Peer Review Papers

Qatar's school safety program: applying Safe System principles

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Abstract

Children's safety is a priority outside schools where there is often a mix of vulnerable road users and high numbers of vehicles. This paper outlines some of the issues presented by schools in Qatar and provides an overview of how the Safe System approach has been incorporated into school zone improvements.

Protecting children, who by their nature are unpredictable and impulsive, around schools has always been a sensitive safety issue. It is a key Safe System principle that the road user is not blamed for the crash and that other measures are developed to manage safety. Likewise, it is unrealistic to rely on motorist's willingness to comply with speed limits in order to create a safe speed environment.

Across the globe school zone programs have reasoned that any reduction in vehicle travel speed is evidence of success. This argument does not align with Safe System principles and more is required. The Qatar experience is proposed as a Safe System model for developing and implementing Safe School Zones.

Keywords

Safe System, School zone, Speed, Self-enforcing

Introduction

The protection of children travelling to and from school is a highly emotional issue that has challenged road safety professionals across the globe for decades. Speeding in school zones is of particular concern given the high levels of vulnerable road user activity. The most common measure to reduce vehicle speeds is to introduce a dedicated school zone speed limit which is lower than the prevailing speed limit. School zone speed limits typically range from 24 km/h (15 mph) to 40 km/h (25 mph) (Fitzpatrick, 2009). A reduced speed limit is typically implemented via a timed, or temporary, restriction based on periods of peak school related traffic activity.

Supplementary devices such as high-visibility signs, flashing lights, electronic speed feedback signs and enhanced road markings such as coloured speed numerals, zig-zag lines and dragon's teeth markings have all been used, with varying effect, in an effort to achieve compliance with school zone speed limits. Despite efforts aimed at reducing speeding in school zones, speeding still remains very common (Ellison, 2011). Concerns regarding compliance have naturally led to greater levels of enforcement including fixed speed cameras. However, while speed enforcement strategies are proven to be effective, reducing speeding by 71% in New South Wales (Road Safety Council Position Paper), they can be highly unpopular and risk negatively impacting the credibility of the school zone safety program (Courier Mail, 2014).

This paper proposes a method of improving school zone safety that is demonstrably safe, popular with school communities, improves traffic management, increases parking provision and does not require enforcement of the speed limit. 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

Ellison (2011) includes a comprehensive literature review that considers many of the recently published papers, and notes that speeding through school zones is common. The suggestion is made that engineering the environment may be more effective than relying on measures to affect driver behaviour.

Over the years there have been numerous attempts to improve the compliance with school zones however, most have relied on measures that seek to affect driver choice of speed. The state of New South Wales manages temporary speed limits of 40 km/h applied in school zones on weekdays from 08:00 to 09:30 and from 14:30 to 16:00 during school terms (Ellison, 2011) and continues to implement initiatives designed to further enhance the school zone. In addition to the high-visibility fluorescent signs and yellow and black 40 pavement patches, the Minister for Roads announced in 2006 a major package of initiatives to improve safety of school zones: flashing lights, speed cameras, increased fines and demerit points and volunteer marshals (to accompany children to the school gate) which allowed drivers to stay in their vehicle. In addition, he announced a round table to further improve safety and a plan to recruit additional school crossing supervisors (New South Wales Government, 2006). A further initiative utilising road marking known as Dragon's Teeth (or longitudinal triangular road markings) was implemented in 2009 to again enhance the school zone to drivers in New South Wales (Roads and Traffic Authority, 2009).

However, the measures that are most often used to improve safety around schools, such as part-time speed limits, warning signs, and flashing lights have limited effect on driver compliance (Ellison, 2011; Radalj, 2002; Roper et al., 2006; Fitzpatrick, 2009).

Graham and Sparkes (2010) found that in addition to a reduction in child pedestrian crashes (46%) there was also a reduction in other pedestrian crashes (45%), of all vehicles crashes (35%) and a reduction of speed related crashes (20%) in school zones during school zone times. This result can also be understood as the expected benefit of reducing travelling speed and demonstrates that the benefits of school zones can be applied more broadly.

Flashing lights have been found to have a positive effect on travel speed. However, it is significant to note that these evaluations show a reduction in mean speeds ranging from 1.65 to 2.65 km/h (Radalj, 2004) with the greatest effect attributed to vehicles travelling at very high speeds (Saibel, 1999). This suggests that drivers travelling at very high speeds moderate their speed but are still exceeding the speed limit through the school zone.

It has been argued that small reductions in mean speeds can deliver good safety benefits, which can be predicted using the Power Model. This is positive but still not in accordance with the Safe System and survivability threshold speeds. Arguably a model that delivers consistent safe speed through a school zone will deliver even greater road safety benefits.

Qatar School Safety Program

The State of Qatar is a peninsula located on the north east coast of the Arabian Peninsula, with a total land area of approximately 11,500 square kilometers. The population is approximately 2.5 million (QMDPS, 2016) with more than 80% of inhabitants residing in Doha. The State of Qatar has experienced rapid economic growth over the last several years, which has resulted in an increased demand for the State to construct and provide first-class road and transport infrastructure.

Growing concern about the level of road trauma led to the development of Qatar's National Road Safety Strategy (2013-2022), which was launched in January 2013 (QNRSS, 2013). The strategy has adopted the Safe System, an ambitious vision to reduce road trauma, and included a commitment to improve safety outside schools.

School zones in Qatar often comprise multiple educational facilities clustered together in the same area. Travel patterns vary greatly with schools serviced by fleets of buses, students driving themselves to school, students being dropped-off by parents or carers, or any combination of the above. In addition, trips associated with schools are often distributed across the city. This creates high traffic demand on the road network surrounding the schools, particularly where schools are located close to major roads. Vulnerable road user activity is generally confined to the immediate vicinity of schools during the hot summer months.

Safety conditions outside schools had been of concern for some time. The fast pace of infrastructure development in Qatar has led to a legacy of schools serviced by incomplete or undeveloped road networks. This means that there is often a lack of formal road space allocation and a lack of provision for parking and pedestrian activity.

It was necessary to develop a school safety program that:

(a) Provides a safe environment for vulnerable road users;

(b) Efficiently manages the very high traffic peak;

(c) Provides for parking of cars and buses;

(d) Includes safe and convenient pedestrian crossing facilities; and

(e) Discourages parking on footways.

The program needed to be relatively simple to apply and based on proven road safety and traffic management principles, while being sufficiently flexible to accommodate the needs of individual schools. Delivering the school safety program involved several steps: 1) writing a school zone guide; 2) installing and monitoring school zones; and 3) evaluating the performance of school zones.

School zone guide

The school zone guide was developed based on a number of assumptions and guiding principles:

(a) A speed limit of 30 km/h was adopted based on pedestrian impact survivability threshold levels. Where motorised traffic mixes with pedestrians and cyclists, the speed limit must not exceed 30 km/h (WHO, 2015). This is due to the vulnerability of these road users at increasing speed: human biomechanical injury tolerance for a pedestrian hit by a car will be exceeded if the vehicle is travelling at more than 30 km/h (Johansson, 2009);

(b) The speed limit needed to be applied full-time, not part-time. Schools can be pedestrian generators outside of school zone times and children can be hit at any time of the day. It was also observed that many school premises are used for a range of purposes in the evenings and on weekends. Full-time speed limits avoid the problems associated with informing drivers when the reduced speed limit applies. In addition, research has shown a substantial benefit to all road users when reduced school zone speed limits apply (Graham and Sparkes, 2010);

(c) The school zone was to be self-enforcing. The combination of traffic calming measures was to be implemented in such a way as to create a zone that naturally reduced driver's speeds without the need for enforcement (Fildes and Lee, 1993). Further, traffic-calming devices were to be placed at regular intervals to ensure desired speed profiles throughout the school zone were achieved (Austroads, 2008);

(d) All marked (zebra) pedestrian crossings were to be on a raised platform. Research shows that a raised pedestrian crossing is safer than an at-grade crossing (Austroads, 2012). A raised crossing also serves as a traffic calming measure to slow vehicles;

(e) To keep the process simple, the application of various engineering measures and facilities was not limited by traditional design warrants; such as a pedestrian demand warrant for a particular crossing type. Instead, the type and placement of traffic calming measures were to be implemented based on engineering principles supported by consultation with the school community.

The Guide was written based on Safe System principles and includes a toolkit of devices for the designer to select from, a guide for the project manager or designer to consult with the school community and a checklist for the designer to ensure all relevant design elements were addressed. The Guide also required preparation of supplementary standard drawings and approval of new products such as:

(a) High visibility signs: a new sign was designed with a fluorescent yellow backing board which incorporated a supplementary plate with the word 'school' in Arabic and English. The sign at the end of the school zone has the same design with a single thick diagonal line, indicating end. The fluorescent yellow colour was used as a 'theme' and repeated on pedestrian sign backing boards and reflective bands on bollards;

Figure 1. Example school zone signs and bollards

(b) Drop-and ride facility: there was a need for a facility at many schools that allowed cars to stop and let children out near the school gates. A design was prepared for a drop-and-ride facility that was wide enough to enable a vehicle to pass another stopped vehicle. Drop-and-ride facilities are typically installed as close to the main gate as possible;

(c) Raised pedestrian crossing: it was necessary to prepare a standard drawing for a pedestrian crossing on a speed table together with associated signage. All pedestrian crossings under the school safety program are installed on raised platforms/ tables;

(d) Bollards: due to the problems associated with vehicles parking on the footway outside schools it was necessary to identify a suitable bollard that was also passively safe. The European specification EN12767 was adopted as the basis for selecting suitable school zone bollard systems;

The preferred position for schools adjacent to high-speed multi-lane roads was to deny access from the high-speed road and to provide safe and convenient access from adjacent suburban roads. On some high-speed roads there was sufficient space to provide a service road, which would receive the full school zone treatment depending on consultation with the school. Lengths of pedestrian fencing were installed to separate pedestrians from fast moving traffic.

Installation and monitoring

The installation of traffic calming measures to create a self-enforcing, 24-hour, 30km/h speed environment was central to the school zone concept. Standard school zone signs were used in combination with a gateway treatment to reinforce the limits of the school zone and the lower speed environment. Gateways typically incorporate narrowing of the carriageway with central islands. In some locations, gateways are combined with speed humps or raised pedestrian crossings. A typical 30 km/h school zone gateway treatment is shown in Figure 2.

Figure 2. School zone gateway treatment at London School

Where the right-of-way width is sufficient, a central median is typically installed to smooth traffic flow and to prevent undesirable turning and U-turn manoeuvres. This also has a calming effect on vehicle speeds. Other measures to reduce vehicle speeds within the school zone include speed humps, speed tables and raised pedestrian crossings. All formal pedestrian crossings within a school zone are provided on a raised speed table. Safety is further enhanced for pedestrians with fencing to direct pedestrians to formal crossing locations and bollards to prevent vehicles from parking on footpaths. A typical treatment within a school zone including a raised pedestrian crossing, a central median, pedestrian fencing, bollards, angle parking and a pick-up/drop-off facility is shown in Figure 3.

Figure 3. Treatment within Middle East International School zone

Pedestrians are a priority in the school zone. Where possible, footways are at least 2.5m wide and provided on both sides of the road. Safe and convenient pedestrian crossings are installed on pedestrian desire lines. Pedestrian fencing can be selectively used to support the pedestrian facilities. Based on the individual needs of the school, drop-and-ride facilities are provided adjacent to school entry points and parking is maximised through provision of

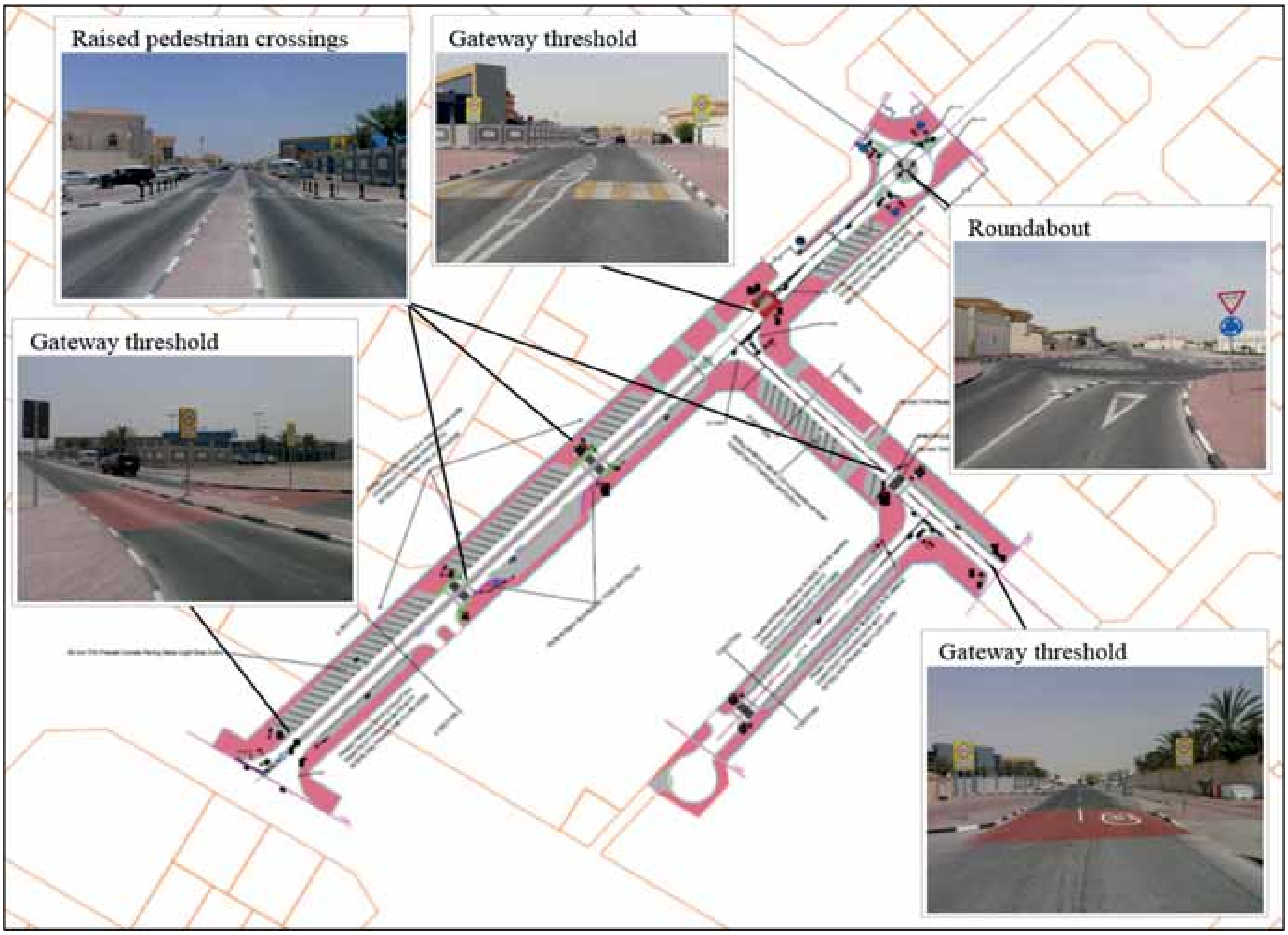

Figure 4. Typical school zone layout (Middle East International School)

angle parking wherever possible. Where there is insufficient width, roads have been converted to one-way operation. Raised central medians are installed in all designs where there is space in order to manage ad-hoc turning movements and to improve pedestrian safety (Bowman, 1993). Raised central medians are also very useful in managing traffic peaks. Roundabouts are used whenever there is a raised median to provide for connectivity while providing the added benefits of managing traffic speed and improving pedestrian safety (Harwood, 2008).

A typical school zone layout is shown in Figure 4.

As the first school zones were installed they were closely monitored to check whether the pedestrian facilities were being used, that vehicle speeds had been reduced to safe levels, and that traffic flow and operation had improved. Some of the observations included:

- The pedestrian facilities were generally being used correctly. This was a pleasing outcome as previously there were no pedestrian crossings. However, where people were not using the designated crossings they were still in a safer environment due to the reduced vehicle speeds and, where installed, the presence of raised medians;
- Pedestrian facilities were most effective when used in combination with pedestrian fencing;
- It was noted that traffic-calming devices were more effective in reducing speeds when placed at about 80 metre intervals;
- Central medians have proven effective in stopping ad-hoc turning movements and U-Turn manoeuvres;
- Roundabouts have been successful in calming traffic and accommodating U-Turn manoeuvres;
- Bollards were successful in preventing vehicles from parking on the footway. However, it was noted early in the program that long lengths of bollards installed at 1.5 metre intervals were excessive and future installations used bollards more selectively and in combination with pedestrian fencing.

While traffic flow has improved, the high demands placed on the road network due to the concentration of multiple schools and high student numbers means that congestion is still experienced, though to a lesser extent, at some clusters of schools. There has been pleasing support from school communities with numerous requests for similar school zones. Several letters of appreciation have been received from school principals including recognition of the consultation that has been undertaken. Overall, the engineering of the road layout, pedestrian facilities, parking, pick-up/drop-off areas, etc., has significantly improved safety while managing traffic flow and operation around schools.

Evaluation

Speed surveys were undertaken to evaluate the impact of Qatar's school zones on driver speed behaviour. The surveys were designed to capture vehicle speed data after school zones were implemented to assess the effectiveness of speed reduction upon entry and throughout the school zone. The objectives of the surveys were, firstly, to determine whether the school zones had successfully reduced vehicle speeds to 30 km/h and, secondly, whether reduced speeds were maintained throughout the entire day, i.e. over 24-hours.

The sample consisted of 23 survey sites at eight school zones within the city of Doha. All of the schools included in the evaluation were located on single carriageway local roads. Surveys were undertaken on approach to the school zone, at the school zone entry gateway point, approximately midway between the entry gateway and the first raised pedestrian crossing or speed hump, at various locations fully within the school zone and approximately midway between the last raised pedestrian crossing or speed hump and the exit gateway.

Surveys on approach to the school zone were undertaken at three schools approximately100 metres before the school zone entry gateway. Whilst there was no formal posted speed limit on the approach roads, each was considered typical of a 50 km/h or 60 km/h local residential road. Gateways at the other five schools coincided with intersections, either with boundary roads or with roundabouts that were installed as a speed management measure. The separation distance between each gateway and first or last raised pedestrian crossing or speed hump ranged from 55 metres to 110 metres, with an average of 80 metres. The separation distance between raised pedestrian crossings and speed humps within each school zone ranged from 65 metres to 170 metres, with an average of 90 metres.

All surveys were undertaken over a period of one week including the weekend except for the International School of London and Middle East International School. The survey period for these two schools was 24-hours. All speed surveys were undertaken using MetroCount pneumatic tube counters.

Results

To evaluate the school zones, only recorded vehicle speeds of 10 km/h or more were included in the analysis. Vehicle speeds of less than 10 km/h were assumed to be indicative of congestion or dropping off or picking up children within the school zones.

The speed surveys undertaken at 23 sites throughout the eight school zones resulted in 527780 vehicle records that satisfied the set criteria of travelling 10 km/h or more. This assessment adopts a different approach to most research on school zones in that it does not specifically evaluate vehicle speeds during school peak time periods. Rather, to evaluate the first hypothesis, i.e. that Qatar's school zones are effective in reducing vehicle speeds to 30km/h, 85th percentile speed data was extracted in both directions (two-

Table 1. Survey site numbers for each school by description of site location

School	Site survey number and distance between measures				
	Before School Zone (1)	**At gateway (2)**	**Between gateway & crossing (3)**	**Middle of School Zone (4)**	**Between crossing & gateway (5)**
International School of London [a]	1 *(100m)*	2 *(20m)*	-	3 *(65m)*	-
Aatika Primary School	1 *(90m)*	-	2 *(55m)*	-	3 *(60m)*
Middle East International School [a, b]	-	-	-	2 *(90m)* & 3 *(70m)*	1 *(55m)*
Al Falah Independent Primary School [b]	-	-	-	1 *(85m)* & 2 *(170m)*	-
Tarik Bin Zayid Secondary School	1 *(100m)*	-	2 *(80m)*	3 *(70m)* & 4 *(60m)*	-
Khalifa Secondary School [b]	-	-	-	1 *(95m)*	2 *(95m)*
Park House English School[b]	-	-	3 *(110m)*	1 *(110m)* & 2 *(60m)*	-
Madinat Khalifa North School [b]	-	-	1 *(95m)*	2 *(85m)* & 3 *(90m)*	-
Total sites	**3**	**1**	**4**	**12**	**3**

[a] 24-hour survey
[b] Gateways at intersections

way) over a 24-hour period at all recorded locations on approach to and throughout each school zone. This data was then aggregated across all of the school zones to determine a “typical” 24-hour, two-way, 85th percentile speed profile as vehicles approach and pass through a “generic” school zone. Speed results for the first hypothesis are presented in Table 2 and Figure 5.

While the aggregated results indicate a negligible speed reduction at the school zone gateway treatment, closer inspection of the individual results for the International School of London reveals a substantial drop in speed. The 85th percentile speed on approach to the school zone drops from 66.2 km/h to 51.5 km/h at the gateway, representing a reduction of 14.7 km/h. This effect is not prominent in the aggregated results because the higher approach speed for International School of London is offset by the significantly lower 24-hour survey sample size.

Table 2. 85th percentile speed survey results (24-hour, two-way)

School	**85th percentile speed (km/h) and sample size *(n)***				
	Before School Zone (1)	**At gateway (2)**	**Between gateway & crossing (3)**	**Middle of School Zone (4)**	**Between crossing & gateway (5)**
International School of London [a]	66.2 *(4224)*	51.5 *(4215)*		33.1 *(4098)*	-
Aatika Primary School	43.9 *(35769)*	-	33.8 *(33136)*	-	33.5 *(31772)*
Middle East International School [a, b]	-	-	-	34.9 *(18657)*	31.3 *(9345)*
Al Falah Independent Primary School [b]	-	-	-	36.4 *(11797)*	-
Tarik Bin Zayid Secondary School	54.7 *(36449)*	-	33.5 *(24982)*	32.0 *(36513)*	-
Khalifa Secondary School [b]	-	-	-	38.5 *(19874)*	31.0 *(19098)*
Park House English School[b]	-	-	33.5 *(26407)*	32.8 *(40574)*	-
Madinat Khalifa North School [b]	-	-	39.2 *(67158)*	37.4 *(103712)*	-
Aggregated Results	52.2	51.5	37.1	35.8	32.4

[a] 24-hour survey
[b] Gateways at intersections

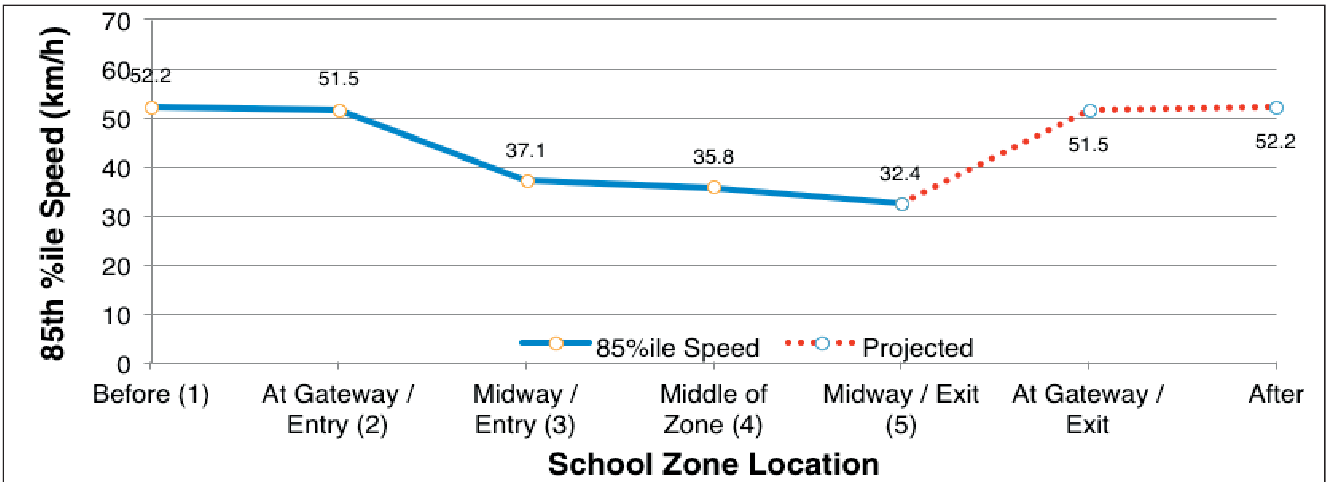

Figure 5. 85th percentile speed profile as vehicles approach and travel through school zones

The results show that speeds are significantly lowered once vehicles enter the school zone. The "transition" length, i.e. the distance between the entry or exit gateway and the nearest traffic calming device, which is typically a raised pedestrian crossing, averages around 80 metres. The length within the school zone, i.e. between locations (3) and (5), represents the area of greatest school related activity. Within this area, the 85th percentile speed is reduced by between 15.1 km/h and 19.8 km/h. This represents a substantial reduction in vehicle speeds, which would translate to significant reductions in fatal and serious crash risk (Nilsson, 2004).

The longitudinal speed profile demonstrates the effectiveness of the school zone treatment. The results indicate that vehicle speeds recorded within the school zone are consistent with Safe System 30km/h levels.

To test the second hypothesis, i.e. that Qatar's school zones are self-enforcing and that lowered vehicle speeds are maintained throughout the entire day, 85th percentile speed data was extracted in both directions (two-way) and compiled into 24-hour speed profiles at the same locations: before the school zone, at the gateway, mid-way in the school zone and in the middle of the school zone (Appendix A).

The aggregated 24-hour speed profiles on approach to the school zone and at the school zone gateway are shown (in Appendix) in Figures A1 and A2, respectively. The approach profile shows a reasonably consistent 85th percentile speed that fluctuates from around 50 to 58 km/h. This is considered typical of a 50 km/h local residential road, though it is notable that the approach speeds for individual schools indicate some variation, with International School of London indicating an 85th percentile speed more typical of a 60 km/h local residential road. The gateway profile shows the greatest variation, which may be attributed to the fact that gateways will typically have less traffic calming effect than the measures further into the school zone, and that the sample size is substantially lower than the other profiles.

Profiles for the speed surveys conducted within the school zone (Figures A3, A4 and A5) show clearly that vehicle speeds are maintained at lower Safe System 30km/h levels at all times of the day. The evidence suggests that this will deliver a substantial road safety benefit to all users at all times (Graham and Sparkes, 2010).

Conclusions

The Qatar school zone program demonstrates that there is a better model for designing and implementing school zones. By applying sound traffic engineering principles, it is possible to install school zones that manage vehicles speeds to safe levels while managing high traffic volumes. The school zone program does not need to have complications associated with temporary speed limits, or require additional supplementary measures such as flashing lights. It is simpler and safer for all road users to apply a full time speed zone supported by traffic calming measures.

The Qatar program relies heavily on input from school communities who have welcomed the initiative. The Qatar program also demonstrates that it is not necessary to rely on enforcement within the school zone. Enforcement is highly unpopular in school zones and complex when based on time of day and whether it is a school day. The simpler and much more effective solution is to have an engineered self-enforcing road environment. As Fildes and Lee (1993) have suggested, self-enforcing traffic calmed areas can also have a positive benefit-cost-ratio for all road users.

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APPENDIX

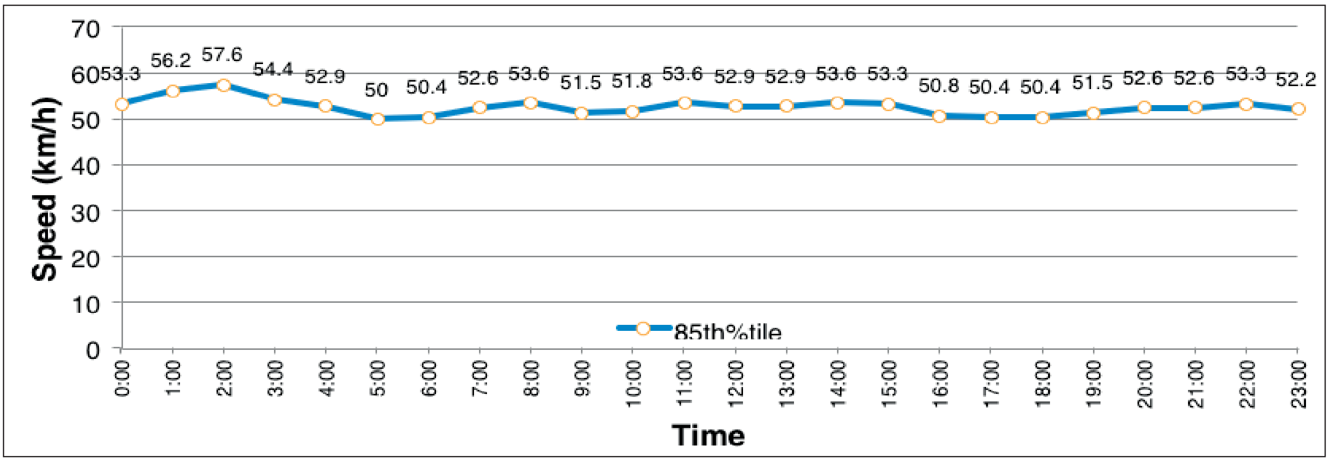

Figure A1. Before school zone (aggregated 24-hour two-way profile)

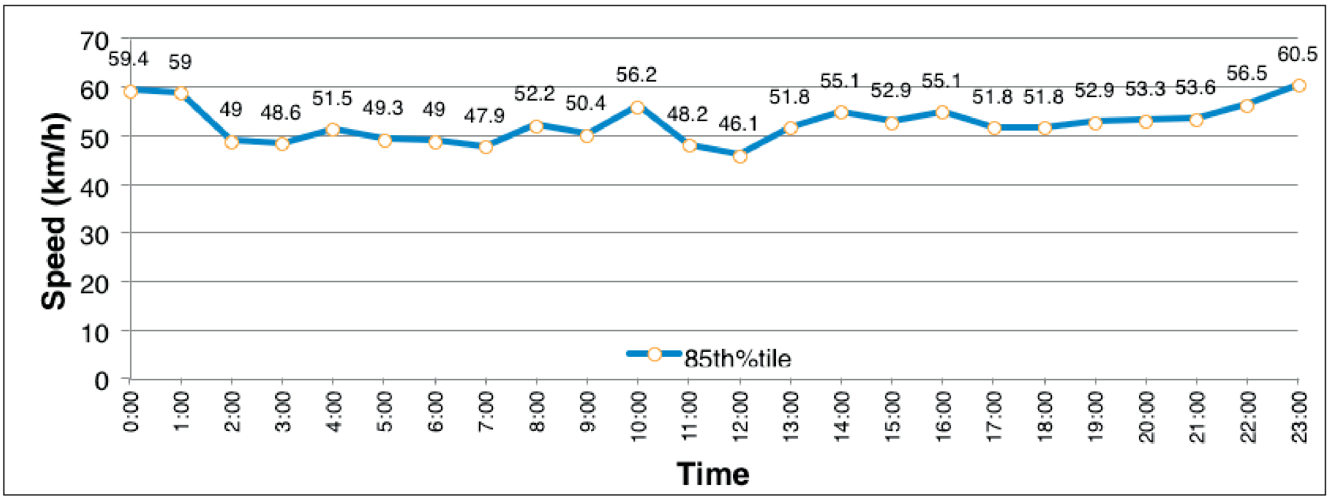

Figure A2. At gateway (aggregated 24-hour two-way profile)

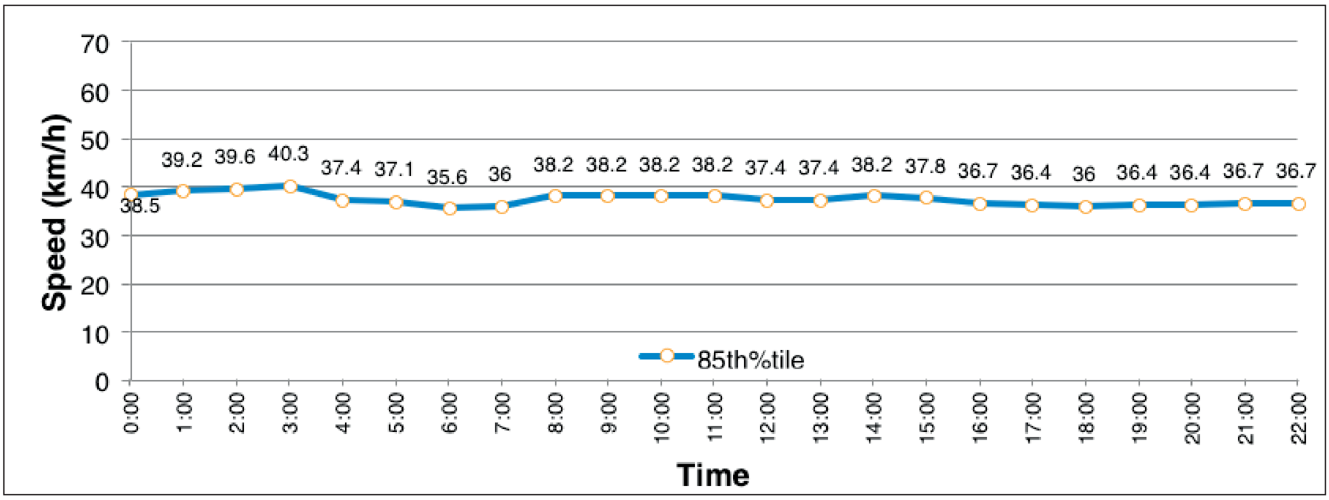

Figure A3. Between gateway & first crossing (aggregated 24-hour two-way profile)

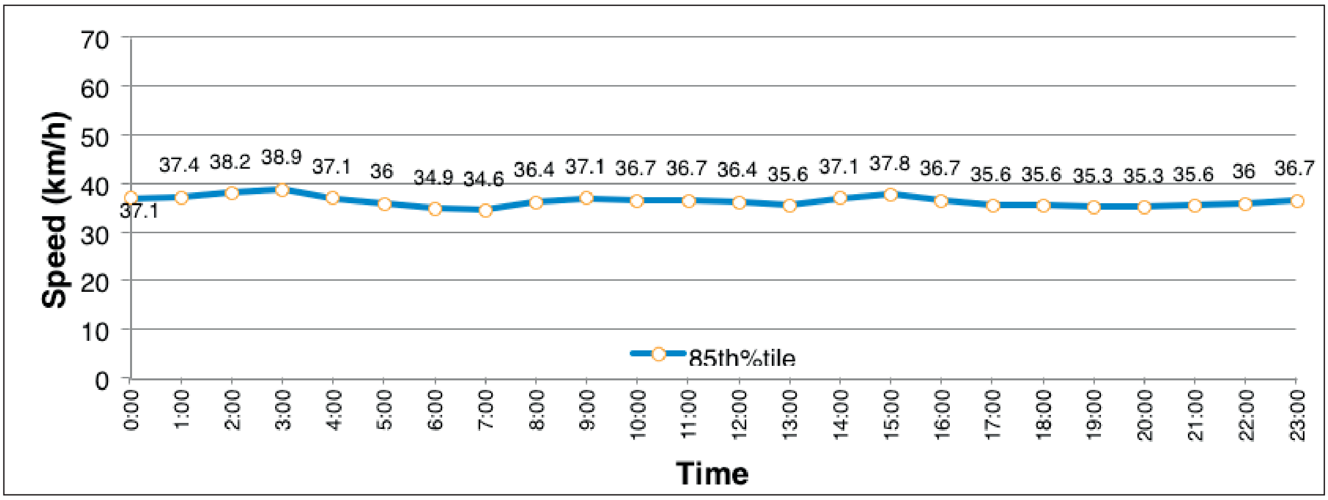

Figure A4. Middle of school zone (aggregated 24-hour 2-way profile)

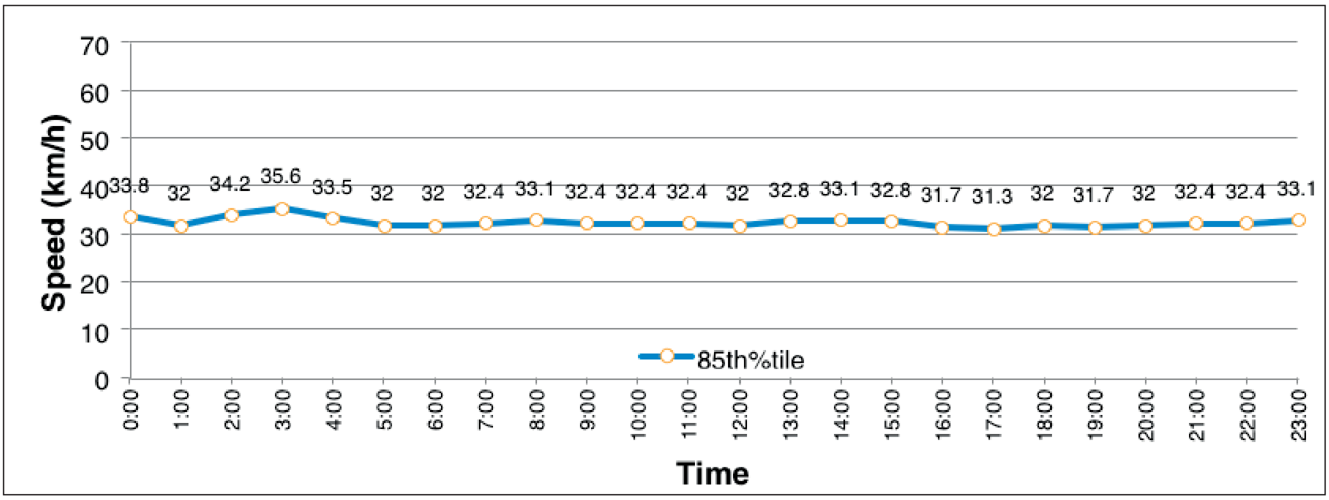

Figure A5. Between last crossing & gateway (aggregated 24-hour 2-way profile)

Canadian Legislation on excessive speeding: successful intervention through penalty increases

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Abstract

Excessive speeding is a global problem experienced on roads all around the world. The impacts of this behaviour on the safety of all road users have led many jurisdictions to adopt more significant sanctions when dealing with such offenders. This paper assesses the impacts of adopting more significant sanctions against excessive speeders in Canada while also considering issues which should be explored when adopting such a policy. The paper uses ARIMA intervention analysis to assess changes in fatal collision data since the adoption of stronger penalties. The changes were assessed for statistical significance, and the magnitude of the change was quantified. In general, the findings show that the legislative changes allowing for stronger penalties were associated with significant drops in province-wide fatal collisions. Reductions in the mean level of monthly collisions ranged from 5% to 22% at the three provinces. Moreover, the paper highlights four major areas, which must be considered for jurisdictions attempting the adoption of such a legislation.

Keywords

ARIMA, Intervention analysis, Time-Series, Severe sanctions, Canadian Legislation, Excessive speeding, Fatal collisions.

Introduction

Excessive speeding is an issue on roads all around the world, and many countermeasures have been considered in different provinces to overcome this challenge. Common reasons for exceeding speed limits by extremely high margins are illegal street racing and stunt driving, while speeding generally has multiple causes including simply being late (Prabhakar et al., 1996). However, street racing is not the only motive of excessive speeding.

There is no doubt that, regardless of the motives, excessive speeding puts the offenders at an extreme risk and could also affect the safety of other drivers and road users. Considering three years of data, Nerida L Leal and Watson (2011) found that drivers who were involved in street racing and stunt driving offences had a history of considerably more traffic infringements and crashes compared to non-offenders. Consequently, more attention and significant sanctions have been considered when dealing with such activities.

A form of stronger sanctioning which has often been introduced to supplement licence suspensions is vehicle-related punishment such as vehicle impoundment. Legislative changes enforcing stronger sanctions against excessive speeders have been adopted by many