Near-Misses at School Crosswalks in Canada Study

FINAL REPORT

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Prepared by: Fireseeds North Infrastructure
Miovision Technologies

Research Lead: Craig Milligan, Ph.D., P.Eng., Fireseeds North Infrastructure
Data Science Lead: Shayan Sobhani, Miovision Technologies
Project Manager: Zach Bogdon, Miovision Technologies

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Near-Misses at School Crosswalks in Canada Study

NATIONAL SUMMARY OF NEAR-MISSES



KEY FINDINGS

11 Cities

30 School Pedestrian Crossings

4.5 Average crossing near-misses per day

1 in 84 crossing pedestrians was involved in a near-miss with a vehicle

2.6× Near-misses were more likely when vehicles were exiting an intersection than when entering

67% Without school zone or reduced speed zone signage, near-miss rates were 67% higher

56% Zebra markings were associated with a 56% lower turning vehicle upon exit near-miss rate.

20× Crosswalks at intersections with through traffic control (signal, stop sign or roundabout) had 20x lower near-miss rates

High Level of statistical significance in near-miss prediction model based on crosswalk attributes

Executive Summary

This CAA-commissioned study used Miovision video-based conflict analysis at 30 school zone crossings across Canada to establish safety trends and examine what makes a school zone crossing safe. The use of 30 sites provided a sample size large enough to draw credible conclusions measured by high statistical significance.

Frequency of Near-Miss Conflicts at School Crosswalks

The average school zone crosswalk in this study served 377 pedestrians and 7600 vehicles and had an average of 4.5 near-miss conflicts per day. One in every 84 pedestrians was involved in a near-miss conflict.

Definition and Types of Near-Miss Conflicts

The words near-miss and conflict are used interchangeably in this report to refer to an event where two road users passed the same point with only a short-time interval in between them, and if they had crashed, there would be a material probability of serious injury. Conflict severity thresholds rank events based on the vehicle speed, potential for injury, and the exact size of the time interval. These thresholds are based on crash probability, not how shocking the event looks on video, and a conflict does not mean the road users were angry at each other.

We observed a distribution of low, medium, and high severity conflicts, with the most common severity level being medium risk. The prevalence of medium risk conflicts is both concerning and encouraging. It is concerning because medium risk conflicts occur at vehicle speeds of 30 km/h or below and still carry a material probability pedestrian injury ranging from 5% to 40%. At the same time, these conflicts are better than high and critical risk events which would involve speed closer to 50 km/h and above, and it is encouraging to see that the setting of low speed limits in school zones has resulted in a low prevalence of high and critical risk events.

The study also showed that conflicts more frequently occur when vehicles are exiting the intersection than when they are entering the intersection: exiting conflicts are 2.6 times more common than entering conflicts. When focusing only on turning vehicle conflicts, an exiting conflict is 7.9 times more likely.

What Makes Crosswalks More or Less Safe?

We found several strong associations in the data between crosswalk attributes and the number of conflicts. The volumes of pedestrians and vehicles is strongly linked to the number of conflicts occurring per day. Higher volume sites have more conflicts.

After accounting for volume, we noted other effects. Crosswalks without school zone signs or reduced speed zone signs had a 67% higher conflict rate. Crosswalks with zebra markings had a 56% lower rate of turning hook conflicts compared to crosswalks without zebra markings. Crosswalks at intersections with through traffic control such as a signal, stop sign, or roundabout had conflict rates that were 20 times lower than sites where through traffic was not controlled. Crosswalks on arterials are associated with higher conflict rates. Some of these effects are quantified in this study for the first time ever for North American school zones crosswalks.

Can Conflicts and Crashes in School Zones be Predicted and Prevented?

This study also introduces preliminary conflict prediction models that can predict the number of conflicts at a crosswalk based on that crosswalk's design and operational attributes. We

modelled the impact of 38 crosswalk attributes and found the ones that were significant predictors of conflicts. The best predictive model in this study has an excellent pseudo-R^2 value of 78%.

These models suggest the possibility of design reforms that re-orient the design of individual crosswalks, land use plans, and safe routes to school planning towards designs that are predicted to have low conflict rates. Existing crosswalks and routes to school can be screened against the predictive models, and facilities performing poorly can undergo predictive-based re-design. Taken together with the previously proven links between conflicts and crashes, this study has expanded the set of quantitative tools available for preventing school zone crashes and increasing road safety for all Canadian students.

1. Introduction and Study Objectives

The Canadian Automobile Association (CAA) commissioned a national study of safety trends at school pedestrian crossings using video-based near-miss analysis. The study was delivered as a partnership between CAA, Miovision, Fireseeds North Infrastructure, the following 11 participating cities: Toronto, Vancouver, Montreal, Halifax, Edmonton, St. Catharines, Winnipeg, Ottawa, Calgary, Regina, and Saskatoon.



Figure 1: Participating Cities and Key Stats for the CAA School Crossing Safety Study

The objective of this study is to examine national level trends in school pedestrian crossing safety and answer the following two research questions.

1. How safe are school pedestrian crossings in Canada?
2. What makes a school pedestrian crossing more dangerous or safe?

To answer these questions, Miovision's video-based conflict analysis technology was deployed at 30 school zone crossings in Canada. We measured the frequency, types, and severity of near-miss conflicts between vehicles and pedestrians at these school crossings. We also recorded 38 design, operational, and contextual attributes for each of these 30 crosswalks and examined links between these attributes and safety levels.

The study yielded clear answers to both research questions. In response to the first question, we have new data on the frequency, types, and severity of near-misses at school crossings. In response to the second question, we have identified several factors that are associated with higher or lower near-miss rates.

We obtained permission from cities to run the study and it was conducted in a manner that protected privacy at all times.

2. Methodology

The study methodology had six overall steps which are described below.

2.1. Site Selection and Collection of Video

Cities were selected on an invitational basis, accounting for willingness to participate and availability of required video collection resources. The goal in city selection was to have cross-Canada representation from major cities. Recruiting cities was easy for this study because all cities prioritize school zone safety and staff were eager for the chance to gain insight on near-miss trends at these locations.

Sites within the cities were selected collaboratively between the city staff, the research team, and CAA. City staff were invited to identify sites where having near-miss data would be particularly helpful. The research team provided some guidance towards achieving a good cross section of attributes at a national level. CAA provided input on site selection based on topics of interest to their membership, such as the presence of crossing guards, the age level of schools, and the size of schools. It was not necessary that the crossing be within a formally defined school zone, only that it be on an established travel route to a school.

Video was collected by City staff using Miovision Scout cameras, illustrated in the figure below. The cameras were deployed over five school days for 12 hours per day from 7 AM to 7 PM.



Figure 2: Miovision Scout Plus - Portable Video Collection Unit Used for CAA School Crossing Safety Study

2.2. Automated Extraction of Near-Miss Conflicts

Near-Miss conflicts were extracted using AI-powered computer vision and Miovision's scientifically validated kinetic energy-based risk model (see Figure below). The model takes into account vehicle speed and the dynamically measured time gap between the vehicle and the

pedestrian in order to assign the conflict to one of four severity levels: low, medium, high, or critical. These risk models were recently shown to have 69% accuracy in predicting long-term pedestrian crash counts based on short-term video conflict measurement[1], which is very high accuracy in domain of pedestrian crash prediction.

The output of near-miss conflict extraction was a detailed file containing each near-miss, the time of day, the severity level, the vehicle movement (through, right, left), and the vehicle progression (entering the intersection / near-side, exiting the intersection / far-side). Shown below is a conflict with a left turn vehicle exiting the intersection, also known as a left-hook conflict.

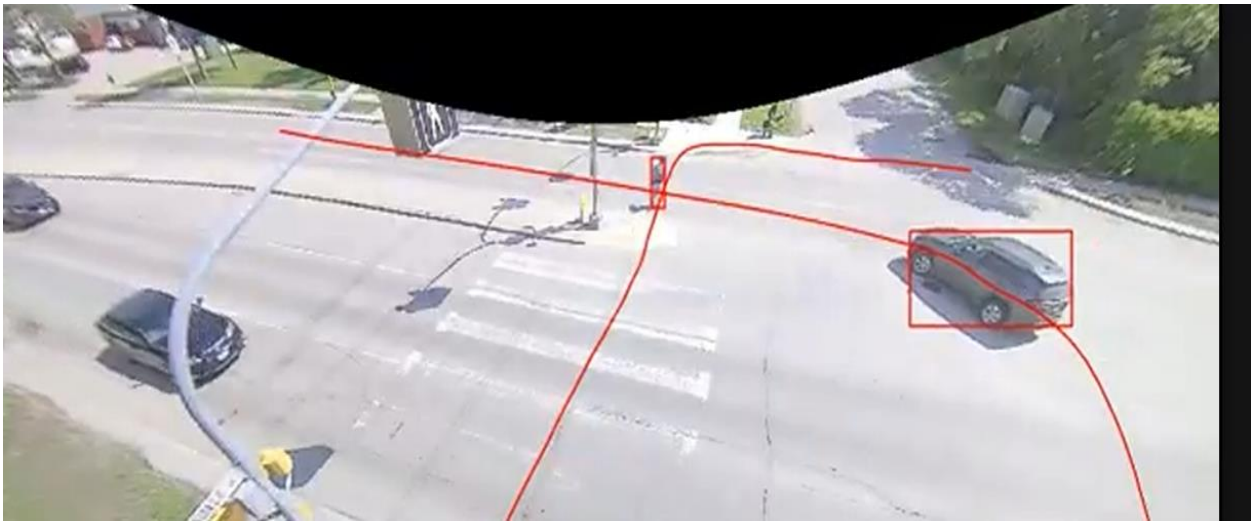


Figure 3: Miovision Video-Based Near-Miss Measurement Technology for CAA School Crossing Safety Study

2.3. Collection of Crosswalk Attribute Data

In order to investigate whether some types of crosswalks were safer than others, 38 crosswalk attributes were collected, consisting of contextual attributes, design attributes, and operational attributes as described below.

The following 7 contextual attributes were collected using information from City staff or internet searches. Note that intersection names and individual city results are not reported in this study. Only aggregated results are presented.

1. City
2. Intersection Name / Midblock Location Name
3. Crosswalk Location within intersection
4. Location Type: Intersection or Midblock
5. Road classification (local, collector, arterial)
6. Signed designated a school zone or reduced speed zone
7. Grade levels of schools within 400m (or of closest school if more than 400 m)

The following 19 design attributes were collected through review of aerial and street-level imagery from Google Maps:

[1] Hasanpour, M., Persaud, B., & Milligan, C. (2025). Integrating Traffic Conflict Frequency and Severity Indicators to Estimate Pedestrian Safety Performance Functions for Signalized Intersections. *Transportation Research Record: Journal of the Transportation Research Board*, *2679*(5), 583-599.

1. Number of lanes crossed by crosswalk
2. Crosswalk width
3. Road has a median
4. Median width
5. Median refuge is present
6. Zebra pavement markings present
7. Parallel line pavement markings present
8. Pavement marking condition
9. Ground mounted signs present on road-side
10. Ground mounted signs present in median
11. Flexible signs present in center or lane lines
12. Overhead signs present
13. Side mounted flashing lights present
14. Overhead flashing lights present
15. Crosswalk ahead warning signs on approach
16. Intersection control type
17. Through traffic control type
18. Curb extension present
19. Raised crosswalk

The following 12 operational attributes were collected through Google street-level imagery, Miovision video analysis, and derived computations.

1. Speed limit
2. Adult crossing guards present during school hours
3. Adult crossing guards present during school hours
4. Through entering volume (daily)
5. Through exiting volume (daily)
6. Right turn entering volume (daily)
7. Left turn entering volume (daily)
8. Right turn exiting volume (daily)
9. Left turn exiting volume (daily)
10. Total Vehicle Volume (daily)
11. Pedestrian volume (daily)
12. Vehicle-pedestrian cross-products (daily, in aggregate, and by movement)

2.4. Statistical Overview of Near-Miss Conflict Trends at School Crossings in Canada

Before examining the potential links between crossing attributes and safety levels, an exploratory statistical overview was performed to identify national level safety trends. This exploratory overview employed the following methods:

- Examination of total conflicts, average number of conflicts, and the dispersion / concentration conflicts across sites
- Examination of the severity distribution of conflicts
- Examination of the prevalence of conflicts involving various vehicle turning paths
- Examination of the distribution of conflicts by hour of day
- Examination of conflict normalization approaches (adjustments for vehicle and pedestrian volumes)

2.5. Exploratory Analysis of Conflicts and Crosswalk Attributes

Conflict data was organized according to various crosswalk attributes to develop exploratory observations. This involved analysis of conflict distribution according to:

- School type (grade levels)
- Speed limit
- Road classification
- Number of lanes
- School Zone Markings
- Zebra Markings
- Traffic control features

The exploratory analysis generated standalone insights as well as guidance for the subsequent regression analysis.

Three types of exposure metrics were used to create normalized conflict rates. First, the basic rate is conflicts per 1000 pedestrians. Second, the cross-product rate is conflicts per 100,000 cross-product, where cross-product is the pedestrian volume multiplied by the vehicle volume, including only those vehicle volumes relevant to a conflict type. Third, the minimum volume rate is the number of conflicts divided by the minimum of either the vehicle or pedestrian volumes for any relevant movements. The cross-product rate was found to provide the best normalization and the rest of the report generally concentrates on this rate.

2.6. Regression Analysis of Links Between School Crossing Attributes on Safety Levels

The final step of the methodology was to construct statistical models which look for links between crossing attributes and safety levels. These links may or may not be causal. The point of this step is to reveal design insights: if some crossing attributes are correlated with lower conflict levels, they should be incorporated in design where possible.

The analysis systematically tested different conflict scopes, exposure definitions, severity treatments, outcome forms, model types, and combinations of site attributes. This broad screening identified candidate models without beginning from a preferred specification.

The results were narrowed using data eligibility, model convergence, fit, coefficient support, and interpretability. Negative binomial regression was selected for the main findings because the conflict counts varied substantially across sites and included many low or zero values. Eligible zero-conflict sites remained in the analysis.

Models were evaluated based on their ability to predict the number of conflicts for a crossing based on that crossing's attributes.

3. Crosswalk Data Overview

The selection of crosswalks was done pragmatically with two objectives. The first objective was to obtain a good cross-section sample of the attributes we hoped to investigate. The second objective was to support cities with the opportunity to get near-miss data on sites that were of interest to them and feasible for them to collect video at. Table 1 below gives an overview of the diverse types of crosswalks examined in this study. The sites were mostly on collector or arterial roads. Just over 70% of the crossings were on roads without a median. On the roads with a median, half had a median refuge consisting of a physically protected place for pedestrians to wait halfway across. Two thirds of the crossings were in a designated school or reduced speed zone. The majority of crossings had zebra pavement markings while about a third had parallel lines, and in most cases the pavement markings were in good condition. In terms of signage,

just over three quarters of the crossings had ground mounted signs at the roadside, while 20% had them in the median. Another 30% had flexible signs on lane lines and one third had overhead signs. Advanced warnings signs were present at 30% of crossings. There was a wide range of intersection control types, but the most common through traffic control was none – meaning that vehicles approaching the crosswalk were not ordinarily required to stop. Adult crossing guards were present in 30% of cases. The sample did not end up including any sites with student patrollers or raised crosswalks, and these attributes therefore cannot be analyzed.

Table 1: Data Overview - Categorical Variables

Attribute	Categories / Values
Location type	Intersection: 30 (100.0%)
Road classification	Collector: 15 (50.0%); Arterial: 14 (46.7%); Local: 1 (3.3%)
Road has a median	Present: 8 (26.7%); Absent: 22 (73.3%)
Median refuge present	Present: 4 (50.0%); Absent: 4 (50.0%)
School zone or reduced speed zone signing	Present: 20 (66.7%); Absent: 10 (33.3%)
Zebra pavement markings	Present: 22 (73.3%); Absent: 8 (26.7%)
Parallel line pavement markings	Present: 9 (30.0%); Absent: 21 (70.0%)
Pavement marking condition	Good: 22 (73.3%); Poor: 8 (26.7%)
Ground-mounted signs on road side	Present: 23 (76.7%); Absent: 7 (23.3%)
Ground-mounted signs in median	Present: 6 (20.0%); Absent: 24 (80.0%)
Flexible signs in center or lane lines	Present: 9 (30.0%); Absent: 21 (70.0%)
Overhead signs	Present: 10 (33.3%); Absent: 20 (66.7%)
Side-mounted flashing lights	Present: 9 (30.0%); Absent: 21 (70.0%)
Overhead flashing lights	Present: 9 (30.0%); Absent: 21 (70.0%)
Crosswalk-ahead warning signs	Present: 9 (30.0%); Absent: 21 (70.0%)
Intersection control type	Minor Road Stop Control: 17 (56.7%); Traffic Signal: 8 (26.7%); Half-Signal: 3 (10.0%); Roundabout: 2 (6.7%)
Through traffic control	none: 20 (66.7%); signal: 8 (26.7%); roundabout: 2 (6.7%)
Curb extension	Present: 3 (10.0%); Absent: 27 (90.0%)
Raised crosswalk	Present: 0 (0.0%); Absent: 30 (100.0%)
School grade levels within 400m	K-8: 7 (23.3%); K-9: 5 (16.7%); K-6: 4 (13.3%); K-12: 4 (13.3%); PreK-6: 3 (10.0%); K-5: 2 (6.7%); JK-8: 2 (6.7%); PP-9: 1 (3.3%); PP-5: 1 (3.3%); PreK-8: 1 (3.3%)
Adult crossing guards present	Present: 9 (30.0%); Absent: 21 (70.0%)
Student patrollers present	Present: 0 (0.0%); Absent: 30 (100.0%)

Table 2 shows an overview of the continuous data elements, including crosswalk attributes with a continuous measurement as well as traffic volume and conflict measurements. Of note from this table are the following points. The crossings cover a variety of road widths from 2 to 6 lanes. The most common speed limit was 30 km/h although we did include crossings with speed limits up to 60 km/h. Traffic volumes were low to moderately high, with total vehicle volumes ranging from 1620 to over 18,000 vehicles per day. The average crosswalk served 377 pedestrians and 7600 vehicles per day.

Table 2: Data Overview - Continuous Variables

Attribute	Mean	Min / Median / Max
Lanes crossed	3.77	2.00 / 4.00 / 6.00
Crosswalk width (m)	16.63	11.00 / 15.50 / 27.00
Median width (m)	2.81	0.50 / 2.00 / 8.00
Speed limit (km/h)	35.33	30.00 / 30.00 / 60.00
Through entering volume (daily)	3389	492 / 1820 / 11,816
Through exiting volume (daily)	3870	505 / 2167 / 9052
Right turn entering volume (daily)	367	1 / 188 / 1348
Left turn entering volume (daily)	411	1 / 147 / 1929
Right turn exiting volume (daily)	420	11 / 178 / 1908
Left turn exiting volume (daily)	441	30 / 220 / 1810
Total vehicle volume (daily)	7614	1620 / 6512 / 18,371
Pedestrian volume (daily)	377	74 / 183 / 1402
Vehicle-pedestrian cross-product exposure	3,387,571	182706 / 1,157,874 / 23,784,930
Average daily conflicts (site-level)	4.49	0.00 / 0.90 / 25.40
Total mapped conflicts (site-level)	22.00	0.00 / 4.50 / 127.00
Cross-product conflict rate per 100k (site-level)	0.1550	0.0000 / 0.1077 / 0.7707
Conflicts per 1,000 pedestrians (site-level)	10.93	0.00 / 6.95 / 47.54

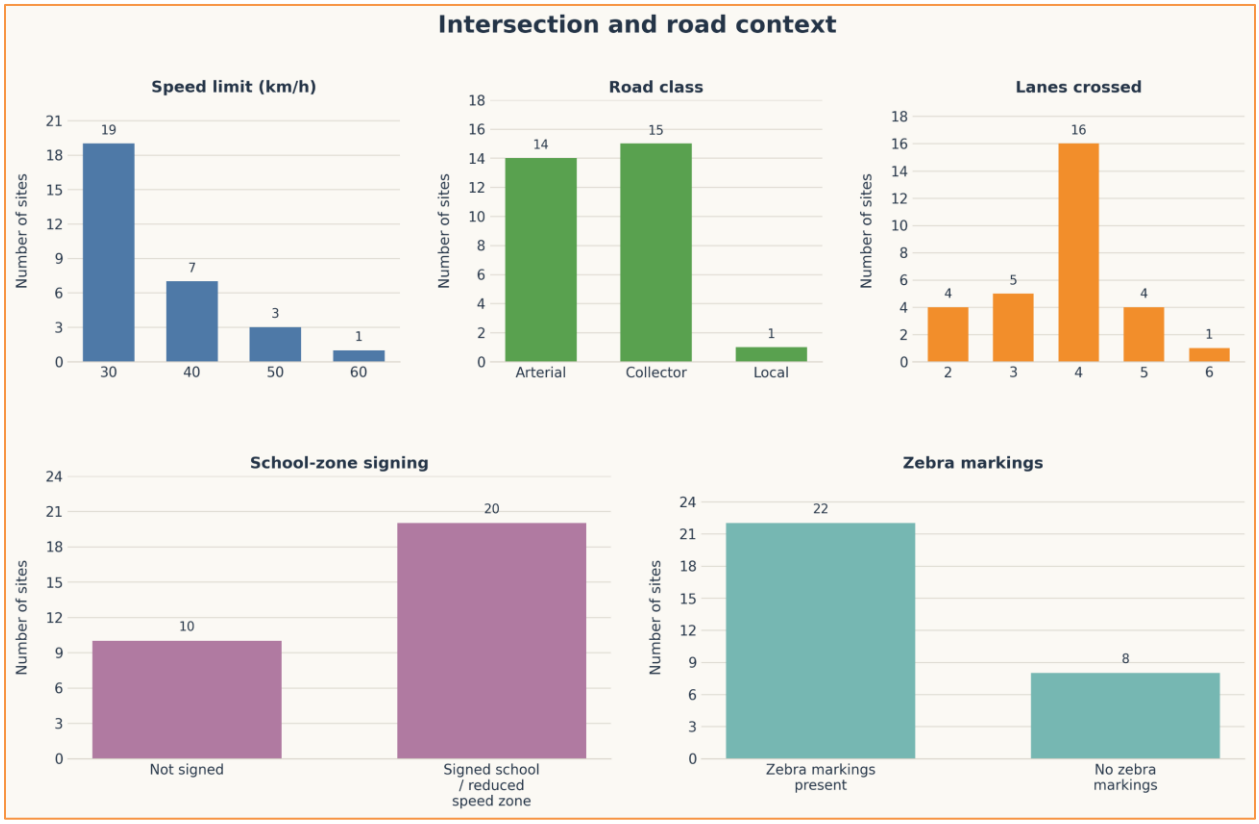


Figure 4: Breakdown of school zone crossings in this study by select attributes

The figure above shows the sampling variability that the study achieved for a selection of attributes and gives an idea of the types of school zone crossings included in this study.

4. Near-Misses at School Zones – National Trends

4.1. Conflict Counts

We measured a total of 660 conflicts at 30 school zone crossings in Canada over an approximately 5-day period. Across the entire study, there was one near-miss conflict per 84 pedestrians.

The average school crossing saw 4.5 conflicts per day and this daily conflict count ranged from a low of zero to a high of 25.4 across the sites.

All conflict data has been shared with the local municipalities.

4.2. Conflict Rates Normalized to Volume

When conflicts per site were normalized to the number of pedestrians using that site, the average site saw 10.9 conflicts per 1000 pedestrians, and this figure ranged from a low of zero to a high of 47.5.

We also normalized conflicts to pedestrian-vehicle cross product. Cross product is the number of pedestrians per day multiplied by the number of vehicles per day, and it is an indication of the number of opportunities for pedestrians and vehicles to interact. Conflicts per 100,000 cross product ranged from a low of zero to a high of 0.77, with an average of 0.155.

4.3. School Grade Levels

We found no clear pattern in conflict frequency or rate between grade levels. Many of the crossings served multiple schools and a wide range of grade levels. There is also significant variability across Canada in typical grade level ranges which made putting schools into a small number of discrete bins difficult.

4.4. Variability Between Crossings

Although the average site saw 4.5 conflicts per day, more than half of the sites saw 1 or fewer conflicts per day while a small handful of sites saw a large number of daily conflicts.

Similarly wide ranges are seen when conflict counts are normalized to either pedestrian count or pedestrian-vehicle cross-product. The highest conflict crosswalk had a conflict rate that was almost 5 times higher than the average conflict rate.

This wide variability, highlighted in in the figure below, suggests that it may be possible to understand why some sites have high numbers of conflicts and why the majority of sites have low numbers. This could support a program of screening and retrofitting high-conflict crosswalks and in turn guide the design of future low conflict crossings.

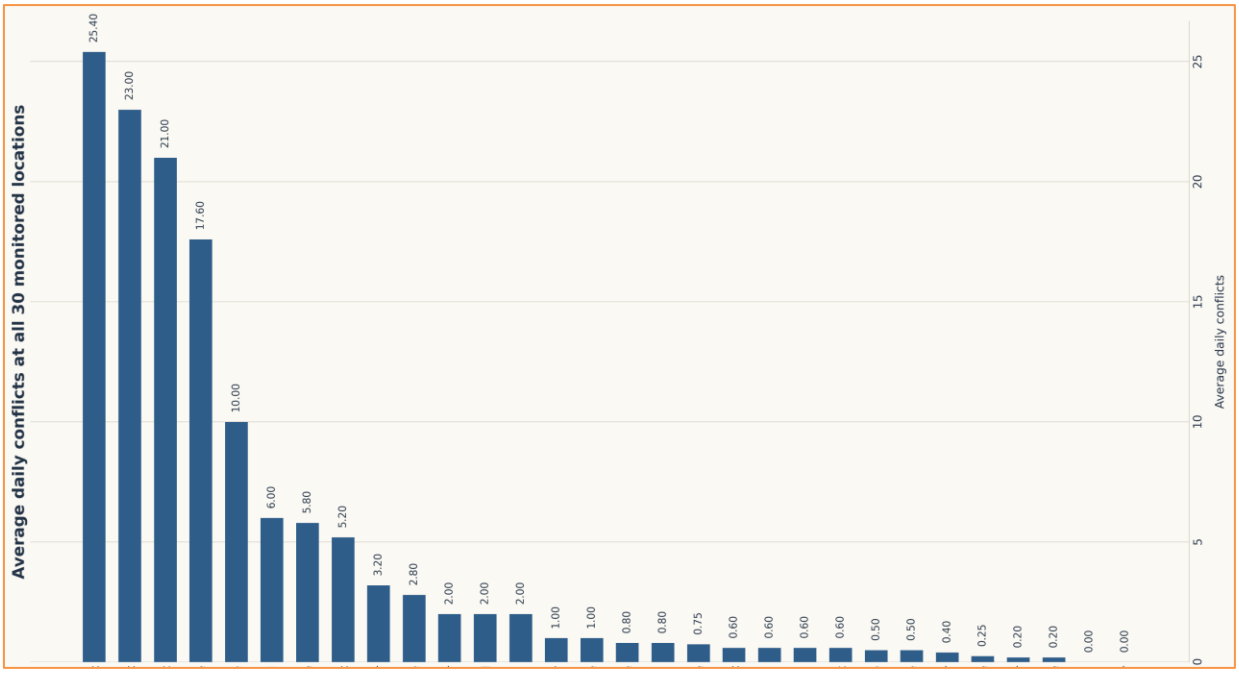


Figure 5: Variability in Conflicts per Day Across 30 School Crossings in CAA School Zone Study

4.5. Conflict Severity Trends

Miovision uses a four-level risk classification system based on a kinetic energy risk model. The large majority of conflicts were observed in the medium risk category, as shown in the figure below. This is related to 30 km/h being the most common speed limit at these crossings during school hours. Although there were a few sites with speed limit at 50 km/h and 60 km/h, the average speed limit was 35.3 km/h. Based on kinetic risk models, the high and critical risk categories are not possible when a 30 km/h speed limit is complied with.

The concentration of conflicts in the medium risk category suggests that efforts over the past few decades to reduce posted speed limits to 30 km/h in school zones have been effective in the prevention of high and critical risk conflicts.

Medium risk conflicts are still significant because if they materialize into a crash, the impact speeds are such that the chance of a serious injury is between 5% and 40%. The glossary at the end of this report provides a definition of the different conflict severity levels as they relate to injury probability.

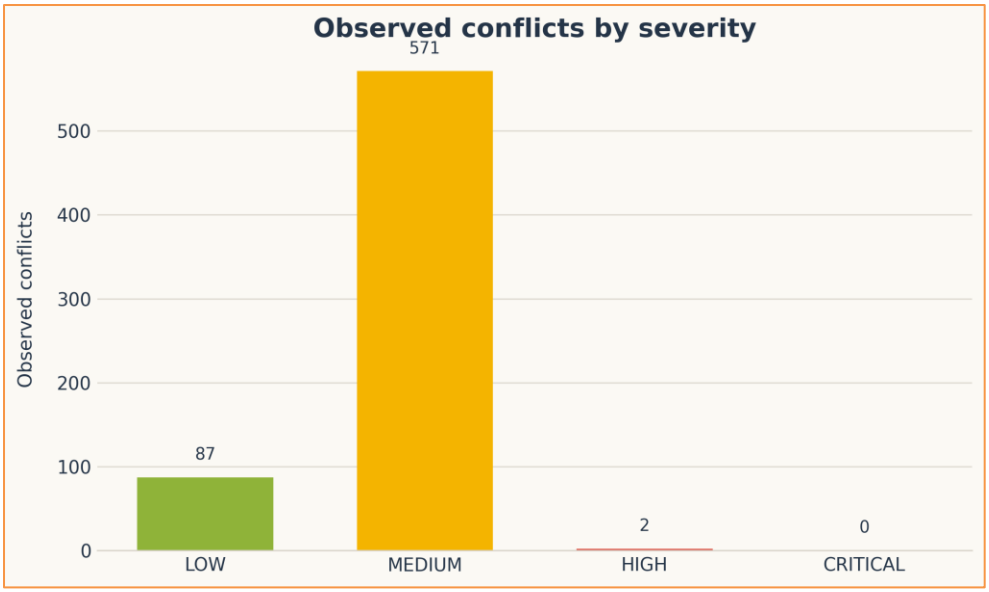


Figure 6: Conflict Severity Distribution

4.6. Conflicts by Time-of-Day

The majority of conflicts took place during the school day, which emphasizes the importance of school crosswalk safety. Interestingly, the 5 to 6 PM hour had the highest single hour total, suggesting that it may be wise to extend the duration of reduced speed zones to accommodate various after school activities that extend into the evening.

The gentle rise during the afternoon period suggests that moderately additional attention needs to be paid to safety during school dismissals. However, the peak at 5 PM is notable for being after the typical school dismissal window. This suggests that pedestrian use of school crossings remains a significant safety issue outside of exact school hours, and this could guide decisions about the time of day during which reduced speed zones apply. Some cities have reduced speed zones during school hours only and others have them in force 24 hours per day.

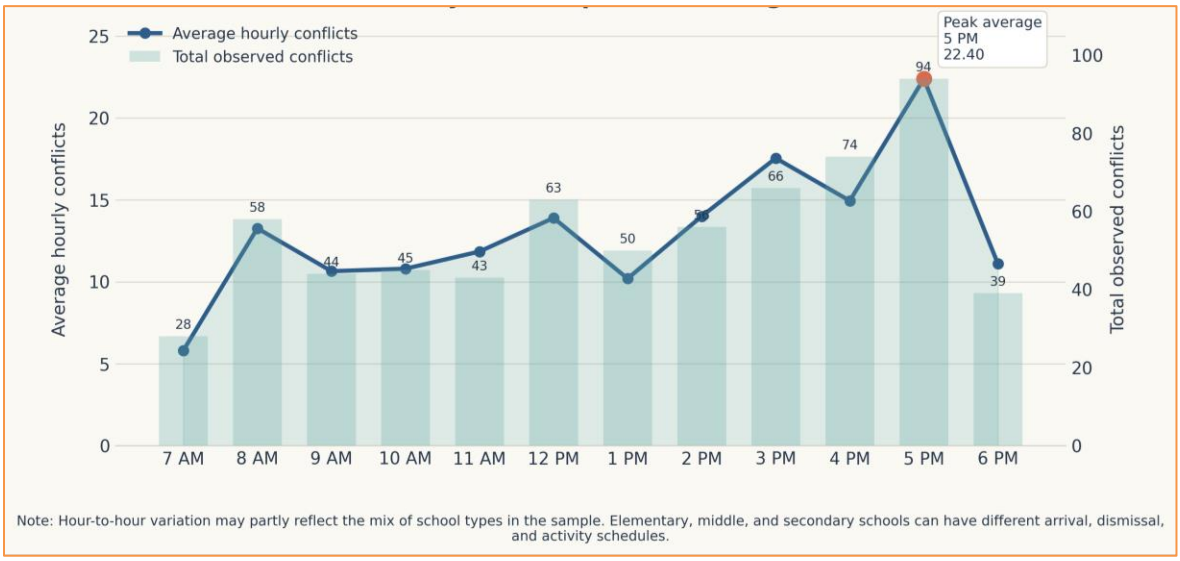


Figure 7: Conflict Time-of-Day Distribution

4.7. Trends in Conflict Configurations and Involved Vehicle Movements

The Table below shows the breakdown of conflicts at school crossings by configuration and involved vehicle movements. Please note that far-side means a conflict with a pedestrian when the vehicle is exiting the intersection, while near-side means the vehicle is entering the intersection.

Table 3: Conflict Configuration Breakdown

Conflict side	Vehicle movement	Observed conflicts	Share of all conflicts
Far-side	Through	215	32.58%
	Right-turn hook	127	19.24%
	Left-turn hook	134	20.30%
Far-side total		476	72.12%
Near-side	Through	151	22.88%
	Right turn	26	3.94%
	Left turn	7	1.06%
Near-side total		184	27.88%
Total		660	100.00%

A conflict is called far-side if it occurs when a vehicle is exiting the intersection. Far-side conflicts accounted for 72.12% of the total conflicts in this study. It may be harder for drivers to see pedestrians across the intersection when they begin their driving movement. Drivers may also be focused on other elements of the intersection first, and the downstream crosswalk as they exit receives less attention. These two reasons may explain why far-side conflicts are 2.6 times more common than near-side conflicts.

In this study, through vehicle movements accounted for just over 55% of the total conflicts, with 32.58% being far-side through and 22.88% being near-side through. Conflicts with right and left turn vehicles were approximately evenly split, accounting for 23.18% and 21.36% of total conflicts respectively. For turning conflicts, the skew towards far-side is more dramatic than the far-side skew overall: turning conflicts were 7.9 times more likely to be far-side than near-side.

4.8. Adult Crossing Guard Presence

In our sample we had 9 sites with adult crossing guards and 21 sites without. We observed an obvious link between guard sites and traffic volumes: guard sites carried about 50% more pedestrians and 60% more vehicles. These sites will naturally be more conflict-prone due to volume alone. The data showed that overall, the 9 guard sites had a cross-product conflict rate of 0.16 per 100,000, moderately higher than the 21 no-guard sites which had a rate of 0.11. However, within the guard sites there were two outlier sites at extremely high volume intersections with very high conflict rates. When these two outlier sites are removed, the remaining 7 guard sites had a conflict rate of 0.086, which is moderately lower than the no-guard sites.

Based on this data we can conclude that cities and schools have been effective in assigning their crossing guards to the higher volume sites with higher conflict potential. However, this non-uniform assignment of crossing guards to sites and the statistical reversal when outliers are removed make it unwise to draw any conclusions about the effectiveness of crossing guards from this cross-sectional study. Because of the observed strong correlation of guard assignment with traffic volume, it would be better to study the effectiveness of adult crossing guards with a before-after study.

5. Influence of Crossing Characteristics on Near-Miss Rates

5.1. Exploratory Analysis

5.1.1. Road Classification

Arterials had higher conflict rates even when adjusted for exposure. The figure below shows a conflict rate for collectors that is 14.7% lower than the rate for arterials, and a rate for residential streets that is 43% lower.

This intuitive finding supports an approach to integrated transport and land use planning that minimizes the need to cross arterials to get to school. When arterials must be crossed, additional care should be applied to enhance the safety of these inherently high-conflict crossings.

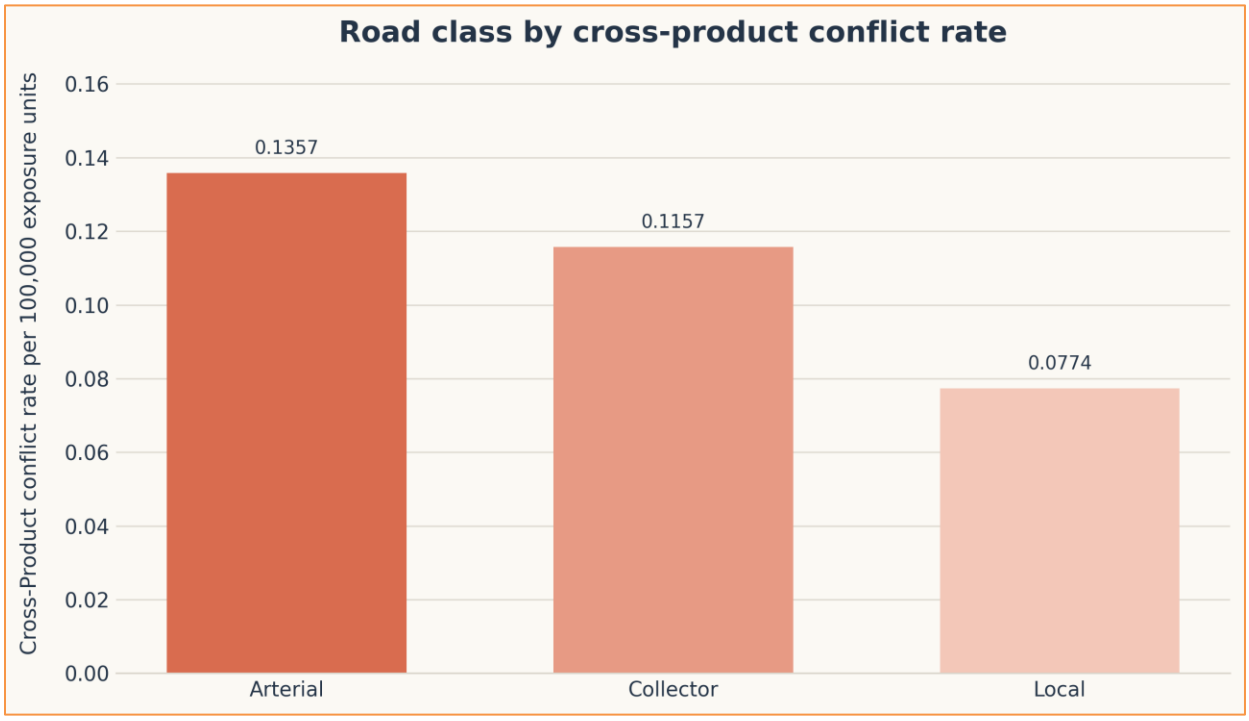


Figure 8: Conflict Rate by Road Classification

5.1.2. School Zone or Reduced Speed Zone Signing

Signs indicating a school zone or reduced speed zone were associated with a much lower conflict rate. The conflict rate at crossings without zone signage is 1.67 times higher than the conflict rate at crossings with zone signage.

This finding suggests that the use of school zone and reduced speed zone signage has a positive effect above and beyond the actual crosswalk signage. This supports continuing and increasing the practice of zone based signage, and potentially supports increasing the size of school zones to include more of the journey to school.

Table 4: Effect of School Zone and Speed Zone Signage on All Conflict Types

School-zone signing	Sites	Average daily conflicts	Cross-product rate per 100,000
Not signed	10	108.80	0.1497
Signed school or reduced-speed zone	20	26.00	0.0899

The impact of zone signage is even more dramatic for hook specific conflicts, which are conflicts with turning vehicles as they exit the intersection. This dramatic impact is shown in the figure below, where the cross-product conflict rate at sites without zone signs is 8.6 times higher than the rate at sites with zone signs.

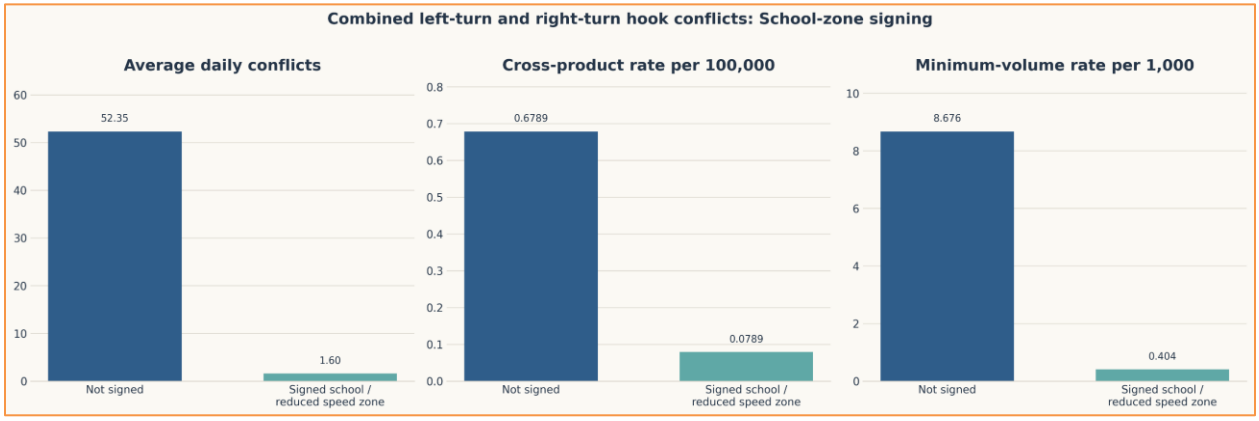


Figure 9: Effect of School Zone or Speed Zone Signs on Hook (turning vehicle exiting) Conflicts

5.1.3. Zebra Markings

The exploratory analysis of zebra markings shows a counterintuitive result when all conflict configurations are considered in aggregate: the cross-product conflict rate at sites with zebra markings was 0.1456 conflicts per 100k cross-product, and it was slightly lower at 0.1163 for sites without zebra markings. This should not be used to conclude that zebra markings increase conflicts, as there may be confounding reasons for this non-intuitive result.

When hook conflicts (conflicts with turning vehicles as they exit the intersection) are considered as a subclass, zebra crossings are associated with a large reduction in conflict rate. The Figure below shows that for hook conflicts, the cross product conflict rate for sites with zebra markings was 56% lower than sites without zebra markings.

Because the evidence is mixed between total conflicts and hook conflicts, this study cannot yet offer any firm conclusions on the effectiveness of zebra markings.

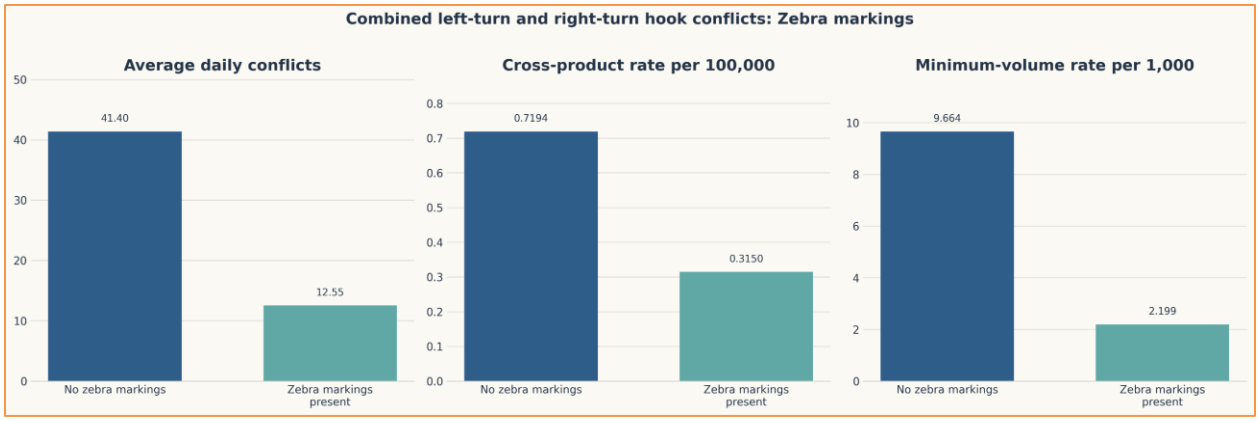


Figure 10: Effect of Zebra Markings on Lef-Turn and Right-Turn Hook Conflicts

5.1.4. Traffic Control

The presence of traffic control applicable to through traffic approaching a crosswalk was found to have a large impact on the conflict rate. When through traffic is ordinarily controlled by a stop sign, traffic signal, or roundabout entry yield requirement, and not just crosswalk signage, the cross-product conflict rates were about 20 times lower than cases where through traffic is not ordinarily controlled beyond crosswalk signage. This suggests that the design of routes to school should favor crossings at locations that have existing traffic control.

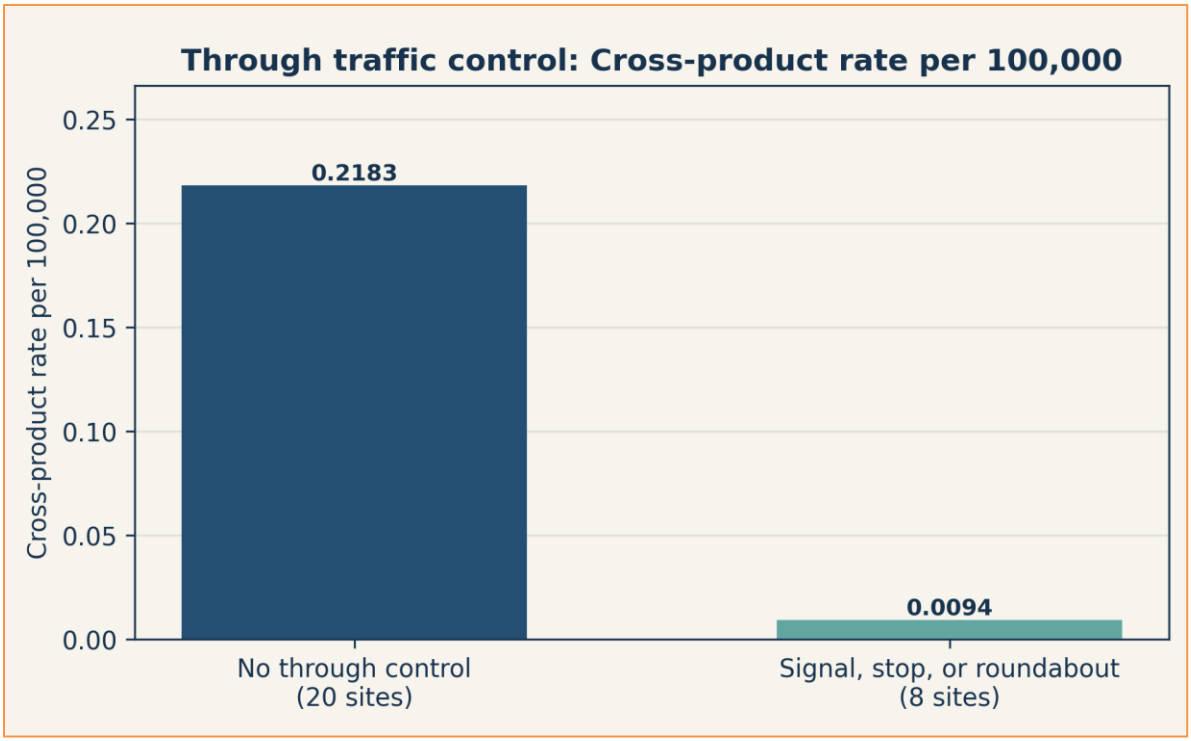


Figure 11: Effect of Through Traffic Control on Conflict Rate

5.2. Regression Analysis

The goal of regression analysis was to determine if we could create equations that predict the number of conflicts at a crossing based on its exposure and crossing attributes.

We found that conflicts can indeed be predicted based on some crosswalk design attributes. Pedestrian and vehicle volume is the most important predictor of the conflict count. In addition, school zone or speed zone signage resulted in lower predicted conflicts, zebra markings resulted in lower predicted conflicts, traffic control for through vehicles resulted in lower predicted conflicts, and crossings on arterials are predicted to have more conflicts.

We found that creating separate models for different movement groups produced models with better predictive power, and we ended up with one model for hook conflicts, one for far-side through conflicts, and one for near-side conflicts.

Note that the regression analysis reports different effect sizes for certain attributes than the exploratory analysis, for two reasons. First, the regression is for subsets of certain conflict types while the exploratory analysis generally considers all conflicts. Second, the exploratory analysis considers the actual observed conflict difference between sites with different individual attribute values, while the regression analysis adjusts this observed difference as the models account for other explanatory variables.

5.2.1. Prediction Model for Hook Conflicts

This model has a very strong fit, achieving a pseudo-R2 value of 0.709. Roughly speaking, this means that the model accurately explains a high proportion of the variability in conflict counts across sites.

The significant variables for predicting hook conflicts are left and right turn cross product exposure, the presence of school zone signing, and the presence of zebra markings. These were all statistically significant at the 95% confidence level.

The prediction model for hook conflicts is as follows:

log(expected average daily hook conflicts) = -12.9349 + 1.1176 × log(LT/RT cross-product exposure) - 1.6433 × school-zone signing - 1.0969 × zebra markings.

The coefficients of the model have the following practical meanings:

- Sites with twice the turning traffic have about twice the number of hook conflicts, if all else is equal.
- Sites with reduced speed zone signs or school zone signs have approximately 81% fewer hook conflicts, when accounting for other model variables.
- Sites with zebra markings have approximately 67% fewer expected hook conflicts, when accounting for other model variables.

A clear implication of this model is that it provides support for using reduced speed zone or school zone signage as well as zebra markings to reduce the number of hook conflicts.

Another useful application of this model is as a type of benchmark. Any school crossing in Canada can now be checked against the prediction of this model: if the actual hook conflicts are substantially higher than what the model predicts, it would suggest that there is a unique problem at that site which could be amenable to treatment and improvement.

5.2.2. Prediction Model for Far-Side Through Conflicts

This model has an even stronger fit, achieving a pseudo-R2 value of 0.7806. It also explains a high proportion of the variability in conflict counts across sites.

The significant variables for predicting far-side through conflicts are through exposure, through traffic control, number of lanes crossed, and road classification. These were all statistically significant at the 95% confidence level.

The prediction model for far-side through conflicts is as follows:

log(expected average daily far-side THRU conflicts) = -13.5396 + 0.6462 × log(THRU cross-product exposure) + 3.2317 × no through traffic control - 0.4386 × (lanes crossed - 4) + 2.7389 × arterial road

The coefficients of the model have the following practical meanings:

- Through conflicts are less responsive to through vehicle volume than hook conflicts are to turning vehicle volume: a site with twice the through volume would be expected by this model to have only 1.6 times the number of far-side through conflicts.
- Sites without traffic control had 25 times as many far-side through conflicts.
- Each additional lane crossed was associated with 36% fewer far side through conflicts, when accounting for other model variables. This counterintuitive result should be interpreted with caution and may be a result of correlation with other explanatory variables.
- Arterial roads are predicted by the model to have 15 times as many far-side through conflicts as non-arterial roads, when accounting for other variables.

The design implications are consistent with what was mentioned in the exploratory data analysis results: crossings of arterials should be avoided or treated with extra caution, and safe routes to school planning should emphasize routing crossings to sites where traffic control results in the ordinary stoppage of vehicles.

This model can also provide a benchmark for screening new sites to determine if the conflict rates are abnormally high and should be prioritized for improvements.

5.2.3. Prediction Model for Near-Side Through and Turning Conflicts

We did not obtain a good fit for near-side models. The best pseudo-R2 value for near-side through conflicts was 0.237 and for all near-side (including turning) was 0.258. This means that the models explain a low proportion of the variability in near-side conflicts.

Furthermore, these models retained only exposure as a significant explanatory variable, and no other variables were statistically significant for near-side conflicts, and they give no insights to which crosswalk attributes affect safety.

Based on these predictive models, we cannot draw out any design implications or provide a network screening benchmark specifically for near-side conflicts like we can for hook conflicts and far-side through conflicts. It is possible that increasing the number of sites in a future version of this research could offer more insightful conclusions on near-side conflicts.

5.2.4. Modelling Limitations and Disclaimers

These are preliminary predictive models for school zone crosswalk conflicts. They represent pioneering work in this field, but they should be thought of as providing exploratory insights that are open to confirmation or refinement. The sample size of 30 locations is a good starting point for generating exploratory insights, but a much larger sample size could eventually provide more definitive modelling results. Furthermore, due to the fairly modest sample size, no out of sample testing was done to assess the predictive accuracy of the models on crosswalks that were not used to create the models. For now, the high pseudo r^2 indicating good model fit can be taken as an early proxy that model accuracy may be favourable, and a future larger study should include model testing samples carved out from the model estimation sample.

6. Conclusion and Study Recommendations

This cross-Canada video-based study of 30 school zone pedestrian crossings commissioned by CAA generated several new and interesting insights which have implications for how school crossings should be designed, managed, and rehabilitated in the future.

The study provided information on the typical frequency of vehicle-pedestrian conflicts, showing that 1 in 84 pedestrians is involved in a near-miss at school zone crosswalks. Thankfully, most of these near-misses are in the medium risk category or lower, because most school zone crossings in this study have modified speed limits of 30 km/h. This study thus provided a glimpse into the payoff from the last few decades of reducing speed limits in school zones.

The study showed what types of conflicts were most common, revealing that far side conflicts with vehicles exiting the intersection were more common than near-side conflicts. This finding was especially strong for turning vehicles.

The study also showed that some school crossings have many more conflicts than others, and this is true in absolute terms as well as when adjusting for exposure rates. The safer crosswalks in this study were those that had some form of ordinary traffic control requiring vehicles to stop, those that were located in signed designated school zones or reduced speed zones, and those that were not on arterial streets. For turning hook conflicts in particular, zebra markings were associated with dramatically lower conflict rates.

Some of these associations between crosswalk attributes and safety were quantified in the form of conflict prediction models for school zone pedestrian crossings, which is a first for North America using modern video analytics technology. These conflict prediction models can serve as preliminary screening benchmarks for detecting abnormally unsafe crossings, and they can serve as interactive design aides leading to safety school zone crossings in the future.

Key recommendations from this study include the following:

- Continue implementing reduced speed school zones, and consider expanding their geographic coverage or time of day applicability.
- Plan routes to school so that pedestrians cross at locations with existing traffic control.
- Plan routes to school that avoid crossings of arterials, and when crossing of arterials is absolutely required, it should be at well-designed locations, ideally with traffic control.
- Expand the use of signage to mark school and reduced speed zones, given its association with lower conflict rates.
- Expand the use of zebra pavement markings because of their association with lower conflict levels for exiting turning vehicles.

- Consider a larger study in the future to strengthen the possibility of moving towards predictive based design with a model that is sensitive to more crosswalk atttributes

The authors would like to thank CAA for their support of this study, Edlyn Sottie for assistance with attribute data collection, and all of the participating cities for their efforts in selecting the sites and collecting video.

7. Glossary

- **Cross-Product:** the result of multiplying two traffic volumes such as vehicle through volume and pedestrian crossing volume; typically used as a risk exposure metric.
- **Far-side / Near-side conflicts:** Far-side means a conflict with a pedestrian when the vehicle is exiting the intersection, while near-side means the vehicle is entering the intersection.
- **Hook conflict:** a conflict between a turning vehicle and a pedestrian when the turning vehicle is exiting the intersection.
- **Near-miss / conflict:** an event where two road users passed the same point with only a short-time interval in between them, and if they had crashed, there would be a material probability of serious injury
- **Regression Analysis:** a statistical modelling technique for measuring if a set of data can predict an outcome of interest.
- **Road Classes**
  - **Collector road:** A road that gathers traffic from local streets and connects it to arterial roads, balancing access to properties with moving traffic.
  - **Arterial road:** A major road designed primarily to move larger volumes of traffic between areas, generally with fewer driveways and access points.
  - **Local road:** A road designed primarily to provide direct access to homes, businesses, and other properties, typically carrying lower volumes of traffic at lower speeds.
- **Severity levels**
  - **Critical risk conflict**: if the crash occurred, the chance of serious injury would be between 84% and 100%, based on the speeds, angles, and vulnerability levels of involved parties.
  - **High risk conflict:** if the crash occurred, the chance of serious injury would be between 40% and 84%, based on the speeds, angles, and vulnerability levels of involved parties.
  - **Medium risk conflict:** if the crash occurred, the chance of serious injury would be between 5% and 40%, based on the speeds, angles, and vulnerability levels of involved parties.
  - **Low risk conflict**: if the crash occurred, the chance of serious injury would be below 5%, based on the speeds, angles, and vulnerability levels of involved parties.