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Walking And Automobile Traffic Near Schools: Data To Support An Evaluation Of School Pedestrian Safety Programs

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Abstract
Pedestrian accidents among children are an important transportation issue. Several recent policy initiatives have focused on reducing childhood pedestrian accident in the United States, yet those efforts exist within a context of limited and often insufficient data. This paper describes new data that can give much more detailed information on the determinants of pedestrian safety near schools. The data were developed to support an ongoing evaluation of a major childhood pedestrian safety program – the California Safe Routes to School construction program.

BACKGROUND

Pedestrian accidents account for a disproportionately large share of fatal traffic accidents, and children are disproportionately vulnerable to pedestrian accidents. For example, in California, 20% of all fatal traffic accidents in 1999 involved a pedestrian – a share that was higher in urban counties, with 30 percent of all 1999 traffic fatalities in Los Angeles County involving pedestrian accidents, and 54 percent of traffic fatalities in San Francisco County involving pedestrian accidents in traffic (1).

In California, injuries to pedestrians and bicyclists account from more than 60% of transportation-related injury hospitalization/death for each one-year age group from 5 to 12 years (2). Pedestrian and bicycle injuries in traffic are the third leading cause of death among children 5-14 years of age (3).

Available evidence suggests that much walking, and many pedestrian accidents, occur near schools. A study in Great Britain found that 39% of pedestrian casualties among children ages 10 to 16 occurred on the trip to or from school (4). In response to a perceived pedestrian safety problem near schools, the State of California passed legislation in 1999 creating the Safe Routes to School construction program. The program, which as currently authorized will last through 2004, has so far allocated $44 million to projects designed to improve pedestrian safety near schools.

LITERATURE

A number of studies have examined the influence of environmental variables on the risk of pedestrian injury (5,6,7,8). Speed is an important risk factor for injury and an important determinant of injury severity (9). Poor visibility is also a risk factor, as demonstrated by the association of pedestrian injuries among children with the presence of parked cars (7). On the other hand, education of child pedestrians does not appear to be effective (10).

Past research on pedestrian accidents has often been limited by data. For example, many studies that examine pedestrian accidents do not have information on the amount of walking, making it difficult to develop an accident rate or similar measure that compares the frequency of walking activity. For pedestrian safety problems near schools, the most common way around this problem is to collect original data by surveying schoolchildren or parents of schoolchildren.

A study by Roberts, et. al. (11) provides an example of using original data to compare childhood pedestrian accidents to a measure of "exposure," or childhood walking. The authors surveyed 13,423 parents of children in six cities in Australia, New Zealand, and North America, and Sweden to get insight into the relationship between walking and childhood pedestrian accident rates. The authors developed measures of the fraction of children in each city who walked to or from school, and the number of streets crossed while walking to or from school. The results suggest that the low childhood pedestrian accident rates in Sweden are not explained by lower rates of childhood walking in Sweden, leading the authors to hypothesize that factors related to the urban environment in Sweden might contribute to higher childhood pedestrian safety.

In other research, Roberts and co-authors examined the correlates of childhood pedestrian accidents in traffic (12). They found that streets with traffic volumes greater than 750 vehicles per hour were associated a 14-fold increase in the risk of childhood pedestrian accidents compared to streets with traffic volumes less than 250 vehicles per hour, and that traffic speeds in excess of 50 kilometers per hour were associated with 1.26 times the risk of childhood pedestrian accidents when compared with streets with travel speeds less than 40 kilometers per hour.

The results from papers such as Roberts et al. (12) and Roberts et al. (11) highlight the need for two types of data – data on traffic patterns and data on walking activity near schools. In this paper, we describe the special character of traffic and walking near schools, and we describe new data that can illuminate pedestrian safety issues near school sites.

DATA AVAILABILITY

For programs like California's SR2S that focus on school sites, the data needs are especially challenging. These programs require data on traffic volumes and speeds and information on the frequency of walking near schools.

Traffic patterns near neighborhood schools are often under-documented when compared with what is required for an analysis of pedestrian safety. School neighborhoods typically have prominent but short-lived peak traffic flows. Many schools are in residential neighborhoods on low-traffic streets, but during the periods immediately before and after the beginning and end of the school day, streets near these schools experience much higher traffic levels as caregivers use these roads to drop off and pick up children. Similarly, pedestrian activity near schools also typically has pronounced but short-duration peaks when classes begin and end.

Because many roads near schools are on residential streets, loop detector traffic information is typically not available for those roads. Also important, traffic characteristics during the before-school and after-school "peak" periods are necessary. Measures of traffic flow or speed averaged over an entire day can be deceptive when used to characterize the context for trips to or from school. Traffic flows near schools include congestion and the possibility of many pedestrian-automobile conflicts both on public roads and on school properties such as parking lots. Data on public streets might not characterize the full character of pedestrian safety problems near a school. Because many schools in California accommodate more students than the designed capacity, traffic problems can be exacerbated by factors such as congested parking lots.

THE CALIFORNIA SAFE ROUTES TO SCHOOLS PROGRAM AND EVALUATION

The California The SR2S program has so far provided $44 million to municipal governments in California for street, sidewalk, and planning improvements to increase walking and bicycling activity and safety among children. In the Fall of 2000, the California Department of Transportation (Caltrans) funded the first cycle of SR2S projects – 85 projects in 73 municipalities. In the second cycle, 101 projects were funded. Data on both first and second cycle projects are available on the web (13).

Projects awarded in the first cycle represent a spectrum of neighborhood design changes, including the installation of sidewalks and curb ramps, the inclusion of pedestrian signals and crosswalks at signalized intersections, and the installation of traffic calming measures such as traffic circles and speed humps. Of the 85 first cycle projects, several serve multiple schools, and several projects include more than one type of construction improvement. When accounting for both multiple school sites and multiple construction improvements, the distribution of funded first cycle work types is shown in Table 1, below.

To evaluate the effectiveness of different SR2S work types, the authors have begun a study of traffic and pedestrian characteristics near a sample of SR2S schools before and after SR2S project construction. Data on traffic characteristics are currently available for five SR2S schools, and they illuminate the unique nature of both automobile and walking travel near schools. The methods for collecting the data, and the data, are described below.

METHODS

Traffic data were collected at each school location by a team of four observers. Observations were made at intersections selected to demonstrate the effect of funded SR2S projects that had not yet been constructed. One observer recorded child and adult pedestrians and bicyclists. Groups traveling together were noted, as well as the streets crossed by each individual or group. Pedestrians and bicyclists were counted if they crossed at the intersection, passed adjacent to the intersection, or crossed midblock on a single pre-selected segment.

A second observer counted vehicles entering the intersection from one direction, or if volume was low, from two directions. The number of vehicles turning right and left from each direction was also recorded.

Vehicle traffic speeds were calculated by timing cars driving along a street segment. A segment that began and ended at least 50 feet from any intersection with a total length of at least 200 feet long was measured with a measuring wheel. The third observer used a stopwatch to measure the time to travel the measured segment, and recorded the times by hand. As soon as travel time was recorded, another vehicle was identified, timed and recorded. This method allowed the measurement of average travel times over the segment even when traffic was heavily congested.

A fourth observer recorded yielding behavior of drivers, pedestrians, and bicyclists, but those data are not presented here.

All observers recorded two-minute intervals in the raw data, and the data were summarized over these intervals. The data were graphed using these two-minute intervals and a cubic polynomial fit to the two-minute data is shown to illustrate trends over the observation period.

The census tract in which each school was located was identified from census maps. The median annual household income was determined from the 1990 Census. The ethnic distribution of the students at each school was obtained from data included by each school in their application for SR2S funding.

SUMMARY OF TRAFFIC AND PEDESTRIAN TRAVEL CHARACTERISTICS NEAR THE SCHOOLS

The counts of child pedestrians and bicyclists and of vehicles and the mean vehicle speeds for two-minute increments are shown in Figures 1 through 10.

Sheldon Elementary is located on May Road, a two-lane collector, one block from San Pablo Dam Road, a 4-lane arterial road without sidewalks, in an unincorporated area of Contra Costa County. Measurements were made at the signalized intersection where May Road ends at San Pablo Dam Road. No other streets proceed north from San Pablo Dam Road in the vicinity of May Road, and all students who walk to Sheldon Elementary from the San Pablo Dam Road or further south pass this intersection. The median annual household income of the census tract was $39,000. Eighteen percent of the students were Asian or Pacific Islander, 25% were African-American, 21% were Hispanic, and 36% were non-Hispanic White.

Traffic assessments for Sheldon Elementary are shown in Figures 1 and 2. The vehicle counts and speeds are for the four-lane arterial. Child pedestrian and bicyclist counts were lower and vehicle counts and speeds were higher than at most of the other locations. Pedestrian crossing of San Pablo Dam Road is facilitated by the traffic signal, which has a pedestrian phase. The small number of child pedestrians at this intersection before and after school hours do no appear to have any effect on vehicle speed or volume.

Cesar Chavez School is in a densely populated city in the inner suburban ring of Los Angeles County. The streets form a conventional urban grid. Measurements were made adjacent to the school at the intersection of two collectors. The intersection is controlled by 4-way stop signs, and a crossing guard is present before and after school. A high school is located two blocks from the site. The median annual household income of the census tract is $23,000 and 98% of the students are Hispanic.

This site had the highest pedestrian and bicyclist counts (Figures 3 and 4). Some students crossed midblock to and from vehicles on the opposite side of the street. Pedestrians ranged from elementary to high school age, with more high school students present in the afternoon. Dips in vehicle speed indicate some congestion due to vehicular and pedestrian traffic near the beginning and end of school (see Figures 3 and 4).

Jasper Elementary is located on Jasper Street three blocks south of Nineteenth Street in a San Bernardino County suburb. Jasper Street is a two-lane collector and Nineteenth Street is a four-lane arterial with left-turn pockets. There are no traffic controls at this intersection and for more than one-quarter mile to the east and west. Before and after school, students cross Nineteenth Street with the aid of a crossing guard. The median annual household income of the census tract was $50,000. Eleven percent of the students are American Indian, 3% are Asian or Pacific Islander, 21% are Hispanic. 2% are African-American, and 63% are non-Hispanic white.

The traffic assessments for Jasper are shown in Figures 5 and 6. The vehicle counts shown are for the four-lane arterial. Although the vehicle counts were lower than for the four-lane arterial at Sheldon Elementary (Figure 1), speeds were high for a pedestrian crossing. There was no congestion at this location.

West Randall Elementary is located in a low-density residential area in an unincorporated portion of San Bernardino County. Lime Street ends at Randall Street adjacent to the school site. At this intersection Lime Street has a stop sign and there are no traffic controls on Randall Street. This intersection has the only marked crosswalk of Randall adjacent to the school site and there is a crossing guard present before and after school. The vehicular volumes and speeds were measured on Randall Street. The median annual household income of the census tract was $25,000. Two percent of the students are Asian or Pacific Islander, 69% are Hispanic, 9% are African-American, and 20% are non-Hispanic white.

This site had the most marked congestion of the five schools (Figures 7 and 8). Both pedestrian and vehicular volumes were large. Speeds dipped notably around the beginning and end of school. In the afternoon there were four successive speed measurements of less than 2 miles/hour. The measurements were made during a period of extreme congestion with vehicles double-parking and students entering cars in lanes of travel. Many students crossed midblock to and from vehicles on the opposite side of the street. Speeds were below 20 miles/hour for about 30 minutes in the morning and in the afternoon. The high pedestrian and vehicular volumes and the chaotic traffic flow present many opportunities for conflict between vehicles and pedestrians.

La Gloria Elementary is located in Gonzales, a small town in Monterey County. The school is located on Elko Street. A middle school is adjacent to the elementary school and there is pedestrian access to a high school one block away. Traffic was observed at the intersection of two two-lane collectors, Elko and Fourth Street. The median annual household income of the census tract was $26,000 and 92% of the students are Hispanic.

The traffic assessments for La Gloria Elementary School are shown in Figures 9 and 10. Pedestrian, bicyclist and vehicular counts were extremely low away from the time of school opening or closing. Traffic increased markedly and speeds dropped below 15 miles/hour around the time of school opening and closing. As at Jasper Elementary, congestion lasted for less than thirty minutes twice a day. In the afternoon, vehicle counts were lower and speeds were higher at La Gloria than at Jasper Elementary School.

DISCUSSION

The most striking characteristic of the vehicle counts, vehicle speeds, and pedestrian counts is the variation over time (at each school site) and across schools. Every school showed a peak in vehicle counts during at least one of the morning or afternoon observation periods, and while less striking, vehicle speeds also often displayed a "u-shape" indicating congestion during the period around the beginning or end of school. West Randall and La Gloria Elementary Schools showed some of the most dramatic peaks, with traffic, in the case of West Randall, going from a peak of 450 vehicles per hour at 8:15 a.m. to fewer than 100 vehicles per hour by 8:40 a.m.

Variations across schools are also dramatic. In Table 2, we summarize the peak vehicles per hour, the range of observed vehicle speeds, and an approximate number of pedestrians per hour based on pedestrians counted during the observation period. All of these are based on the smoothed data, displayed in the cubic curves shown on Figures 1-10. For comparison, recall that Roberts, et al. (12) found that the risk of pedestrian accidents is 14 times higher along streets with traffic levels that exceed 750 vehicles per hour (when compared with streets with traffic levels below 250 vehicles per hour). These authors also found that the risk of accidents increased with traffic speeds over 40 kilometers per hour. Based on those findings, we classified schools as "safe" or "unsafe", with "unsafe" schools having the following two characteristics: (1) peak vehicle volumes in excess of 750 vehicles per hour during at least one of the morning or afternoon observation periods, and (2) a full range of observed traffic speeds above 40 kilometers per hour for both the morning and afternoon observation periods. Based on Roberts et al. (12), these schools are at increased risk for pedestrian accidents compared with schools with lower traffic volumes and speeds.

Note that we do not mean to imply that the school sites labeled "unsafe" are actually less safe. Improved traffic control or various other measures might countervail the risk posed to pedestrians by vehicle traffic volumes and speeds at these schools. Instead, we use this classification simply to note which schools have traffic characteristics that have been found to correlate with a higher risk of pedestrian accidents in previous studies. Table 2 also shows the approximate number of pedestrians per hour, based on extrapolating the average number of pedestrians observed to a one-hour period.

Two schools, Sheldon and Jasper, have unsafe walking environments based on the traffic characteristics identified in Roberts et al. (12), as described above. In the morning, traffic flows peak at 1200 vehicles per hour at the measurement site for Sheldon Elementary, and 900 vehicles per hour for Jasper Elementary. Vehicle speeds near both schools were in excess of 40 kilometers per hour in both the morning and afternoon. The other three schools, Cesar Chavez, West Randall, and La Gloria, have traffic volumes that peak below 750 vehicles per hour, and the peak for all three schools only exceeds 450 vehicles per hour for the afternoon observation at Cesar Chavez. Vehicle speeds at the measurement sites at all three schools include lower bounds that were below 40 kilometers per hour.

There is a striking difference in pedestrian volumes observed at the five school sites. The two schools with vehicle traffic associated with unsafe walking environments had few pedestrians – approximately 75 pedestrians per hour at Sheldon and approximately 30 pedestrians per hour at Jasper. The observations at the three schools with vehicle traffic characteristics consistent with safer walking environments had pedestrian counts ranging from 150 to 600 per hour. This suggests the possibility that the traffic environment is an important determinant of walking activity near schools, although statistical verification of that hypothesis will have to wait until data at more school sites is collected.

More generally, the data needed to evaluate the link between traffic characteristics and pedestrian activity near schools, while not available in conventional data sources, can be collected in a manner similar to what is described in this study. Such data, which focus on the time-trend of vehicle counts, vehicle speeds, and pedestrian counts during the period around the beginning and end of the school day, are well suited to illuminate walking safety issues. As pedestrian safety receives more attention, the development of these and similar data collection techniques will assist transportation officials in assessing and improving the safety of the walking environment near schools.

ACKNOWLEDGEMENTS

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List of tables and figures

TABLE 1 Cycle 1 SR2S Projects By Work Type

Work Type	Number of Projects
Sidewalk improvements	47
Traffic calming & speed reduction	8
Pedestrian/bicycle crossing	20
Bicycle facilities	13
On-street	6
Off-street	7
Traffic control devices	23
Traffic diversion improvements	3

Source: Authors tabulation of data on SR2S project work type.
Note: Some projects apply to more than one school.

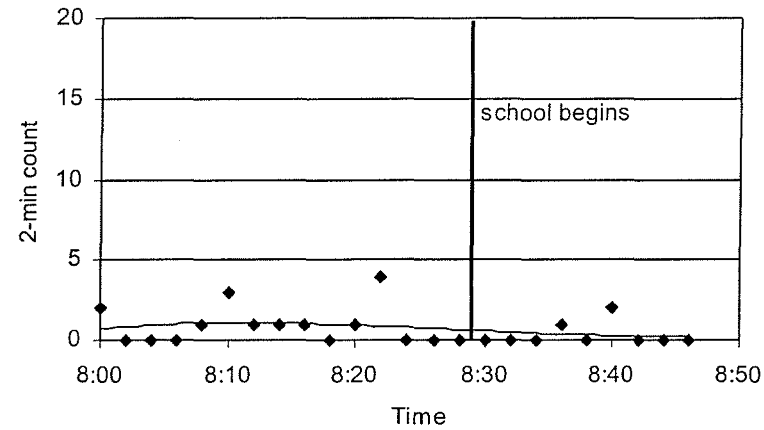
TABLE 2 Summary Of Vehicle And Pedestrian Traffic Near Study Sites

	peak vehicles/per hour (smoothed)	vehicle speed[i] (range, in km/h)	pedestrians per hour (approximate pedestrians per hour)
Sheldon Elementary unsafe/low walking			
am	1200	64-85	75
pm	750	48-64	75
Cesar Chavez Elem safe/high walking			
am	450	32-40	300
pm	600	32-48	600
Jasper Elementary unsafe/low walking			
am	900	56-72	30
pm	450	64-80	30
West Randall Elem. safe/high walking			
am	450	16-48	300
pm	450	16-48	150
La Gloria Elementary safe/high walking			
am	450	16-48	300
pm	450	16-48	150

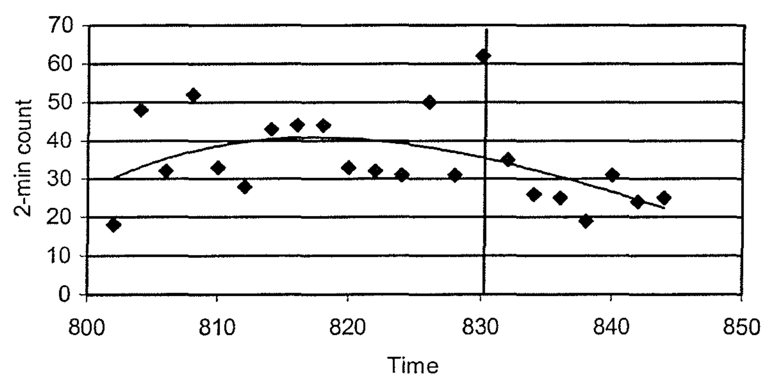
i. Speed ranges, in miles per hour, are (with a.m. speeds first) 40-50 and 30-40 mph at Sheldon Elementary, 20-25 and 20-30 mph at Cesar Chavez Elementary, 35-45 and 40-50 mph at Jasper Elementary, and 10-30 mph in both the a.m. and p.m. periods at both West Randall and La Gloria Elementary Schools.

Figure 1: Sheldon Elementary (before school)

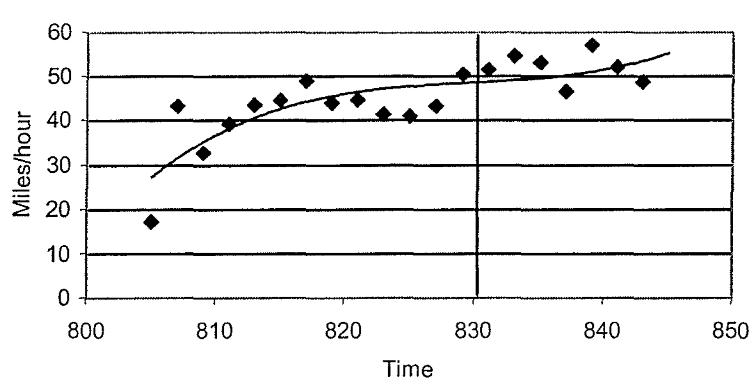
a. 2-minute child pedestrian & bicyclist counts



b. 2-minute vehicle counts

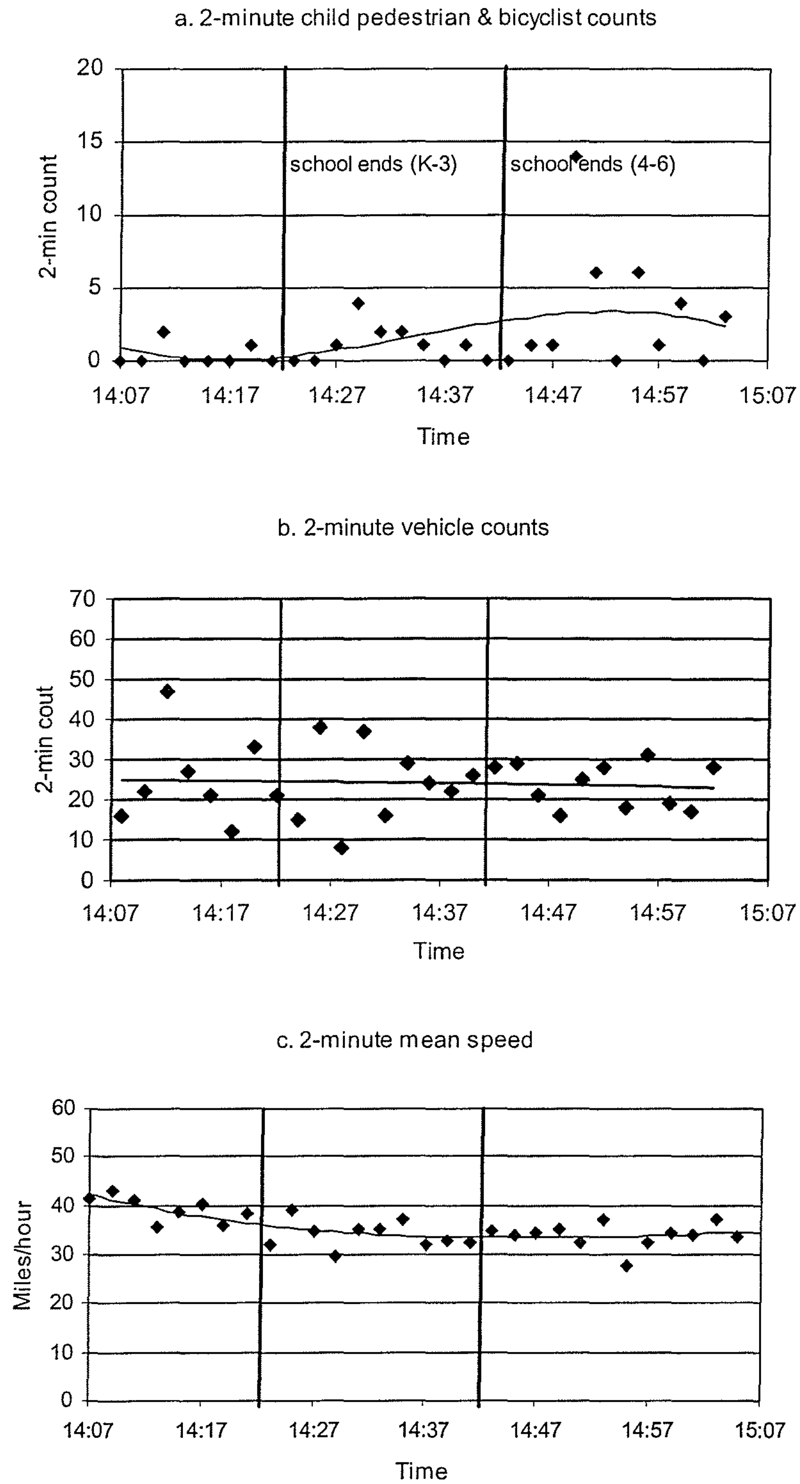


c. 2-minute mean speed



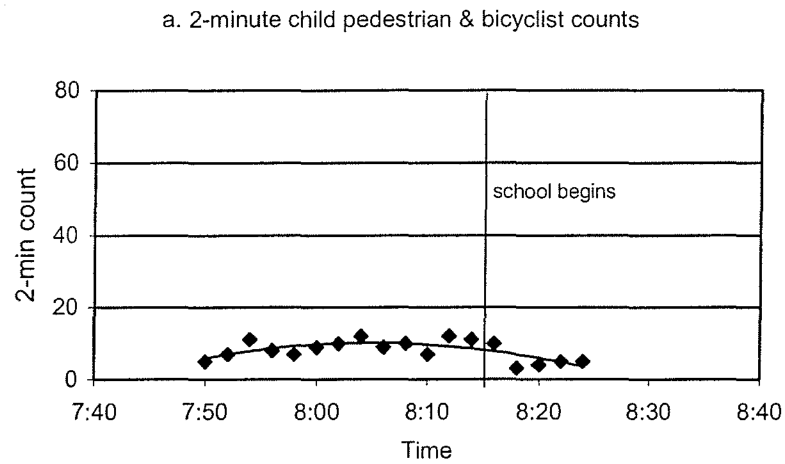
Traffic characteristics at Sheldon Elementary School before school. a. child pedestrian and bicyclist counts; b. vehicle counts; and c. mean speed.

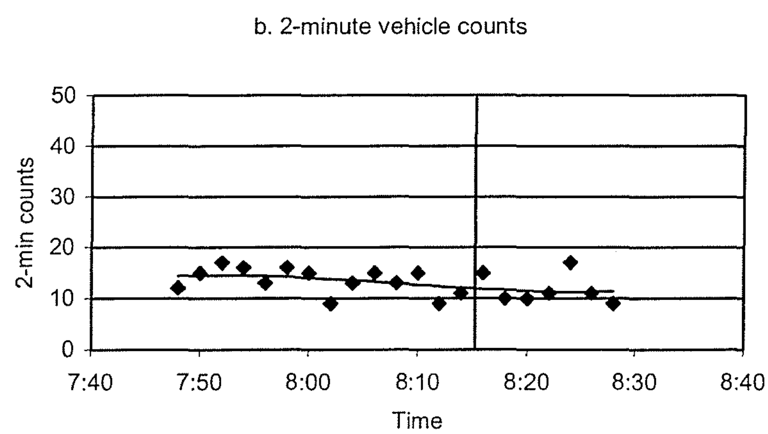
Figure 2: Sheldon Elementary (after school)

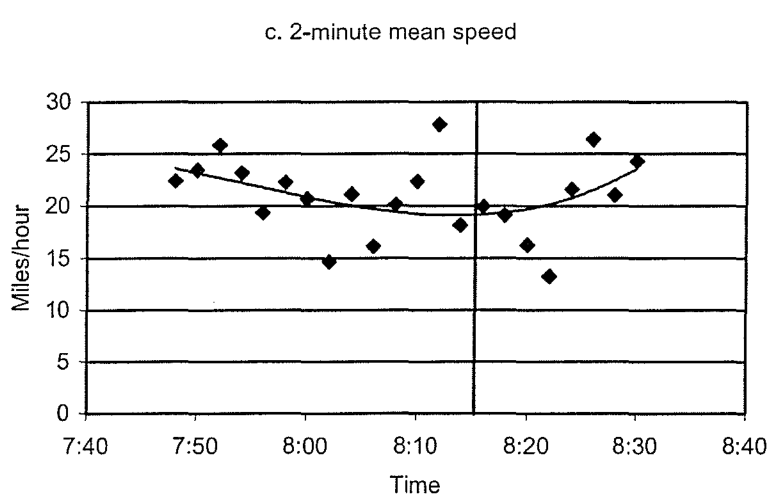


Traffic characteristics at Sheldon Elementary School after school. a. child pedestrian and bicyclist counts; b. vehicle counts; and c. mean speed.

Figure 3: Cesar Chavez Elementary (before school)

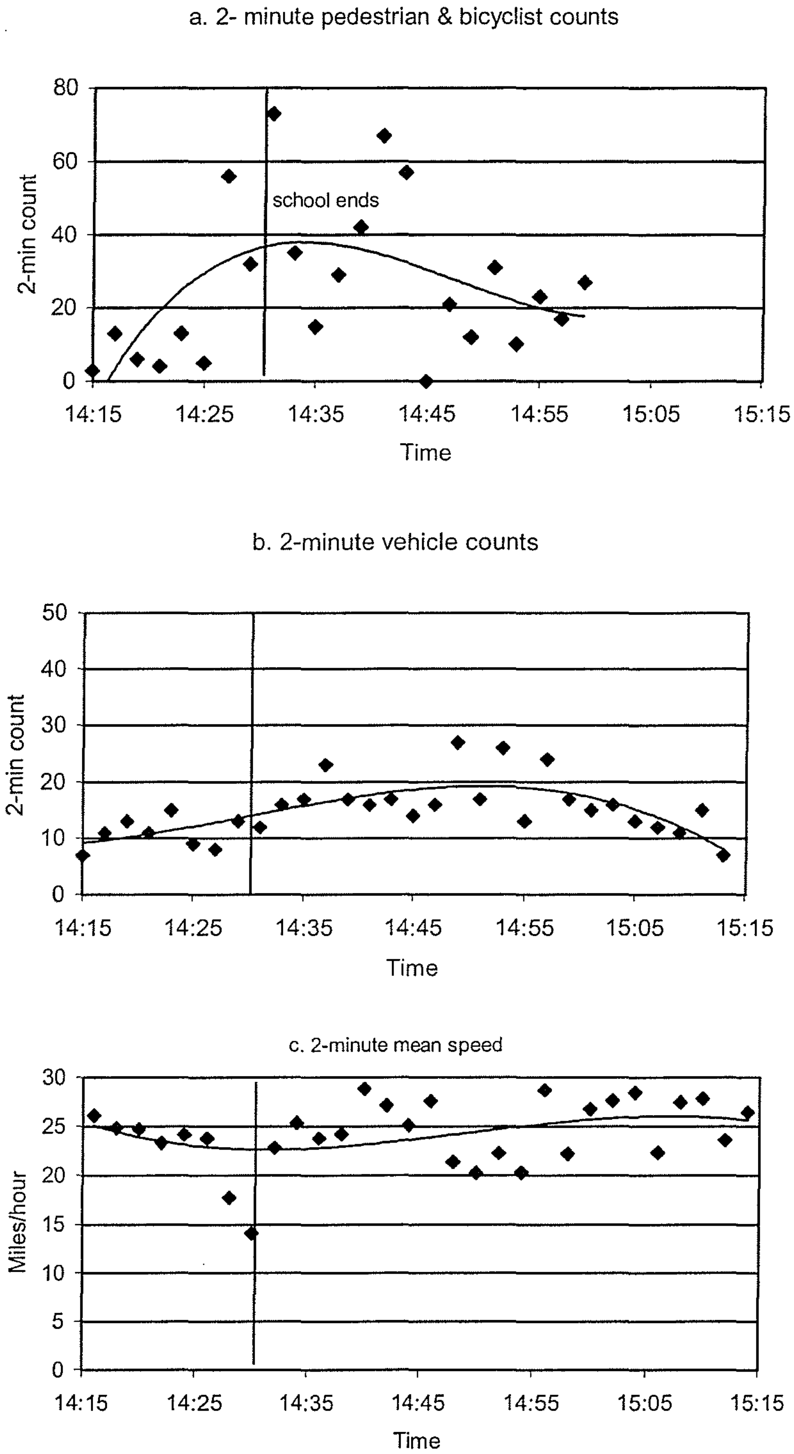






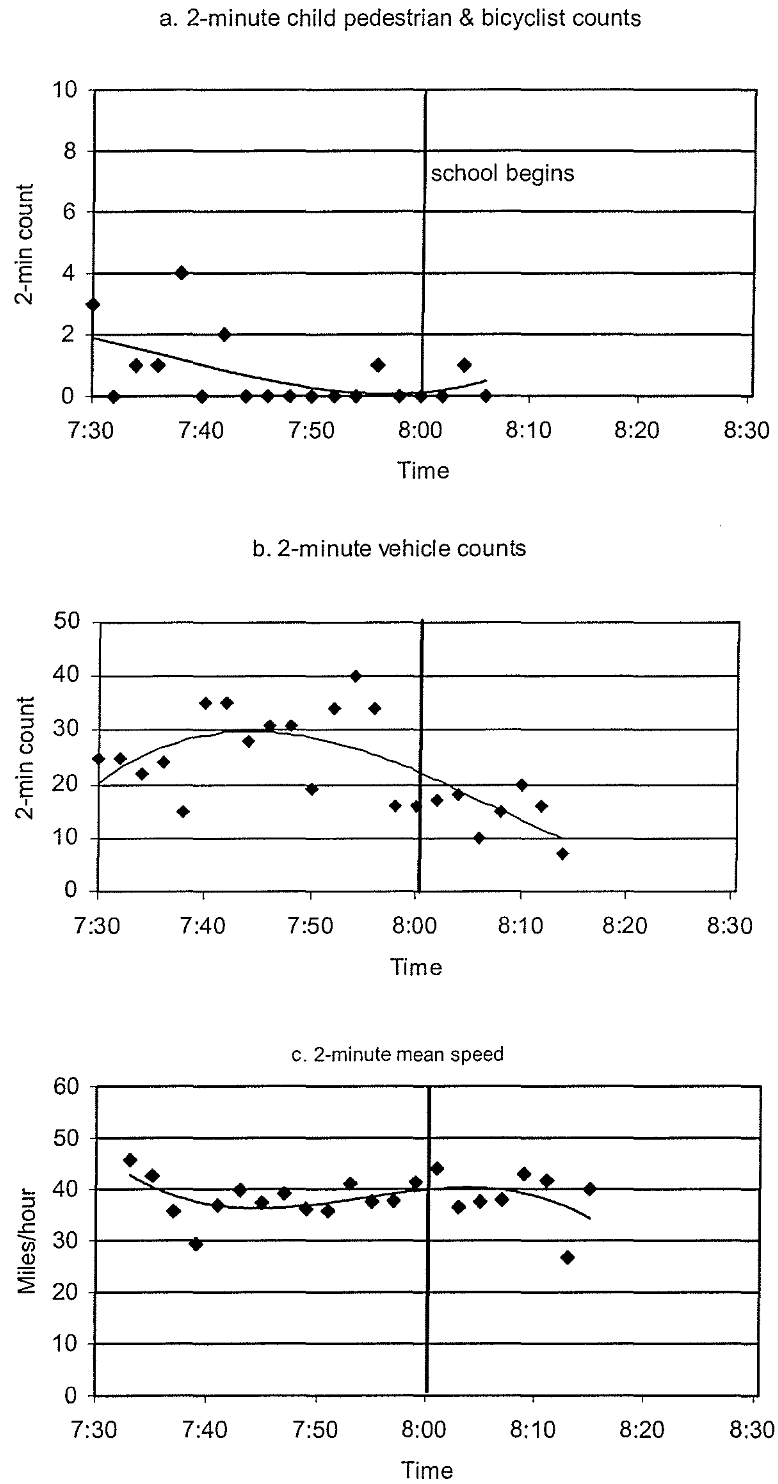
Traffic characteristics at Cesar Chavez Elementary School before school. a. child pedestrian and bicyclist counts; b. vehicle counts; and c. mean speed.

Figure 4: Cesar Chavez Elementary (after school)



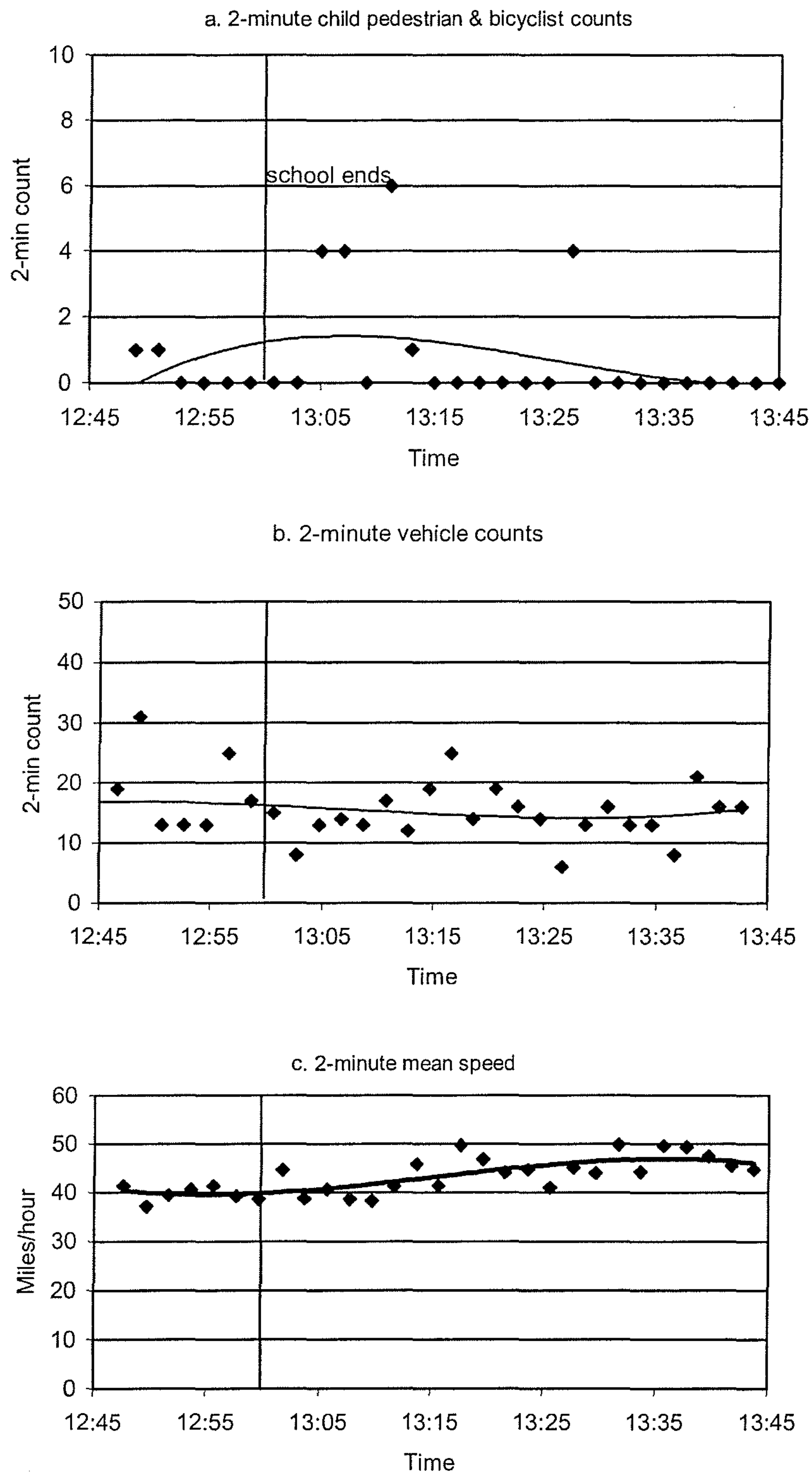
Traffic characteristics at Cesar Chavez Elementary School after school. a. child pedestrian and bicyclist counts; b. vehicle counts; and c. mean speed.

Figure 5: Jasper Elementary (before school)



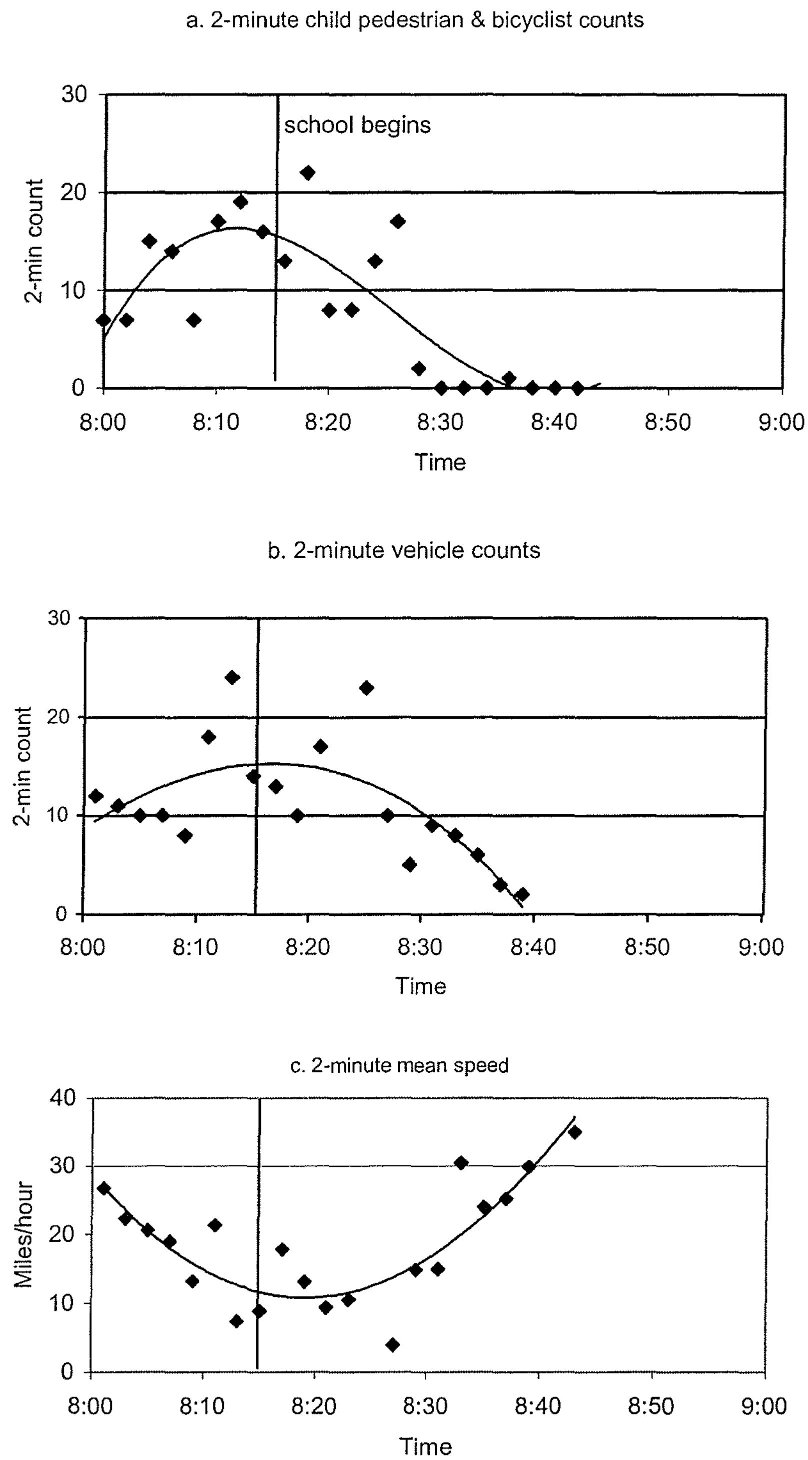
Traffic characteristics at Jasper Elementary School before school. a. child pedestrian and bicyclist counts; b. vehicle counts; and c. mean speed.

Figure 6: Jasper Elementary (after school)



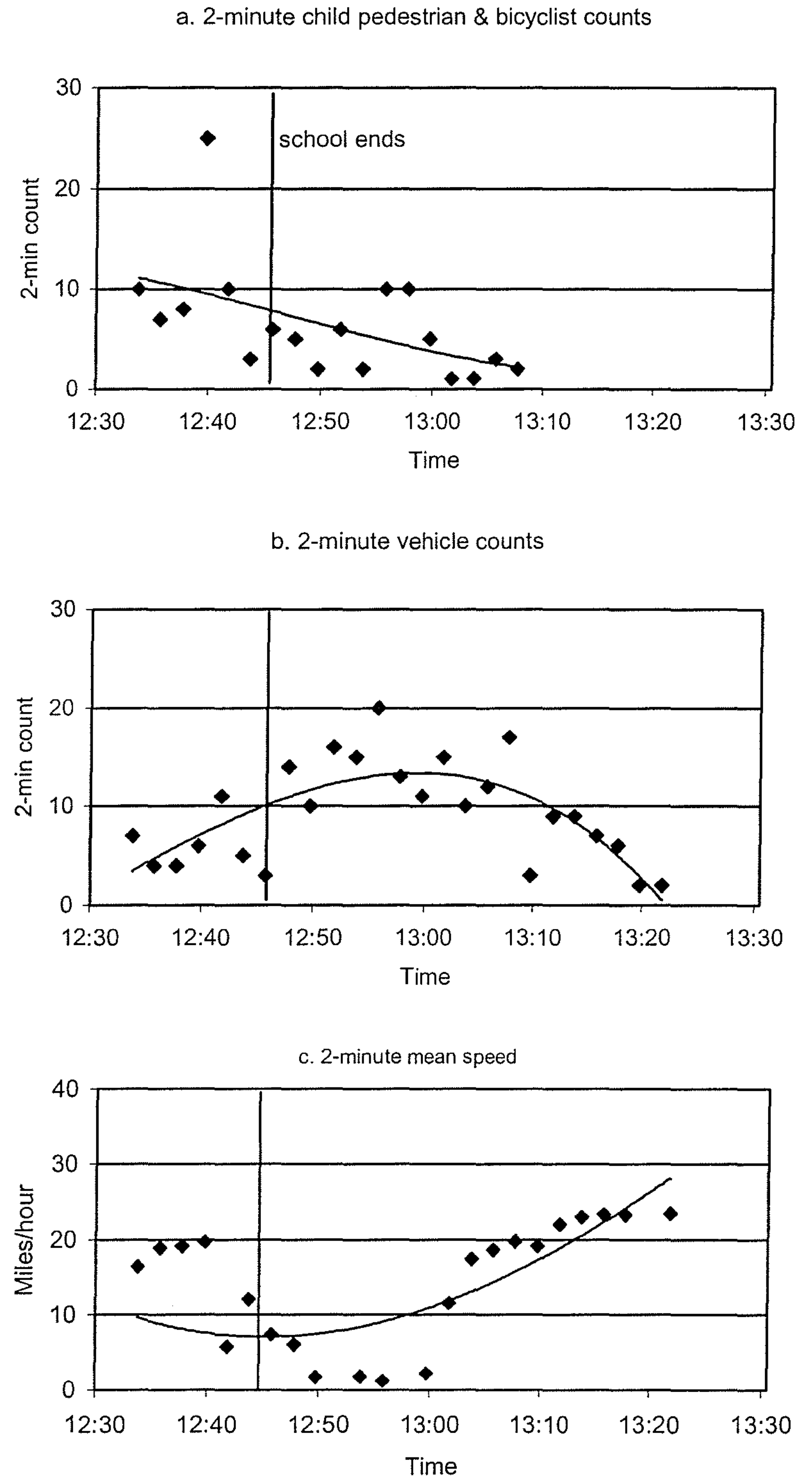
Traffic characteristics at Jasper Elementary School after school. a. child pedestrian and bicyclist counts; b. vehicle counts; and c. mean speed.

Figure 7: West Randall Elementary (before school)



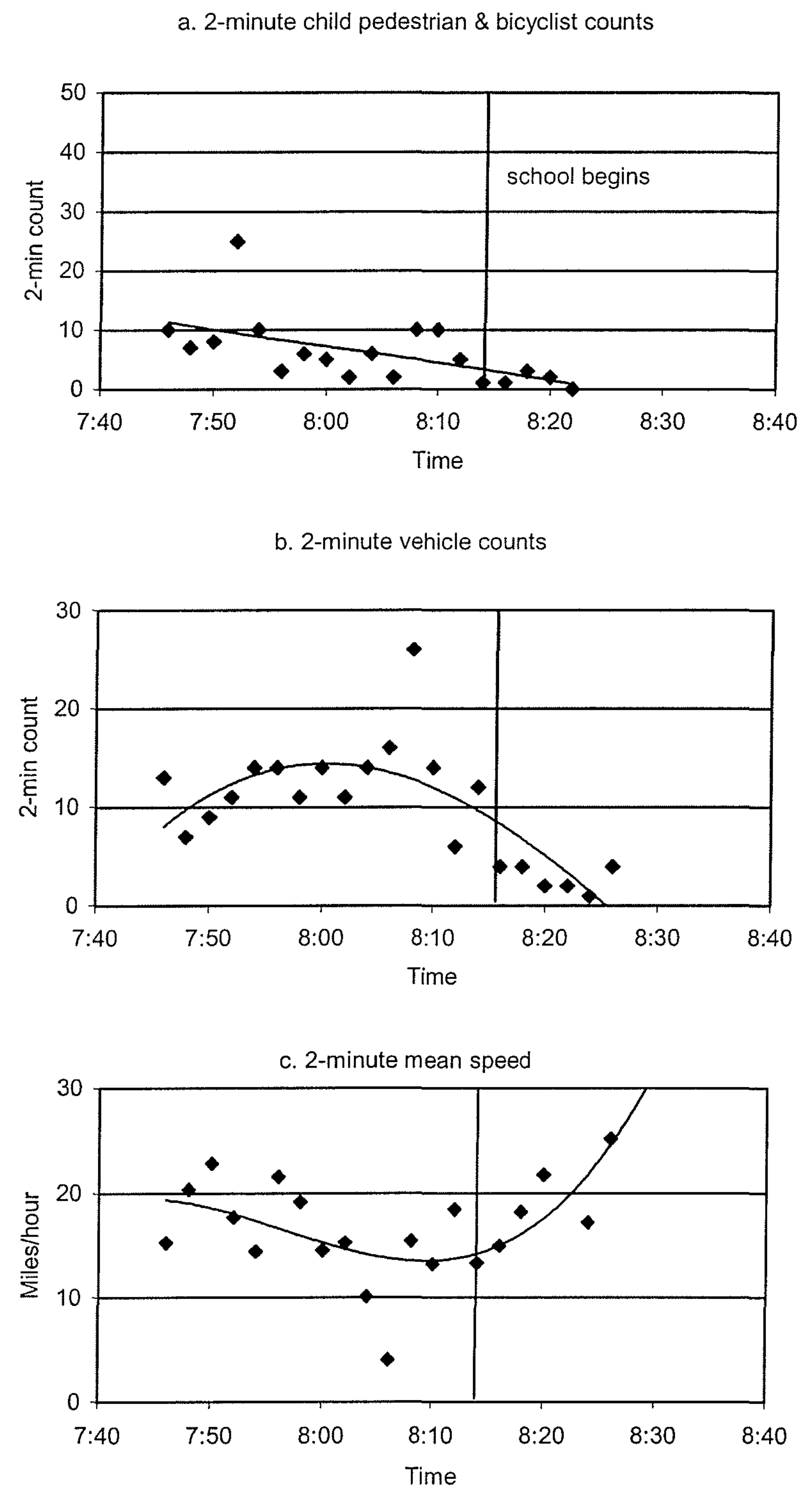
Traffic characteristics at West Randall Elementary School before school. a. child pedestrian and bicyclist counts; b. vehicle counts; and c. mean speed.

Figure 8: West Randall Elementary (after school)



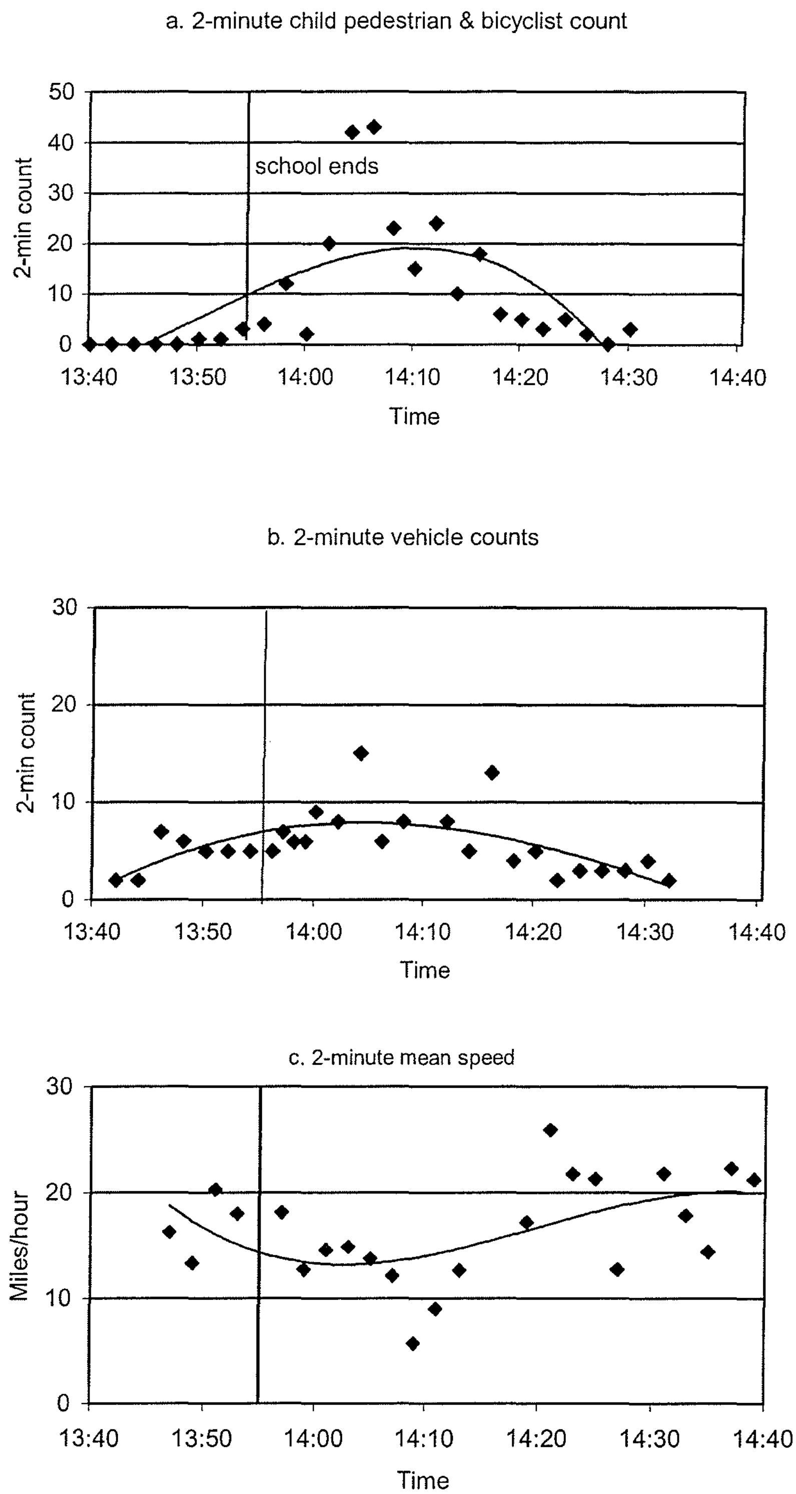
Traffic characteristics at West Randall Elementary School after school. a. child pedestrian and bicyclist counts; b. vehicle counts; and c. mean speed.

Figure 9: La Gloria Elementary (before school)



Traffic characteristics at La Gloria Elementary School before school. a. child pedestrian and bicyclist counts; b. vehicle counts; and c. mean speed.

Figure 10: La Gloria Elementary (after school)



Traffic characteristics at La Gloria Elementary School after school. a. child pedestrian and bicyclist counts; b. vehicle counts; and c. mean speed.