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The impact of school speed zones on driving speed

Yutong Li[1], Emily Moylan[1]
[1]The University of Sydney
Email for correspondence (presenting author): emily.moylan@sydney.edu.au

Abstract

Slower speed limits are safer with benefits in both the risk and severity of crashes. This safety is particularly important when considering children's travel to school. Many places have implemented time-of-day school speed zones that lower default limits around school entrances at school start and end times. These zones are a powerful data source for evaluating how changes in speed limit influence drivers' behaviours, with relevant implications for current discussions on decreasing local-road default speed limits.

This paper investigates the effectiveness of time-of-day speed zones on driver behaviour around schools in Sydney, Australia. Combining spatial data on more than 500 school speed zones across the Sydney area with over 8 million positions and speeds from connected vehicles (Compass IoT), this study describes the distribution of driving speeds during and outside school zone operational hours.

The analysis reveals that vehicle speeds are lower overall in active school speed zones, contributing to enhanced road safety around schools. Despite the reduction, an increase in the rate of speeding during school zone hours highlights the limitations of posted speed limits compared to road design changes. This description of the data contributes to the ongoing discussion about broader implementation of lower local-road speed limits and the interventions required to achieve safer streets.

1 Introduction

Globally, road traffic accidents remain a significant public health issue, with an alarming number of casualties reported annually. In urban areas, the presence of vulnerable road users, particularly children in school zones, necessitates effective traffic management strategies to mitigate risks. School speed zones have been widely implemented as a crucial measure to reduce vehicle speeds in school vicinities, thereby enhancing safety during peak times when children are most likely present. Despite their widespread adoption, school speed zones rely on wig-wag lights and signage as well as enforcement calling into question their effectiveness in altering driver behaviour in isolation.

This study aims to address this gap by exploring the influence of over 500 school speed zones on driving speeds leveraging extensive connected vehicle data from Compass IoT (more than 8 million matched positions and speeds). This analysis provides spatial speed patterns during and outside school zone operational hours illustrating how drivers respond to the zones. By describing these patterns, the study evaluates the effectiveness of school speed zones and explores their implications for traffic safety and policy-making particularly regarding more wide-spread adoption of safer speed limits.

2 Literature

The implementation of school speed zones is a widely recognized measure aimed at reducing vehicle speeds in proximity to schools, thereby enhancing the safety of child pedestrians. Research has consistently shown that lower vehicle speeds can significantly reduce the

likelihood and severity of accidents, especially in areas frequented by children (Elvik, 2005; Tay, 2009).

A variety of studies have explored the effectiveness of school speed zones, yielding mixed results. For example, studies in the United States and Australia have demonstrated a measurable decrease in vehicle speeds and pedestrian injuries within designated school zones (Doecke et al., 2018; Graham and Sparkes, 2010). These zones not only alter driving behaviour but also enhance the perceived safety of the area for both drivers and pedestrians. Conversely, research by McCoy and Heimann (1990) suggests that the presence of school speed zones alone without rigorous enforcement or accompanying traffic calming measures might not be sufficiently effective in maintaining reduced speed limits over time.

Moreover, the psychological and behavioural impact of these zones on drivers has been an area of intense study. The transition to lower speed limits in school zones requires drivers to adjust their speed in response to signage rather than cues in the road design, which some drivers may resist due to habitual speeding tendencies (Ellison & Greaves, 2011), a behavioural factor distinct from signage or enforcement-based influences. The effectiveness of these zones is further complicated by factors such as the time of day, with some studies noting that compliance depends on the difference between the usual and reduced speed limits (Radalj, 2002).

Furthermore, technological interventions such as electronic speed signs and interactive speed limit displays have been examined for their potential to increase compliance within school zones. Initial findings suggest these technologies can be effective, but their long-term impact on driver behaviour remains under investigation (Quistberg et al., 2018).

Past literature surveys the challenges and solutions that have been explored related to implementing school speed zones and highlights the need for multi-faceted approaches that combine design/signage, enforcement, and technological aids to ensure their effectiveness. It also emphasizes the importance of ongoing research to evaluate and optimize these measures within the context of broader urban traffic management strategies.

3 Methodology

3.1 Data description and collection

This study employed two principal datasets: the NSW Speed Zones data and connected vehicle point locations and speeds from Compass IoT. The NSW Speed Zones dataset, provided on the Transport for NSW Open Data Hub, includes detailed characteristics of speed zones across New South Wales, such as type, speed limit, direction, and spatial geometry. In the Compass IoT data, each observation represents a vehicle position, velocity and acceleration. The observations are collected every two seconds and each vehicle may appear multiple times. This high-resolution data allows for an accurate assessment of driving behaviours across different times and conditions within the selected school zones.

3.2 Data cleaning and processing

The initial stage of data processing involved refining the NSW Speed Zones data to focus exclusively on entries classified as school zones. The vehicle data was selected based on geographic location and flagged based on timestamp, ensuring that the analysis would only consider vehicle movements directly within the school zones and distinguish between observations during and outside operational hours. Since slower-moving vehicles spend more time in the speed zones, we expect there to be some bias in the sample towards slower speeds.

3.3 Selection of school zones

School speed zones were only included in the analysis if they contained sufficient vehicle data to support statistically meaningful conclusions. Each zone was required to have at least 1,000 data points from a minimum of 50 unique trips. Additionally, only zones with a single posted

speed limit above 40 km/h (outside school zone hours) were retained. These criteria reduced the number of school speed zones across a diverse selection of Local Government Areas (LGAs) in the central, western, and outer regions of Greater Sydney from 1,637 to 533, while still maintaining broad spatial coverage, as shown in **Figure 1**. A detailed breakdown of the retained school zones and their associated observation counts, disaggregated by speed limit and time of day, is provided in **Table 1**.

Figure 1: Geographic scope and spatial coverage. The map displays the Local Government Areas (LGAs) included in the study, highlighted in green, which span central, western, and outer parts of Greater Sydney. The red rectangular box indicates the Lat-lon boundary used to spatially filter the data.

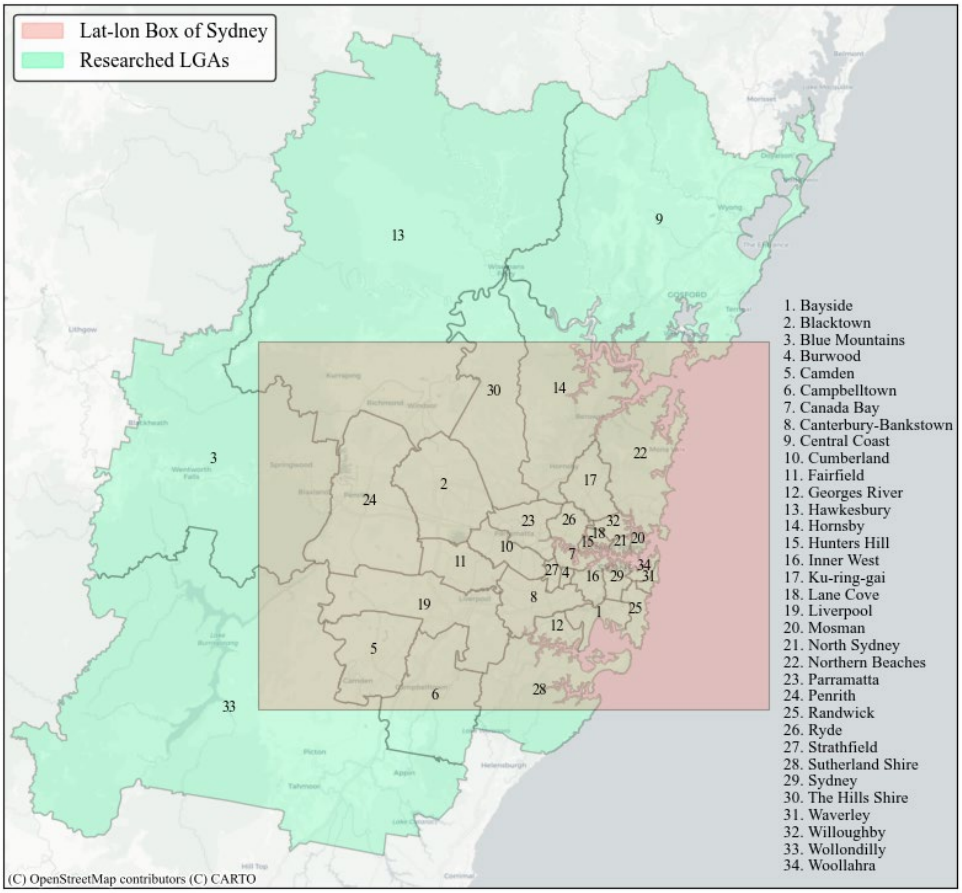


Table 1: Distribution of speed observations across school zones by posted speed limit and time category. Number of school zones and vehicle speed observations across four posted speed limits (50–80 km/h), separated by school zone time category are summarised. The majority of zones were signed at 50 km/h, accounting for the largest volume of observations, while higher speed zones were less common and contributed fewer data points.

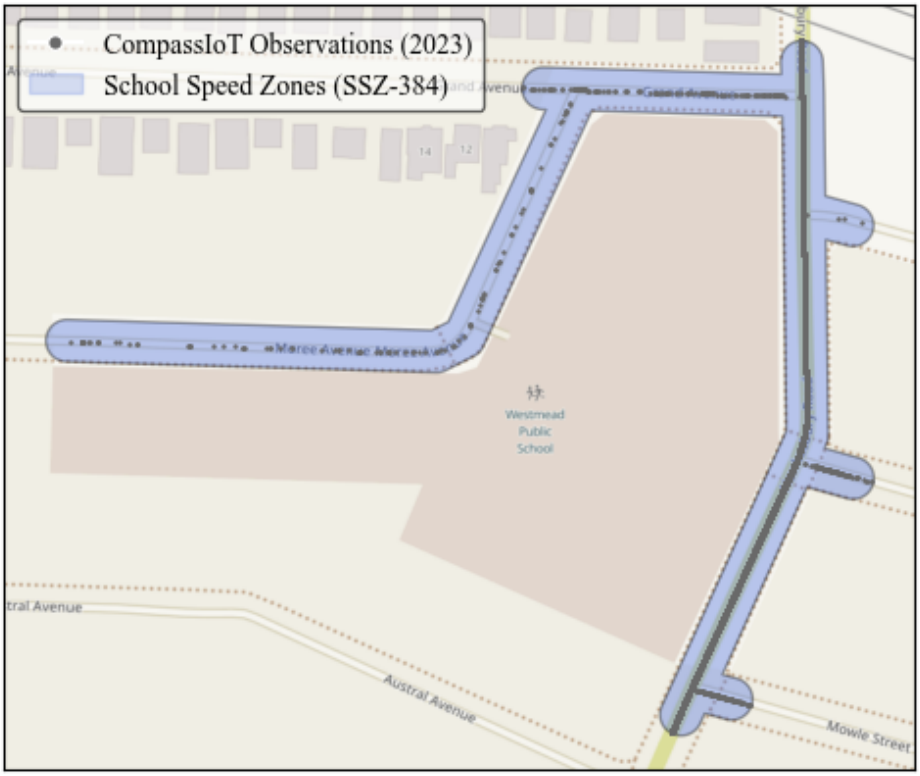
Posted speed limit (kph)	Number of school zones	Time category	Number of observations
50	410	During	1,104,569
		Outside	2,835,235
60	100	During	693,528
		Outside	2,041,983
70	15	During	115,893

		Outside	373,083
80	8	During	19,439
		Outside	43,430

3.4 Driving speed analysis

The core analysis compares driving speeds within the designated school speed zones during and outside operational hours. This was approached using average speeds, speed distributions, and instances of speed violation. Visualisations and descriptive statistics are employed to assess the impact of school speed zones on reducing vehicle speeds, with a particular focus on the efficacy of these zones as a time-varying, context-specific intervention.

Figure 2: Local area of an example school speed zone around Westmead Public School. Most of the vehicle observations are on Hawkesbury Road which has higher traffic volumes than either Moree Ave or Grand Ave which surround the school. Drivers on Hawkesbury Rd should drop their speeds from 50kph to 40kph during operating hours, whereas drivers on the other roads would be travelling at 50kph outside the speed zone.



4 Results

This section details the analysis of vehicle speeds within school zones, focusing on how the implementation of school speed zones influences driving behaviour during operational hours.

4.1 Speed distribution

The analysis of speed shows that driver speeds are distributed according to the time-varying speed limit as depicted in **Figure 3**. As expected, most drivers adhere to or travel below the speed limit, whether at the usual speed limit or at the reduced speed limit. There is a clear ranking of the peaks of the distributions that follows the corresponding speed limits. This illustrates that lower posted speed limits, including time-of-day speed zone limits, do lower driving speeds although the effect is complicated. The distributions associated with 50 and 80 kph—the default speeds associated with local roads and arterials respectively—show sharper fall off than the distributions for 60 and 70 kph. Moreover, the preponderance of data at 50kph

in the 60 kph and 70 kph areas shows that many drivers do adhere to defaults when unaware of the posted speed limit.

Figure 3: Distribution of speeds within school zones by speed limit. This figure illustrates the distribution of vehicle speeds under five different posted speed limits, including 40 km/h zones during school hours and standard limits from 50 to 80 km/h. Speed distributions shift progressively to the right as posted limits increase, with notable overlap between adjacent categories, especially between 40 km/h and 50 km/h zones.

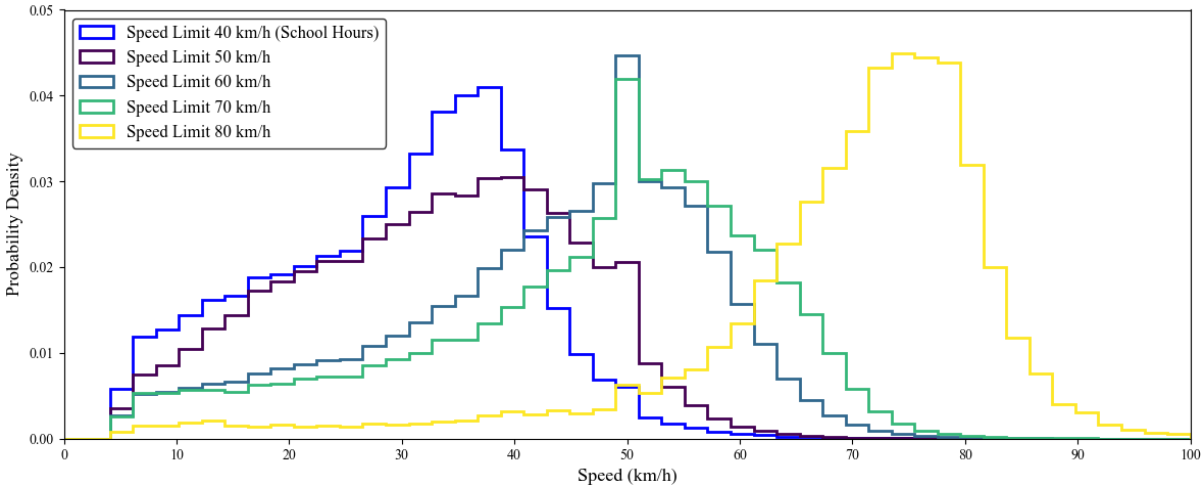


Table 2 summarises the observed speeds categorized by the speed limit. Across all speed limits, the median speeds are always lower than the speed limits. The difference between the limit and the median increases as posted speed increases from 40 kph to 70 kph—this is expected as the tail of low speeds associated with turning or parking movements and congestion stays important for all of these speed limits. The median speed on 80kph roads is closer to the limit at 72 kph, and the distribution shows how relatively rare it is to travel at speeds below 50 kph on those roads.

Notably, during school zone operating hours, the median speeds are slower and the variability of speeds is reduced. This indicates that drivers are responsive to the time-varying speed limit and do not set their driving speed based on the fixed road geometry alone. The median speeds reinforce the trends shown in Figure 3 indicating that speed limits, even time-varying ones, successfully lower speeds.

Table 2: Speed statistics in school speed zones during and outside operation hours. For higher speed limits, observed outside operation hours, both median speeds and speed variability increased with the posted limit. This suggests that driver behaviour becomes more consistent and less variable as speed limits decrease.

Speed Limit (km/h)	Median speed during operation (km/h)	Standard deviation of speed during operation (km/h)	Median speed outside operation (km/h)	Standard deviation of speed outside operation (km/h)
40	31.0	11.2	-	-
50	-	-	34.0	12.4
60	-	-	45.0	14.5
70	-	-	50.0	15.6
80	-	-	72.0	15.1

Figure 4 breaks the distribution of speeds during operational hours by the normal posted limit. The medians and of all posted-speed-limit categories fall below the school speed zone limit of

40 kph, which demonstrates the operation of the school speed zone has an effect across various contexts. The distributions also make it clear that these compliant median speeds are achieved to some extent because a significant number of vehicles travel below 40 kph during the school zone hours. Roads with higher normal posted limits do have higher speeds during operating hours and are more likely to have some vehicles who are unaware or deliberately ignoring the time-varying limit. Note the distribution associated with posted speeds of 80 kph has most cars travelling between 30-50 kph—although the median speed here is compliant with the school speed zone, the prevalence of speeding and the associated road design are unlikely to create a good walking environment for school students.

Figure 4: Speed compliance rates in school zones during operational hours. The figure shows probability density estimates of vehicle speeds during school zone active periods for zones with standard posted limits ranging from 50 to 80 km/h. Speed distributions shift closer to the 40 km/h compliance threshold as the posted limit decreases, suggesting higher compliance and tighter clustering at lower speed environments.

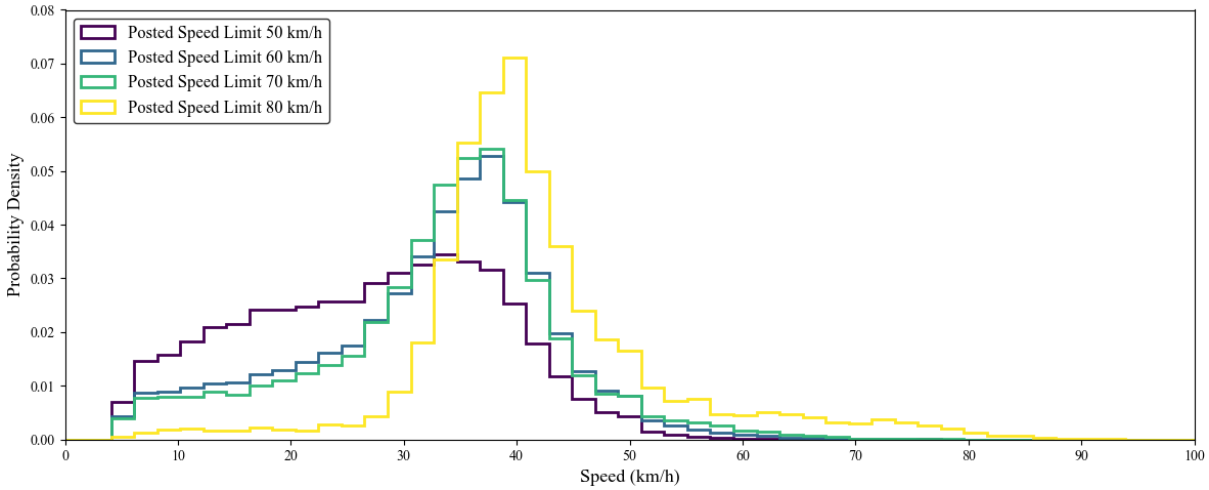


Table 3 summarises the speed statistics under different speed limits during school zone hours, detailing the number of speed measurements of different posted speed limits from the Compass IoT data. In the speed analysis, school speed zones with posted speed limits of 50 and 60 km/h constitute approximately 77% and 19% of the total number of school speed zones, respectively, with fewer zones having higher posted speed limits. However, the results indicate that the median speed under all posted speed limits does not exceed the school speed limit of 40 km/h. Furthermore, according to the percentile 85th speed, the vast majority of vehicles predominantly adhere to the school speed limit when the posted speed limit is the typical 50 km/h for the local roads. However, when the posted speed limit is 60 and 70 km/h, a portion of vehicles have slightly exceeded the school speed limit. This non-compliance becomes more pronounced when the posted speed limit is 80 km/h. This motivates the investigation into speed violation rates presented in the next section.

Table 3: Overview of speed statistics during school-zone operating hours across various posted speed limits. The table presents median speed, 85th percentile speed, and standard deviation for zones with posted limits ranging from 50 to 80 km/h. As the posted speed limit increases, both the median and 85th percentile speeds rise, while speed variability remains relatively stable across categories.

Posted speed limit (km/h)	Median speed (km/h)	Percentile 85th speed (km/h)	Standard deviation of speed (km/h)
50	28.0	39.0	10.92
60	34.0	42.0	10.75

70	35.0	42.0	10.79
80	40.0	51.0	11.27

4.2 Speeding rate

A naive assumption would be that lowering the posted speed limit by 10 km/h would reduce the speed distribution by 10 km/h. This is not the case, as shown in **Figure 4** and **Table 3**. The histogram illustrates varying levels of driver compliance across different speed limit categories and a higher percentage of the speeds exceed the limit during school zone hours. **Table 4** details the occurrences of speeding during and outside school zone hours. The results reveal that the speeding rate nearly doubles, from 5.72% to 11.95%, during school zone hours.

Table 4: Compliance with speed limits in school zones during and outside operation hours. This table summarises the number of vehicle speed observations and associated speeding violations across all school zones by time period. The speeding rate during operational hours was more than double that observed outside operational hours, highlighting elevated non-compliance during times when reduced limits are in effect.

	All times	During operation hours	Outside operation hours
Number of observations	8,274,891	2,314,337	5,960,554
Number of violating observations	617,556	276,444	341,112
Speeding rate (%)	7.46	11.95	5.72

Table 5 presents the details of speeding within school speed zones across various posted speed limits. The results show that the speeding rate during school zone hours is consistently higher than that outside of school zone hours for any posted speed limit. Focusing on extreme speeding (speeding that is more than 10 kph above the relevant limit), violation rates are always higher during operating hours and become more pronounced when the default limit is higher. This suggests that current speed zone signage and enforcement do not entirely overcome either habits or cues from road design that match the normal posted limit.

Table 5: Effect of speed limit on compliance rates in school zones during and outside operation hours. The table disaggregates speed compliance metrics by posted speed reduction and time category, capturing both general and extreme speeding behaviour. More substantial speed reductions were associated with higher speeding and extreme speeding rates during school zone hours, with the 80 to 40 km/h category showing the lowest compliance and greatest risk.

Speed limit change	Time category	Number of observations	Number of violating observations	Number of violating observations (over 10 kph)	Speeding rate (%)	Extreme speeding rate (%)
50 to 40	During	1,104,569	113,542	10,582	10.28	0.96
50 to 40	Outside	2,835,235	177,091	17,428	6.25	0.62
60 to 40	During	693,528	131,475	20,060	18.96	2.9
60 to 40	Outside	2,041,983	151,022	13,189	7.40	0.65
70 to 40	During	115,893	22,897	5,112	19.76	4.41
70 to 40	Outside	373,083	7,224	484	1.94	0.13

80 to 40	During	19,439	8,530	2,929	43.88	15.07
80 to 40	Outside	43,430	5,775	514	13.30	1.18

5 Discussion

5.1 Effectiveness of school speed zones

The implementation of school speed zones in Sydney has clear influence on driver behaviour, with data consistently showing a reduction in speed during operational hours. This reduction supports findings by Nilsson (1982) and Doecke et al. (2018), who both underscore the effectiveness of reduced speed limits in controlling vehicle speeds and enhancing safety within school zones. The evidence in **Figure 3** and **Table 3** illustrates a shift toward lower speeds and a standardization of speed variations. These values indicate that the school speed zones are effective.

The speed distribution patterns in school speed zones with different normal posted limits further highlight the need for a tailored approach to speed management in different urban contexts. The 50 kph zones generally show more disciplined adherence to speed limits compared to zones with higher limits. This adherence is both cause and effect because the baseline limit was already most conducive to pedestrian activity which then reinforces driver behaviour. This research links local-road environments with better compliance to time-varying speed limits, as supported by documentation from Haworth et al. (2001), indicating relationships between urban design and the effectiveness of speed management strategies.

5.2 Paradox of speeding rates

Despite the overall success of school speed zones in reducing average vehicle speeds, there is an unexpected increase in speeding violations during operational hours, as shown in **Table 5**. This paradox underscores significant challenges in achieving uniform compliance with speed limits. This rise in speeding rates, particularly when posted speed limits significantly differ from school speed limits, suggests that mere speed limit enforcement may not be sufficient. Wilmot and Khanal (1999) indicate that discrepancies in speed limits can lead to driver confusion and therefore violation rates, compromising the safety benefits of school zones.

The finding of high violation underscores the necessity for multiple approaches combining variable speed limits with behavioral change strategies and, where needed infrastructure changes. Behavioural change strategies could include enhanced enforcement, such as the use of speed cameras or increased police presence, to deter high-speed violations. Additionally, educational campaigns aimed at raising driver awareness about the dangers of speeding in school zones could emphasize the consequences of non-compliance on community safety. For the most extreme cases, changes in the road design may be effective at reducing driving speeds, although infrastructure changes are generally not time-of-day specific.

5.3 Policy implications and recommendations

The implementation of school speed zones has profound implications for safety, significantly reducing vehicle speeds and fostering a safer driving environment. This reduction not only minimizes the likelihood of accidents but also enhances pedestrian safety, which is particularly crucial in urban areas with high pedestrian traffic. The data described here supports that speed limit reductions do reduce speeds overall, which is to be expected but is by no means assured considering the role of road design in determining driving speed.

Research by Nilsson (1982) and Doecke et al. (2018) has demonstrated that lower speeds can drastically decrease both the risk and severity of accidents, thereby substantially enhancing overall road safety. This dual advantage has important implications for the interpretation of these findings as it motivates strong compliance as well as reduction in the average speed.

The positive psychological impact of visible safety measures, such as school speed zones, can promote more cautious driving behaviour and more confident active travel. Elliott et al. (2003) have observed that these measures significantly shape driver behaviours, making them more aware of their surroundings and careful in their driving practices. The presence of school speed zones also encourages more active travel among school children, making walking and cycling to school safer and more appealing. This shift towards more active travel, supported by Rothman et al. (2021), helps promote healthier lifestyles and reduces traffic congestion, illustrating how safer road environments can encourage more sustainable transportation options. The increased pedestrian activity in these zones both necessitates stringent adherence to speed limits and induces slower driving behaviours through visual cues to drivers that they are in a complex road environment. The distributions of speeds described in this paper illustrate how speed violation persists and even increases despite the overall shift to lower speeds—this finding supports a recommendation to support speed limit reductions with enforcement, education and road redesign to achieve the intended benefits of safer speeds.

5.4 Limitations

This study faces several limitations that affect the interpretation of the results and their applicability to broader contexts. One notable limitation arises from the reliance on quantitative data from the Vehicle Compass IoT and NSW Speed Zones, which may not capture important external factors such as weather conditions, road surface quality, and unrecorded pedestrian activity, all of which can influence driver behaviour. Another important constraint concerns the geographical scope of the study, which is limited to the Sydney area and may restrict the generalisability of the findings to other urban or rural areas with differing traffic patterns and cultural norms around speeding. Lastly, the analysis assumes a uniform level of driver awareness and enforcement of school zone speed limits. In practice, such contextual factors can vary significantly—drivers may be more or less aware of the presence of a school, traffic volumes can differ greatly between locations, and enforcement intensity is unlikely to be consistent across all zones.

5.5 Future Research Directions

Point locations and speeds are a simplistic measure of driving behaviour, and the literature advocates for trajectories to be used to address, for example, measurement bias caused by reobservations of the vehicles. An important extension of this work is to present the trajectories in the school speed zones during and outside of operating hours and to quantify the associated speed changes and compliance rates.

Future research should extend beyond the current datasets to include qualitative studies that explore driver attitudes and awareness regarding school speed zones. Longitudinal studies spanning multiple years would provide a more comprehensive understanding of the long-term impacts of these zones on traffic safety and driver behaviour. Moreover, comparative studies across different cities or countries could offer insights into the global applicability and effectiveness of school speed zones, guiding international best practices in traffic management around schools.

6 Summary

This study has comprehensively described the distribution of vehicle speeds within the Sydney metropolitan area during and outside school speed zone operating hours, revealing insights into their effectiveness and areas for improvement:

- Reduction in vehicle speeds: The introduction of school speed zones has been successful in reducing the overall vehicle speeds during operational hours. This effect has been clearly demonstrated through the analysis of speed distribution data, where a marked decrease in vehicle speeds within these zones has been observed.
- Decreased compliance: There is a general decrease in compliance with speed limits during the operational hours of school speed zones. This suggests that driver behaviour is limited by cues from the road design even in the presence of signage.
- Policy implications: The findings suggest that while school speed zones are beneficial, their full potential is not yet realized. To optimize the effectiveness of these zones, it is recommended to integrate additional measures, such as automated speed enforcement cameras, dynamic speed signs and traffic calming.

In conclusion, school speed zones play a critical role in promoting road safety, particularly in areas frequented by vulnerable populations such as school children. However, to fully harness their benefits, compliance concerns need to be addressed with stricter enforcement, public education, and potential infrastructure changes. Through such comprehensive measures, the safety of school zones can be significantly enhanced, contributing to the overall well-being of the community.

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