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Child Pedestrian Street-Crossing Behaviors outside a Primary School: Developing Observational Methodologies and Data from a Case Study in Changsha, China

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Abstract

Background—Child pedestrian injury is a significant global public health challenge, and prevention programming requires an understanding of the context children face when crossing the street. Methods to understand children's behavior in real-world pedestrian settings are sparse in low- and middle-income countries.

Methods—Children in grades 1-6 were videotaped crossing a three-lane street outside their school in Changsha, China. Tapes were coded to collect: (1) extent of adult supervision, (2) whom children crossed the street with, and (3) safe behaviors exhibited by children.

Results—Observational videotape methods yielded data that could be reliably coded to understand Chinese children's behavior crossing the street outside their primary school. In total, we observed 216 child pedestrians crossing the street, including 105 girls, 105 boys, and 6 for whom gender could not be determined. 51% of observations occurred in the morning before school and 49% in the afternoon after school. Children encountered a busy and somewhat-chaotic traffic environment. Adults were always present to help, but children appeared to heed adult advice concerning the crossing only about 70% of the time. Fewer than 1/3 of children looked at oncoming traffic before they entered a lane and over 1/3 entered a lane with moving traffic approaching.

Conclusion—Observational methods of coding videotaped behavior proved effective to understand and code children's risk and safety while crossing the street outside their primary

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school. At the street environment we studied, we found that children's pedestrian behavior involved significant risk.

Keywords

pedestrian; children; cognitive development; China; safety

1. Introduction

Injury is the leading cause of death for children ages 1-19 in China, accounting for 52.5% of all deaths in 2015.¹ Among injury causes, transportation injury is one of the top two causes of Chinese child injury death, with Global Burden of Disease 2010 estimates suggesting 34% of Chinese pediatric (age 6-9) road traffic deaths occur to pedestrians rather than other road users.¹ Of additional concern, pedestrian injury rates are increasing in China. Ma and colleagues recently reported a pedestrian injury increase of 44% in China from 2006 to 2010² and GBD 2015 estimates indicate a pedestrian mortality of 5.25 per 100,000 population in China.¹ A recent national survey found that about 40% of Chinese children in grades 4-6 walk to school.³

Development of child pedestrian safety programs requires an understanding of the ecological and environmental context children face when crossing the street, and what behaviors children display during their crossings. Such detailed evidence is lacking for China and many other low- and middle-income countries (LMIC), as a large portion of published research on child pedestrian behavior has been conducted in developed nations such as the United States, United Kingdom, France, and Australia, where children face ecological street environments very different from that in LMIC.⁴

To address the absence of data on child pedestrian street-crossing in China, the largest and most populated middle-income country, existing methodologies must be adapted to describe the ecological environment faced by Chinese children crossing to school, and to analyze the behaviors children display in such environments. We conducted an observational case study to evaluate the feasibility of adapting existing observational strategies from high-income countries to analyze behavior, risk and safety of children crossing the street near their school in Changsha, China.

We had two primary goals. First, we evaluated the feasibility of applying behavioral observation methodology developed in high-income countries to a more complex pedestrian environment in China. Second, we sought to offer empirical data on three topics relevant to children's safety while crossing the street near their school in a case study: (1) whom children physically cross the street with, (2) the extent of adult supervision during the crossing, and (3) the extent of safe behaviors exhibited by children.

2. Methods

2.1 Site

This research was conducted in a public street location outside an elementary school in Changsha, Hunan Province, China. The school served students in grades 1-6, suggesting

children crossing the street to school were about ages 6-12. Children crossed at a marked pedestrian crosswalk (“zebra crossing”) that was about 9.5 meters wide and located in a mid-block unsignalized location. Chinese law dictates drivers should yield to pedestrians in marked crosswalks,⁵ but in practice such yielding is uncommon and the law is rarely enforced by authorities. The crosswalk spanned a three-lane thoroughfare. The two lanes closest to the school were one-way, with varied traffic including buses, trucks, cars, two-wheeled motorcycles, electric bikes, and bicycles. During busy hours of school drop-off and pick-up, the near lane closest to the school gate was typically occupied by parked vehicles. The far lane, located on the opposite side of the street from the school, was bi-directional for public bus and two-wheeled vehicle traffic only.

As in most urban Chinese settings, the school was located in a crowded urban area amidst a densely-populated neighborhood. The neighborhood included wide sidewalks, busy major thoroughfares, and smaller arteries having multi-use passage by pedestrians, bicyclists, motorcyclists, and motor vehicles. Traffic at the street-crossing we observed was dense and nearly constant.

Pilot observations suggested adult pedestrians often crossed the street in front of the school one lane at a time, waiting in the middle of the street for a safe gap to enter the next lane. Vehicles slowed or yielded to pedestrians on some occasions. A volunteer adult crossing guard was always present during school drop-off and pick-up times, and a uniformed police officer was sometimes present as well.

2.2 Procedure

Research assistants placed a digital camera with a wide-angle lens on the opposite side of the street from where children were crossing. Thus, a camera was located near the school in the morning as children crossed to enter school and on the opposite side of the street in the afternoon as children departed from school. Not all children crossed the street, as some were walking to their home or a bus stop that was located on the same side of street as the school. Recording lasted for about 10 minutes for each session (slightly longer for morning hours, when children arrived across a wider time window, than for afternoon hours when all children left school at about the same time), capturing all children who crossed the street to and from school during peak hours.

Our goal was to obtain sufficient data to observe patterns in children’s behavior, and to obtain approximately similar amounts of crossings (about 100) in both the morning and the afternoon. To accomplish these goals, we recorded children’s crossing behaviors for 3 morning and 2 afternoon sessions, totaling 59 minutes of recording when children were actively crossing the street to or from school. To obtain maximum variability in behavior and sampling, we selected four different days of the week for recording (Monday and Thursday afternoons and Tuesday, Wednesday, and Thursday mornings). To achieve variation in weather, family behavior, and to some degree in sampling, we recorded in three different months that spanned two academic school years (one recording in April 2016, three in June 2016, and one in August 2016). Weather in Changsha is temperate, so the weather was warm during all recordings. We avoided rainy days.

In total, we observed 216 child crossings, 111 in the morning and 105 in the afternoon. Vehicle traffic density was 26.08 vehicles per minute and child pedestrian density was 4.06 pedestrians per minute. All study protocols were reviewed and approved by the Institutional Review Boards at University of Alabama at Birmingham, USA, and Central South University, China. Informed consent was waived by the review boards, as we were observing behaviors in a public location.

Digital recordings were viewed by research assistants to gather information about children's behavior and the environmental context. Different research assistants were assigned to code different variables; in total, about 6 coders were involved in the work. Recordings were repeatedly viewed with attention to individual pedestrians on multiple variables. To establish reliability of data collection, we created written criteria for behavioral categories and calculated inter-rater reliability between two independent coders on 20% of the sample for all variables. Inter-rater reliability was excellent (kappa coefficient > 0.95) for all measures.

2.3 Measures

Three sets of data were collected: (1) whom children physically crossed the street with, (2) the extent of adult supervision at the crossing, and (3) the extent of safe behaviors exhibited by children. Coding categories were selected based on a review of the literature on children's mid-block pedestrian crossings, and the risk and safety behaviors children generally display during such crossings. Several coding categories were adapted from existing research on the topic in HICs.^{6–8}

We recorded whom the child crossed the street with in three non-exclusive categories: (a) crossing alone; (b) crossing with an adult (even if there were other children present also); and (c) crossing with other children (even if an adult was present also). Adult supervision at the crossing was assessed through two variables. First, we recorded the presence or absence of either a volunteer adult crossing guard or a uniformed police officer. We recorded whether such an adult was present while the child crossed the street, even if the adult was not actively helping the child to cross. On many occasions, even though adults were present they did not appear to offer advice or input to children crossing the street. Second, we recorded whether the child appeared to obey crossing advice provided during the crossing from an adult or whether the child appeared to make the decision about when and how to cross independent of adult input. All adults present – both adults accompanying children and crossing guards/police officers present on the street – were observed to make this coding decision.

Children's safe behaviors were coded using five indicators: (a) whether the child looked left before entering each lane; (b) whether the child looked right before entering each lane; (c) whether the child ran across the lane (marked yes if both feet were simultaneously off the ground); (d) whether the child entered a lane with a moving vehicle approaching or when traffic was stopped; and (e) whether the child "sneaked behind" a vehicle during the crossing. The "sneak behind" category of behavior was defined as "jumping or sneaking right behind a vehicle immediately to fill that space in the road". We considered it a behavior that promotes safety by allowing the pedestrian to enter a traffic gap as soon as possible, but also one that incurs some risk because it presumes oncoming traffic will yield to permit the

pedestrian to cross. We also recorded any instances of crashes between moving vehicles and child pedestrians.

We also recorded sex of children and time period (morning or afternoon).

2.4 Data analysis

Data were primarily analyzed descriptively. We computed the percentage of each category of behavior that was coded. We also performed chi-square tests to test street-crossing behavior differences across boys and girls and morning and afternoon time periods.

3. Results

Among the 216 child pedestrians we observed, there were 105 (48.6%) girls, 105 (48.6%) boys, and 6 (2.8%) for whom gender could not be determined from the video-recording. 51% of observations occurred in the morning before school and 49% in the afternoon after school. Morning observations included 48 boys and 63 girls. Afternoon observations included 57 boys, 42 girls, and the 6 observations for whom gender could not be determined.

The first step of our analyses was to examine the extent of adult supervision at the crossings. As shown in Table 1, children crossed alone 15% of the time, with an adult 21% of the time, and with other children 70% of the time (the categories were non-exclusive, so the total exceeds 100%). Either a uniformed police officer or adult crossing guard was present at 100% of children's crossings. However, children followed adult advice provided during the crossing only 70% of the time, suggesting children were making their own decision about when to cross 30% of the time (Table 1).

Next, we examined the safety of children while crossing the street. As shown in Figure 1, children looked left before entering a lane only 29% of the time and looked right before entering a lane only 23% of the time. Children ran across a lane 6% of the time and entered a lane with moving traffic approaching 36% of the time. Children used a "sneak behind" strategy to enter a lane just behind a vehicle in 10% of the lanes they crossed. We observed no crashes between moving vehicles and child pedestrians.

Our final analysis conducted chi-square tests to evaluate gender and morning vs. afternoon differences for all outcome measures. As shown in Table 1, boys and girls engaged fairly similarly, with chi-square analyses yielding no statistically significant differences between crossing behavior of boys versus girls. There were multiple differences in morning versus afternoon behavior. Pedestrian traffic density was somewhat lower in the morning (3.60 children/minute) than in the afternoon (6.04 children/minute), when children all left school at the same time. Vehicle traffic was comparable (27.31 vehicles/minute in the morning vs. 20.72 in the afternoon). As shown in Table 1, in the morning children crossed more often alone (30% vs. 0% in afternoon, $\chi^2 = 36.21$, $p < .01$) or with adults (27% vs. 15%, $\chi^2 = 5.00$, $p < .05$), and less often with other children (46% vs. 96%, $\chi^2 = 64.15$, $p < .01$). Children obeyed adult crossing advice less often in the morning (42% vs. 99%, $\chi^2 = 81.18$, $p < .01$) and engaged in less safe pedestrian behavior by looking for traffic less frequently (15% looking left vs. 43%, $\chi^2 = 20.27$, $p < .01$, 20% looking right vs. 26%, ns) and crossing when

traffic was stopped (56% vs. 74%, $\chi^2 = 7.50$, $p < .01$) less frequently in the morning compared to the afternoon. We also witnessed higher rates of “sneaking behind” vehicles in the morning (14% vs. 1%, $\chi^2 = 14.02$, $p < .01$).

4. Discussion

Our research had two primary goals: to assess the feasibility of observational methodology in evaluating child pedestrian behavior and risk in a middle-income country with chaotic traffic patterns and to offer empirical data from a case study of children’s safety crossing the street near a primary school in Changsha, China.

We were successful in our first goal, as the observational methodology successfully yielded usable data. Although it took some experimentation to capture behaviors from the best angle, and required purchase of a wide-angle lens to attach to our video recorder, we experienced no logistical difficulties. We also experienced no difficulty from an ethical perspective in recording behavior in China, a country where recording of public walking behavior is common. Ethics boards in both China and the United States approved our research, and few passers-by questioned our intentions or purpose.

Review of videotapes was laborious and time-consuming, but we were able to establish coding criteria with a few iterations of developing a coding scheme. Inter-rater reliability was established quickly and easily by trained student coders, some of whom had experience with observational coding in previous studies. Rare instances of coder determination of inability to code accurately (e.g., when a child’s gender could not be definitively identified given occlusion by vehicles or other pedestrians during the crossing) yielded occasional missing data points.

Observational coding has been used frequently in the past to assess child pedestrian behavior in high-income countries,^{6–9} to assess physical activity in open settings,^{10–11} and in our own laboratory to assess child safety in various locations (e.g., on playgrounds,¹² youth soccer fields,¹³ public swimming pools,¹⁴ and unstructured laboratory environments¹⁵). Our application of these strategies to assess child pedestrian behavior in the busy and somewhat chaotic traffic environment of Chinese cities extends previous work. It proved feasible and effective to gather reliable data and could be scaled and adapted for both descriptive and prevention studies in the future. A notable barrier to future application is overcoming the fact that coding work is laborious and time-consuming. Trained undergraduate students conducted much of the work for this study, and that model might be applied in other studies as well.

The second goal of our research was to offer detailed data from the perspective of a case study on child pedestrian street-crossing outside a primary school in Changsha, China. Our results suggest the children in that environment always had adult supervisors present, but the children did not always follow adult crossing advice. Faced with dense traffic patterns, children very frequently crossed the street alone or with other children. We recorded fewer than 1/3 of children looking at oncoming traffic before they entered a lane and over 1/3 entering a lane with moving traffic approaching. Gender differences were minimal.

The fact that adults were always present at the crossing may have influenced children's behavior. Specifically, children may have recognized an adult was present to protect them, and therefore incorrectly presumed they would be safe because the adult would prevent pedestrian crashes. We observed occasions, however, when adults were distracted from helping children cross the street, and risk emerged when children crossed on their own or with other children.

Behavior did vary significantly in the morning versus the afternoon. In the morning, children tended to walk more often with adults, which may have led children to riskier crossings directed by adults that included "sneak-behind" strategies, looking less often for traffic, and crossing more often when traffic was moving toward them. The riskiest crossings we observed, however, occurred in the afternoon, when children were crossing with other peers. Risk in pedestrian settings can be conceptualized and measured in multiple ways, but by most metrics we witnessed significant risk in children's pedestrian behaviors during both morning and afternoon observations.

Our data demonstrate distinctly some of the cultural differences for children crossing a street to school in China compared to in HICs where most existing research data have been collected.^{16–18} We witnessed with some frequency children entering lanes when vehicles were moving, children stopping in between lanes while crossing a busy street, and use of a "sneak behind" behavior, whereby children entered a lane immediately after a vehicle had passed. In addition, our results reveal threats to the safety of primary school students crossing streets in China, although we acknowledge the rates of risky behaviors at this particular school may not be representative of the broad population.

Solutions to the public health problem of child pedestrian safety in busy LMIC traffic environments are challenging. The cognitive-perceptual task of crossing a street, as described in the literature from high-income countries, is complex.¹⁹ Children must very quickly judge speeds and distances of oncoming traffic, often coming from multiple directions, and determine the safety of entering a gap. At the location we observed, and anecdotally in most Chinese cities, speeds are often slower than in HICs but traffic is denser, so traffic gaps are entered by adults even when they are tight, with the expectation that drivers will slow or yield. Pedestrian decisions must be made with extremely high speed and efficiency, a difficult task for young children who are still developing cognitive skills. Strategies to improve children's pedestrian safety must be developed and implemented. They will likely be most effective if they are multifaceted, incorporating a range of strategies that includes changes to the built environment, calming of traffic, improved adult supervision of children, and training of children themselves to engage safely in traffic.

The study suffers from weaknesses. We used data from a limited amount of days and time, although the behavior patterns became clear and would likely replicate even with further observation periods, especially because we would be repeatedly observing the same children. In fact, a limitation of this study is that we cannot assure independence of the present data. We purposely collected data over several months and two academic school years, but since children are likely to follow similar patterns of walking to and from school daily, some children were likely observed more than once on different days. Like many

observational studies of behavior, our measures had strong inter-rater reliability but unknown validity. Finally, we only focused on street-crossing behaviors of primary school students. Their street-crossing behaviors may differ from the behaviors of secondary school students. Future research might conduct comparative analyses across research sites, prolong observation times to capture road traffic injury incidents and the behavioral antecedents of them, and consider differences that emerge outside schools serving older children.

In conclusion, our study suggests behavioral observation of child pedestrian behavior is feasible in LMIC environments with somewhat chaotic traffic patterns. From the perspective of a case study, we offer some of the first observational data on child pedestrian behavior outside a school in a LMIC nation like China.

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Highlights

- Videotaped observations yielded usable data on child pedestrian behavior.
- An observational case study evaluated child pedestrian safety in Changsha, China.
- Children often crossed the street alone and without adult advice.
- Many child street-crossings involved significant risk.

Figure 1.
Percentage of risky lane-crossing behaviors among child pedestrians in Changsha, China

Table 1
Proportions of street-crossing behaviors among child pedestrians in Changsha, China (%)

Street-crossing behavior	Sex			Time		
	All Children ¹	Boys ²	Girls ³	x2	Morning ⁴	Afternoon ⁵
Crosses alone	15	12	20	2.72	30	0
Crosses with adult	21	20	23	0.19	27	15
Crosses with other children	70	71	68	0.26	46	96
Appeared to obey adult crossing advice	70	71	67	0.43	42	99
Looks left before entering lane	29	25	31	0.97	15	43
Looks right before entering lane	23	20	28	1.85	20	26
Runs across lane	6	4	8	1.34	8	4
Crosses when traffic stopped	64	59	70	2.41	56	74
“Sneaks behind” vehicle	8	7	10	0.52	14	1

¹ n = 214 for all variables but looking left and right, for which n = 209 due to missing data.

² n = 103 for all variables but looking left and right, for which n = 102 due to missing data.

³ n = 105 for all variables but looking left and right, for which n = 101 due to missing data.

⁴ n = 111 for all variables but looking left and right, for which n = 107 due to missing data.

⁵ n = 103 for all variables but looking left and right, for which n = 102 due to missing data.