cycling to cars rather than an improvement in behaviour or adherence to school zone speed limits. An analysis of school zone crashes using exposure may have different results than those found by Graham & Sparkes (2010). Furthermore, some studies have shown children to be more likely to be involved in vehicle collisions near school zones than further away, most likely the result of increased exposure (Abdel-Aty et al., 2007; Warsh et al., 2009).

There have been a number of studies into speeding in school zones. In terms of compliance rates, using traffic counters Roper et al. (2006) determined that depending on the type of signage in use, around half the vehicles exceeded the speed limit in New South Wales school zones. As many as 45 percent of drivers also exceed the speed limit by 10 km/h or more in some school zones and up to 10 percent by at least 20 km/h. These results are consistent with

a study conducted in Texas which found that up to 17 percent of vehicles were driven at speeds of at least 25 miles/hr (40 km/h) in 20 miles/hr (32 km/h) school zones. The same study found that as many as 59 percent of vehicles were driven at speeds of at least 35 miles/hr (56 km/h) in 30 miles/hr (48 km/h) school zones indicating that the speed limit appears to be a factor in compliance (Hawkins, 2007). Although these are surprisingly high rates of speeding, there appears to be relatively small changes in compliance rates from a study conducted in 1999 where 45 percent of drivers exceeded the speed limit by at least 5 miles/hr (8 km/h) (Saibel et al., 1999). To a lesser extent, the same is true in Australia where a 2002 study in Perth determined that 50 percent of vehicles exceeded the 40 km/h speed limit by 10 km/h or more, but it also found that drivers do slow down in school zones (Radalj, 2002).

More recently, a study conducted using laser guns in Calgary (Alberta, Canada) found 53 percent of vehicles sped in school zones and 11 percent sped by 10 km/h or more (Tay, 2009). A follow up study had similar results, finding 54 percent of vehicles exceeded the speed limit and 10 percent of vehicles exceeded the speed limit by 10 km/h or more. The mean speed (31.4 km/h) was slightly above the school zone speed limit but lower than the default speed limit of 50 km/h. These results varied considerably depending on the characteristics of the school zones. For example, zones with fencing had a compliance rate of 51.3 percent compared to 64.8 percent for zones without fencing (Kattan et al., 2011).

Many studies have focused on the impact of signage, road markings and other speed management techniques on compliance with speed limits in school zones. In terms of vehicle speeds in school zones, it appears that the normal speed limit of the road appears to be a more important factor in vehicle speeds than the speed limit of the school zone (McCoy & Heimann, 1990). This may reflect the characteristics of the roads themselves rather than the speed limit itself and may explain why many studies have found large variations in speeding between school zones in the same geographic area (Roper et al., 2006; Hawkins, 2007). Kattan et al. (2011) found the presence of children to be a factor in (lower) vehicle speeds as well as road characteristics such as the use of speed display signs, fencing, fewer lanes and longer school zones. These results are consistent with those of Tay (2009) but in the case of school zone length somewhat contradicts the results of a study conducted in Texas. In that study, drivers reached their minimum speed within the first half of the school zone but speeds increased steadily as the distance from the start of the school zone increased (Fitzpatrick et al., 2009). The use of electronic signs was also found to be effective in New Zealand, however compliance was greater when they were combined with permanent signage and the presence of children (Osmers, 2001). Roper et al. (2006) found the use of flashing lights on school zone speed limit signs to have a statistically significant impact on reduced vehicle speeds in school zones.

Overall, previous research has found compliance rates with school zone speed limits to vary depending on the characteristics of the school zone but in all cases compliance rates can be considered inadequate, below 50 percent of vehicles in some school zones. However, none of these studies were able to determine the characteristics of the driver such as age, sex, trip purpose or personality profile and therefore the influence of these characteristics on their speeding behaviour.

Methods

Over a period of several weeks, 147 drivers in Sydney were tracked using GPS devices as part of a broader study on driver behaviour (Greaves et al., 2010). Driver speeds and speed limits

were logged but participants were not made aware of this at the time due to the possibility of this affecting behaviour. Note that data were excluded from the first week of monitoring to mitigate any potential ‘halo’ effects resulting from the installation of the GPS device leaving five weeks of data for this analysis. The GPS data were processed against a GIS-based (Geographic Information System) speed limit and road network database to identify speeding. Additional data sources included a demographic survey and a psychological survey conducted on each driver at the time of recruitment (Greaves & Ellison, 2011) supplemented by additional sources of spatial information such as weather and the location of school zones. Data sources are summarised in Table 1.

Table 1: Summary of data sources

GPS data	Second-by-second data including latitude, longitude, vehicle speed, speed limit, date and time.
Demographics	Collected from participants during recruitment, includes age, gender, vehicle information, household size and other common attributes.
Psychological survey	50 question, 5 section survey incorporating personality, risk perception and driver behaviour scales (Greaves & Ellison, 2011).
Trip details	Using a website updated daily, drivers indicated the purpose, driver and the number of passengers for each trip (Greaves et al., 2010). Origin, destination, time and date information were retrieved from the GPS data.
Weather	Hourly rainfall data for Sydney collected by the Australian Bureau of Meteorology from 15 observation stations was matched to the GPS data based on location.
School zones	Locations of school zones were used to identify school zone driving.

The second-by-second GPS data were aggregated into road segments such that a new segment began at the start of each trip, school zone or when the speed limit changed (for segments that were not school zones). Since the intention here was to assess the compliance of drivers to the school zone speed limit as a function of distance and school zones, the aggregated variables did not result in much loss of detail.

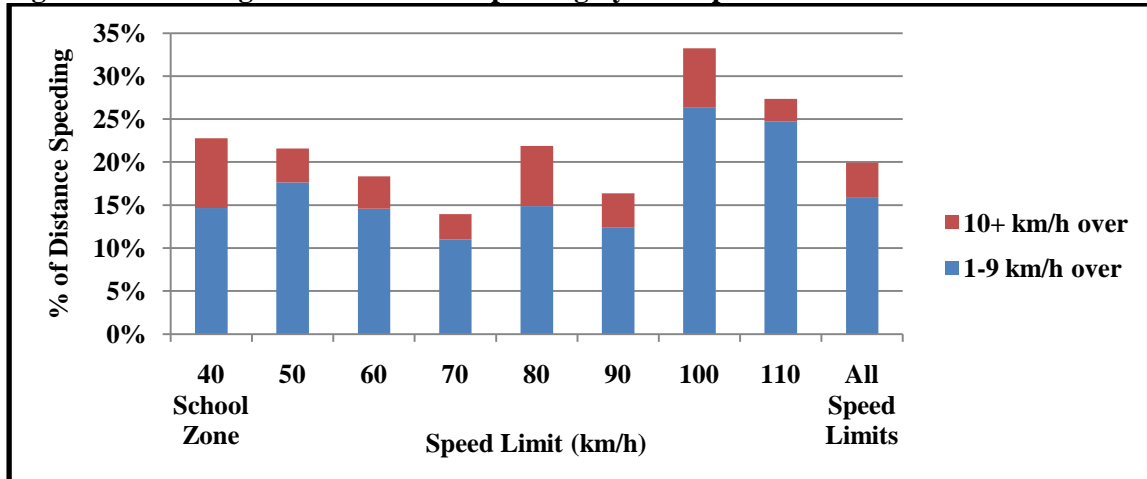
For the purposes of this analysis only data from primary drivers, defined as the driver who completed the demographic and psychological surveys, was included. Of the 147 drivers, 16 had no driving recorded in school zones and therefore were excluded. A further 12 drivers had very little driving recorded in school zones (less than 1 km) and were therefore also excluded. After excluding drivers with little or no driving in school zones, 119 drivers remained for further analysis.

In total more than 1,300 km was driven in school zones by the 119 selected drivers representing one percent of the total kilometres driven over the monitoring period. On average, 11.4 km or 1.2 percent of distance driven was in school zones with a standard deviation of 1.5 percent. As was expected, drivers with a greater proportion of school zone driving tended to have a greater proportion of school zone distance during education trips whilst work trips exhibited the opposite trend.

Results

Overall drivers exceed the speed limit in school zones for 23 percent (i.e., 300 kilometres in total) of the distance driven in school zones which is higher than the average (20 percent) and any other speed limit other than 100 and 110 km/h roads. 50 km/h roads, many of which are residential, have only marginally less speeding as shown in Figure 1. More concerning given the more severe consequences of speeding in school zones is that higher magnitude speeding (≥ 10 km/h) appears to be more prevalent than on roads of any other speed limit.

Figure 1: Percentage of total distance speeding by road speed limit



Further analyses were conducted to determine differences in speeding behaviour between personal, trip, vehicle and road characteristics. Analysis of variance (ANOVA) tests were performed to assess the statistical significance of any observed differences. These results are discussed below and summarised in Table 2 at the end of this section.

Personal characteristics

Age and gender are commonly used variables for classifying drivers. In total drivers aged 18 to 30 comprised 24 percent of the final sample of which 31 percent were male and 69 percent female. Drivers 31 to 45 and 46 to 65 years of age accounted for 44 percent and 32 percent respectively divided fairly evenly between males and females.

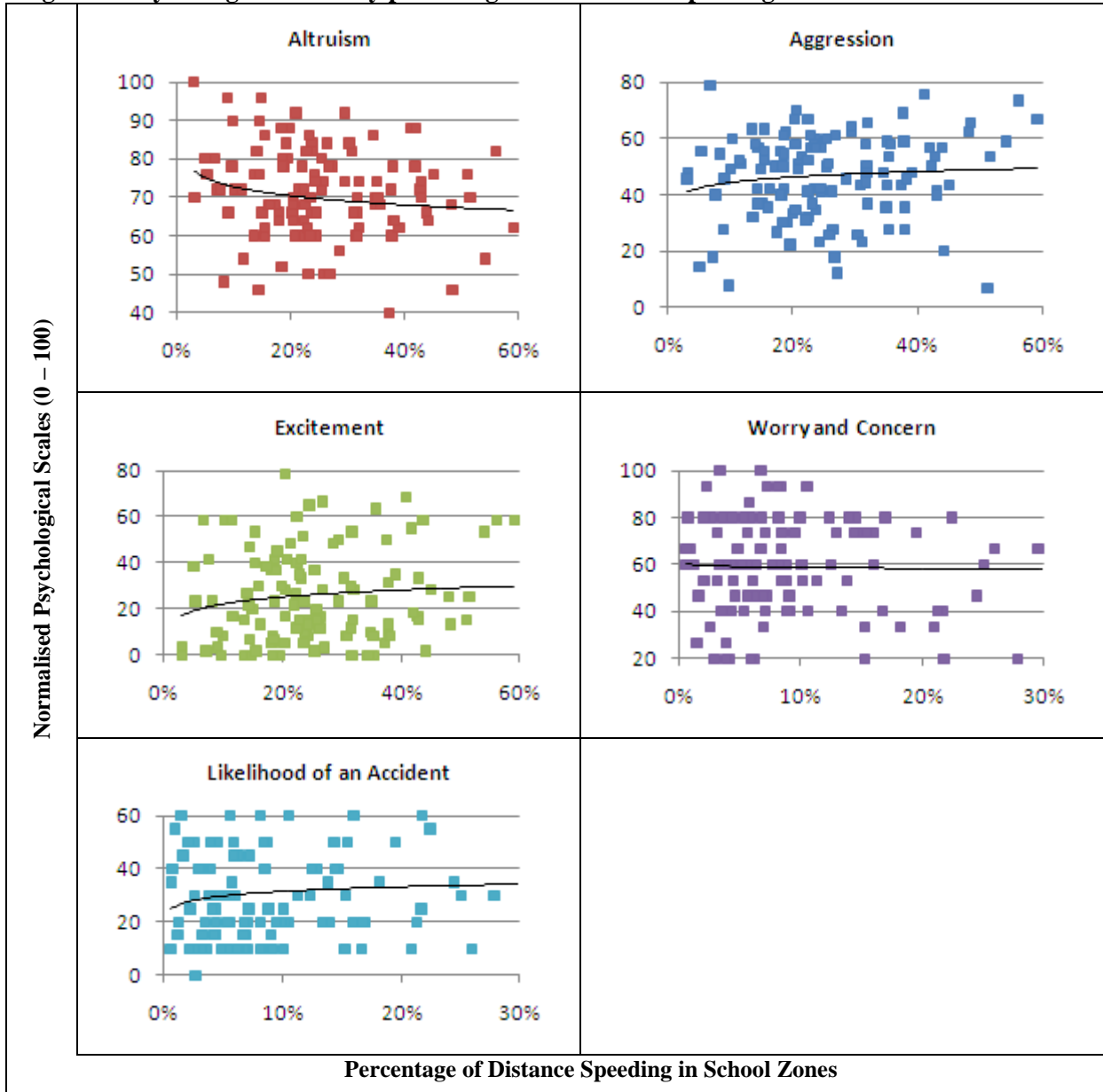
In school zones, results show that although younger drivers speed slightly more (24 percent) than drivers aged 31-45 (23 percent) and 46-65 (20 percent) these differences are not statistically significant. Interestingly, it appears that drivers on provisional licenses speed considerably less frequently in school zones (12 percent) than drivers holding full licenses (24 percent) suggesting that the more severe penalties applied to provisional drivers may be effective. This relationship is statistically significant.

As part of the study, drivers completed a five section, fifty question psychological survey. The sections of relevance here are personality and risk perception scales. The personality scales (aggression, excitement seeking and altruism) are measured on a ten point scale from “Not at all” to “Very much” and have been found to be correlated with self-reported speeding behaviour (Ulleberg & Rundmo, 2003). Two risk perception scales are also included – worry and concern, and likelihood of an accident, for the driver and others of the same age, measured on a five point and ten point scale respectively (Rundmo & Iversen, 2004; Machin & Sankey, 2008). These scales have been adjusted to a common 100 point scale to allow for better comparisons between the different personality scales.

Drivers’ answers to the personality survey were converted into five normalised personality scales representing aggression, altruism, excitement, worry and concern and the perceived likelihood of an accident. For each driver, these scales were plotted against the percentage of distance speeding in school zones and logarithmic trend lines were calculated (see Figure 2). While the trends are generally in line with a priori expectations (i.e., increasing altruism and worry/concern are associated with less speeding, while increasing aggression and excitement are associated with more speeding), there is significant heterogeneity across the participants.

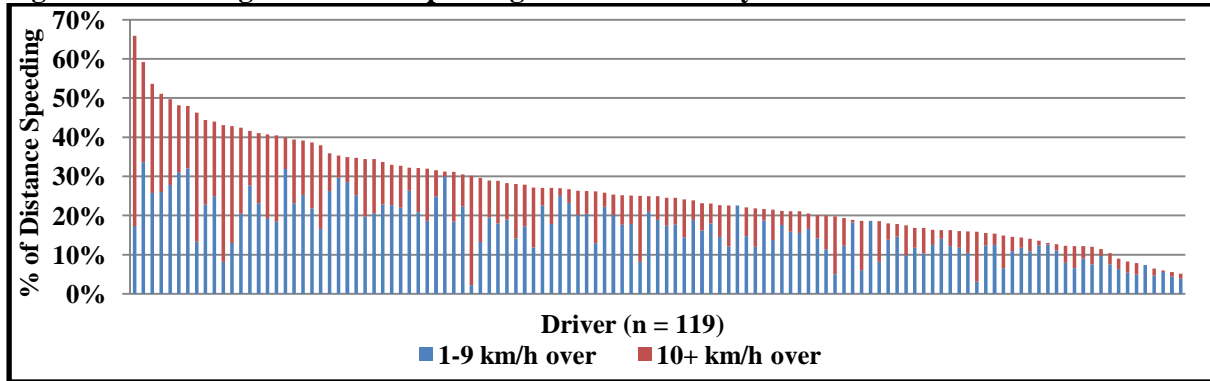
This suggests that psychological factors play a role in school zone speeding but this is influenced by other factors such as the opportunity to speed and other characteristics of the road environment. The impact on speeding in school zones of perceptions of the dangers of speeding also appears mixed. However, this may be a reflection of the lack of any questions specifically addressing school zones.

Figure 2: Psychological scales by percentage of school zone speeding



The percentage of distance speeding by each driver (Figure 3) included in the study shows there is considerable heterogeneity in driver behaviour both in terms of overall speeding and magnitude. All participants exceeded the school zone speed limit (by 10 km/h or more) at some point over the five weeks with 15% of the sample exceeding the speed limit for more than 40% of the distance. Arguably of more concern is the magnitude of the speeding as this suggests negligent or ignorant behaviour – Figure 3 suggests that many of the most frequent speeders drive for a considerable proportion of the driving distance at speeds in excess of 10 km/h above the speed limit (i.e. more than 50 km/h in a 40 km/h zone).

Figure 3: Percentage of distance speeding in school zones by driver

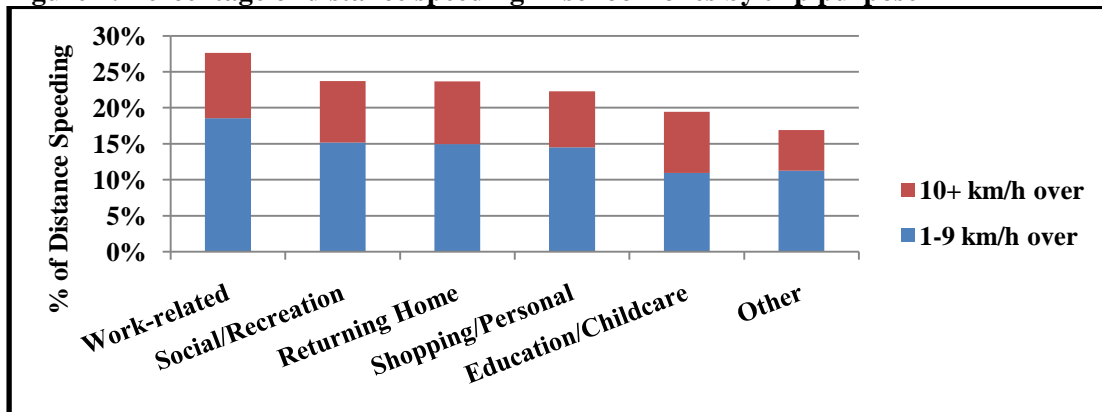


Trip characteristics

Intuitively the characteristics of the trip such as trip purpose and number of passengers may influence drivers’ speeding behaviour in school zones. As expected, a gradual downward trend in speeding behaviour in school zones exists in terms of overall speeding in school zones by number of passengers. As the number of passengers increases, overall speeding is reduced from 25% (drive alone and one passenger), to 19% (two passengers), and 18% (3+ passengers) but this is not the case for speeding by 10 km/h or more. Neither trend is statistically significant.

In terms of trip purpose (Figure 4), education trips have the lowest levels of overall speeding in school zones (19%) and work trips have the highest (28%). This may reflect that drivers are likely to be more aware of school zones during education trips when they are more likely to be carrying children. However, as with speeding by number of passengers, the same trend does not hold for speeding by 10 km/h or more. The differences between work-related, education and other trip purposes are statistically significant for speeding 1 km/h or more but not for 10 km/h or more. There is little temporal difference in speeding behaviour by day of the week.

Figure 4: Percentage of distance speeding in school zones by trip purpose



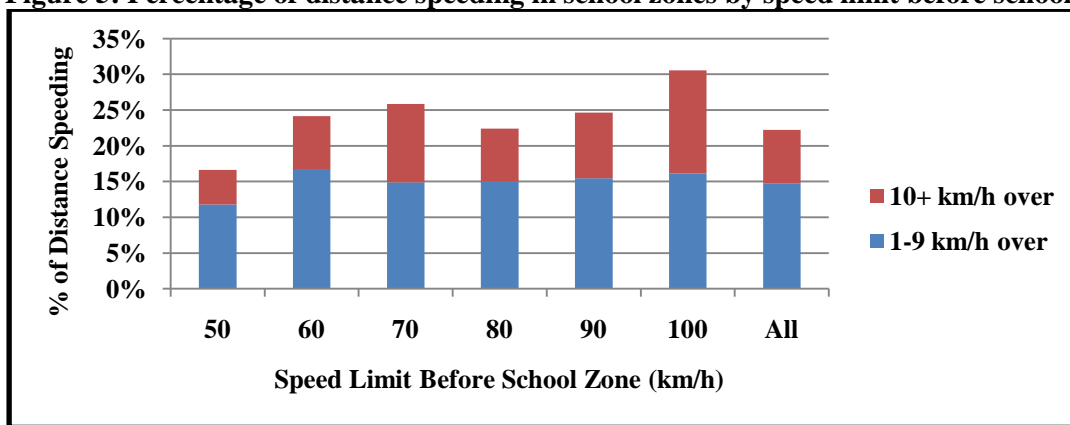
Vehicle characteristics

In terms of the vehicle characteristics, the type of vehicle does not appear to be a factor in speeding in school zones which contradicts some of the broader literature on speeding (Liu, 2007). At an aggregate level, the results suggest that drivers of newer vehicles (manufactured since 2005) speed more frequently – for 26 percent of the distance – compared to 23 percent (manufactured from 2000 to 2004) and 16 percent (manufactured before 2000) but this relationship is not statistically significant.

Road characteristics

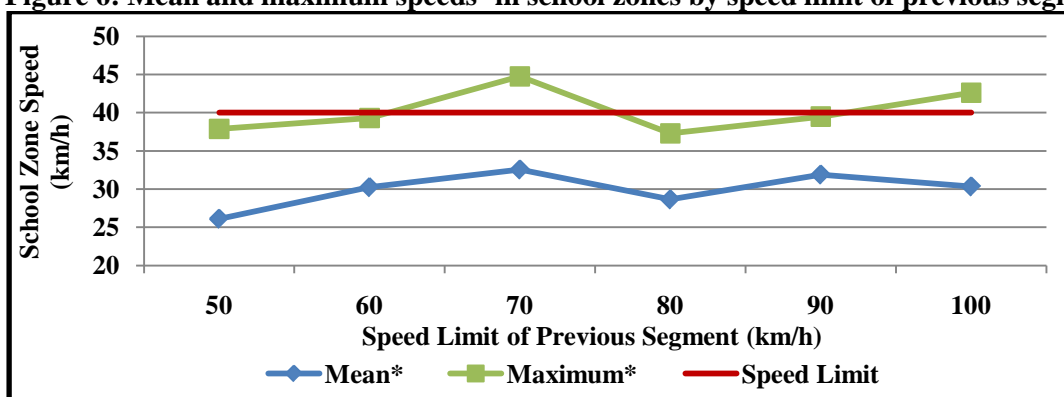
Previous research (Fitzpatrick et al., 2009; Tay, 2009; Kattan et al., 2011) has found road characteristics to be a significant factor in drivers’ compliance with school zone speed limits. In this study, the speed limit of the previous road segment was used as a (crude) proxy for the type of road characteristics as detailed characteristics of school zones (e.g., presence of flashing lights, dragon’s teeth road markings, speed humps, road narrowing, etc.) were not readily available in an easily accessible digital format. It should be noted that the speed limit used here is the speed limit in effect in the previous road segment for each driver. It may not be the same as the speed limit of the school zone segment outside of a school zone’s operating hours. Figure 5 shows that in general, the higher the speed limit of the previous segment, the greater the distance driven above the speed limit. In contrast to other trip characteristics, this effect is stronger for higher magnitudes of speeding. Rain does not appear to be a significant factor in school zone speeding.

Figure 5: Percentage of distance speeding in school zones by speed limit before school zone



While it appears that the road characteristics have an impact on speeding behaviour and that overall speeding in school zones constitutes a significant proportion of school zone driving, Figure 6 shows that, in general, drivers do slow down for school zones, including from higher speeds. With the exception of school zone segments following roads with 70 and 100 km/h roads, drivers maintain an average maximum speed below the 40 km/h school zone speed limit.

Figure 6: Mean and maximum speeds¹ in school zones by speed limit of previous segment



* Differences in mean and maximum speeds by previous speed limit have been tested and found to be significant at the $p < 0.01$ level.

¹ Maximum and mean speeds were calculated for each school zone segment recorded. These are the means of the maximum and mean speeds for all observed school zone segments.

Tests of statistical significance suggest that other than licence type (caution interpretation due to a very small number of provisional licence holders in the sample) and the purpose of the trip, none of the other variables were significant when taken over the sample (Table 2). However, Figure 3 shows there are considerable differences between drivers, which suggests we have not captured the crucial behavioural dimensions or (more likely) roadway characteristics known to reduce speeding in school zones (Fitzpatrick et al., 2009; Kattan et al., 2011).

Table 2: Factors, sample and significance testing of differences in speeding behaviour

Variable(s)	Possible Values (% of sample in brackets)	Percentage Distance Speeding	
		1+ km/h Sig.	10+ km/h Sig.
<i>Driver Characteristics</i>			
Gender	Male (43%), Female (57%)	.936	.834
Age	18-30 (24%), 31-45 (44%), 46-65 (32%)	.294	.336
Age x Gender	Male 18-30 (8%), 31-45 (20%), 46-65 (15%) Female 18-30 (17%), 31-45 (24%), 46-65 (17%)	.679	.944
Licence Type	Provisional (6%), Full (94%)	.011*	.129
<i>Vehicle Characteristics</i>			
Year of Vehicle Manufacture	<= 1999 (20%), 2000 to 2004 (43%), 2005+ (37%)	.810	.994
Vehicle Type	Sedan (52%), Hatchback (27%), Other (21%)	.993	.998
<i>Trip Characteristics</i>			
Number of Passengers	0 (43%), 1 (26%), 2 (22%), 3+ (9%)	.133	.931
Trip Purpose (6 categories)	Returning Home (20%), Work-Related (29%), Education (16%), Recreation (5%), Shopping (13%), Other (17%)	.059	.044*
Trip Purpose (3 cat.)	Work-related (29%), Education (16%), Other (55%)	.020*	.398
<i>Road characteristics</i>			
Previous Speed Limit (km/h)	50 (22%), 60 (37%), 70 (14%), 80 (11%), 90 (10%), 100 (6%)	.099	.186
Rain	Yes (3%), No (97%)	.148	.695

* Differences in percentage of distance speeding tested for significance and found to be significant at the $p < 0.05$ level

Discussion

The results of this study are broadly consistent with that of previous studies on speeding in school zones which show that reduced speed limits in school zones are effective at reducing vehicle speeds. Overall findings are that over 20 percent of the distance driven in school zones is at speeds above the 40 km/h speed limit and 8 percent is driven at speeds 10 km/h or more above the speed limit. This is somewhat lower, but comparable given the different measurements, to the results of Roper et al. (2006) which found that approximately half of all vehicles exceeded the speed limit and those of Kattan et al. (2011) which found that 10 percent of vehicles exceeded the speed limit by 10 km/h or more. However, a significant proportion of the distance driven in school zones remains above the speed limit, in many cases in excess of 10 km/h above the speed limit.

As previous studies did not collect information about drivers or trips, it is not possible to directly compare the results of the driver and trip analyses with other studies of school zone behaviour. There is strong evidence from studies of speeding in a broader context (Ogle, 2005; Fleiter et al., 2006; Machin & Sankey, 2008) which illustrates the importance of studying how personal and trip factors influence drivers' behaviour. The results of this research are consistent with that of the broader speeding literature suggesting that speeding in

school zones has similar characteristics to speeding behaviour in other contexts but more study is needed, likely at a more micro level.

Furthermore, the strong link between speeds in school zones and the speed limit of segments preceding school zones indicates that there is a need to reduce vehicle speeds in some way before the start of the school zone. The introduction of transition or buffer areas (Fitzpatrick et al., 2009) with reduced speed limits and speed management methods such as speed humps are possibilities but may be problematic due to the temporal nature of school zones. Kattan et al. (2011) and Roper (2006) identified a number of other road characteristics – including fencing and flashing lights – that reduces drivers' speeds without impeding vehicle flow during times when the school zone is not operating and these may be other potential solutions. Issues with inadequate signage and road markings which may not provide sufficient advance warning of school zones for approaching motorists are also likely to influence speeding.

The influence of speed display signs found to be significant by a number of studies (Osmer, 2001; Kattan et al., 2011) may be indicative that drivers either are unaware they are speeding or are influenced by perceived enforcement. Incorporating the presence of signage, flashing lights, speed cameras – increasingly common near school zones in New South Wales (Roads and Traffic Authority NSW, 2009) – and other road characteristics into future research would be beneficial in determining the extent of this influence.

Conclusion

The main contribution of this paper has been to ascertain the extent of speeding (both duration and by magnitude) in school zones within the context of normal/regular driving routines and known driver characteristics rather than the 'spot check' approaches that provide most current information. A noteworthy finding is the use of average figures on speeding duration, typically reported, masks the fact that a small, but significant number of drivers are regularly violating school zone speed limits by magnitudes that indicate a negligent and/or ignorant approach to driving. It is these drivers that particular attention must be paid to through either more draconian enforcement or physical countermeasures within the road environment to reduce the opportunity to speed. This behaviour has implications both on injuries and fatalities in school zones and – by virtue of perceived danger – on increased dependence on car travel by children and adults. This trend has social and health implications which go beyond the small number of fatalities that specifically occur in designated school zones.

The results of this research lend credence to the need to focus on the design of school zones to require drivers to slow down. Current research is focused on refining the analysis by incorporating physical measures characterising school zones using GIS tools including Google Earth. This is a painstaking process, but clearly crucial to explaining the differences observed here, which were not explainable by driver socio-demographic characteristics alone.

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