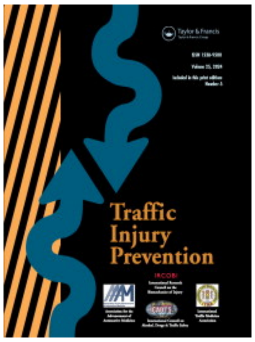

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Driver yield and safe child pedestrian crossing behavior promotion by a school traffic warden program at primary school crossings: A cluster-randomized trial

Jimmy Osuret[a], Ashley Van Niekerk[b,c], Olive Kobusingye[a], Lynn Atuyambe[d] and Victoria Nankabirwa[e]

[a]Department of Disease Control and Environmental Health, School of Public Health, College of Health Sciences, Makerere University, Kampala, Uganda; [b]Institute for Social and Health Sciences, University of South Africa, Cape Town, South Africa; [c]Masculinity and Health Research Unit, South African Medical Research Council, and University of South Africa, Cape Town, South Africa; [d]Department of Community Health and Behavioural Sciences, School of Public Health, College of Health Sciences, Makerere University, Kampala, Uganda; [e]Department of Epidemiology and Biostatistics, School of Public Health, College of Health Sciences, Makerere University, Kampala, Uganda

ABSTRACT

Objective: To determine the effect of a school traffic warden program on increasing driver yield and safe child pedestrian crossing behavior in Kampala, Uganda.

Methods: We designed and implemented a school traffic warden program in specific school zones in Kampala, Uganda. We randomly assigned 34 primary schools in Kampala, in a 1:1 ratio, using a computer-generated randomization sequence, to control or intervention arms in a cluster randomized trial. Each school in the intervention group received one trained adult traffic warden stationed at roads adjacent to schools to help young children safely cross. The control schools continued with the standard of care. We extracted and coded outcome data from video recordings on driver yield and child crossing behavior (defined as waiting at the curb, looking both ways for oncoming vehicles, not running while crossing, and avoiding illegal crossing between vehicles) at baseline and after 6 months. Using a mixed effect modified Poisson regression model, we estimated the prevalence ratio to assess whether being in a school traffic warden program was associated with increased driver yield and safe crossing behavior.

Results: A higher proportion of drivers yielded to child pedestrians at crossings with a school traffic warden (aPR 7.2; 95% CI 4.42–11.82). Children were 70% more likely to demonstrate safe crossing behavior in the intervention clusters than in control clusters (aPR 1.7; 95% CI 1.04–2.85). A higher prevalence was recorded for walking while crossing (aPR 1.2; 95% CI 1.08–1.25) in the intervention clusters.

Conclusion: The school traffic warden program is associated with increased driver yield and safe child pedestrian crossing behavior, i.e., stopping at the curb, walking while crossing, and not crossing between vehicles. Therefore, the school traffic warden program could be promoted to supplement other road safety measures, such as pedestrian safety road infrastructure, legislation, and enforcement that specifically protects children in school zones.

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Child pedestrian; school traffic warden; driver yield; crossing behavior; Uganda

Introduction

Road traffic injuries (RTIs) are the leading cause of death for children and young adults globally (World Health Organization 2018). Pedestrians, particularly children, are vulnerable to these injuries when crossing roads (Rella Riccardi et al. 2022; Zafri et al. 2022). Children in low-income countries (LICs) are more likely to die on the road than in high-income countries (HICs) despite low vehicle ownership (World Health Organization 2018). Pedestrian deaths in LICs have increased over the years due to unsafe roads and ineffective road safety strategies (Tiwari 2020; Zafri et al. 2022). Roads in these settings are designed and constructed with minimal consideration for pedestrian needs and other non-motorized modes of transport (Obeng-Atuah et al. 2017; Osuret et al. 2021). As a result, children negotiate dangerous roads without pedestrian facilities and are at a high risk of being killed or injured in road traffic crashes (United Nations 2018; Muni et al. 2021).

School trips in LICs may involve crossing many unsafe roads with inadequate pedestrian infrastructure, and children may have to navigate a dangerous mix of fast-moving vehicles without safe routes (Obeng-Atuah et al. 2017). This situation contrasts with that in HICs which have pedestrian infrastructure and stricter codes governing the conduct of drivers at pedestrian crossings (Zafri et al. 2022). Like other LICs, Uganda struggles to meet the pedestrian safety demands of rapidly growing and motorizing populations (Poswayo et al. 2019). Driver-yielding behavior largely

CONTACT Jimmy Osuret jimmyosuret@gmail.com Department of Disease Control and Environmental Health, School of Public Health, College of Health Sciences, Makerere University, P.O. Box 7072, Kampala, Uganda.
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determines safety and influences pedestrian crossing behavior at crossings (Zareharofteh et al. 2021). Higher driver-yielding rates are associated with fewer pedestrian motor vehicle collisions (Fridman et al. 2019; Zafri et al. 2022). Driver yield behavior depends on the road environment, pedestrian characteristics, vehicle factors, and regulations for vehicle traffic at crossings (Sucha et al. 2017; Kadali and Vedagiri 2020).

On the other hand, factors influencing pedestrians' wait behavior at uncontrolled crossings include vehicle speed, the car's distance from the crossing, traffic density, number of lanes, pedestrian-driver communication, and the presence of other pedestrians (Sucha et al. 2017). HICs have laws and road infrastructure that support drivers yielding to pedestrians entering or crossing in marked crosswalks, unlike many LICs where the legislation does not support pedestrians' right of way, resulting in pedestrian-vehicle collisions (Mphele et al. 2013; Oporia et al. 2020). Children are inherently vulnerable, and in LICs like Uganda, they negotiate hazardous road environments and have to find safe spaces between traffic before crossing (Muni et al. 2020). A child's developmental maturity is characterized by their still-growing cognitive, emotional, and physical capabilities, which influences injury risk (Jean 1969; Schieber and Thompson 1996; Beilin and Fireman 1999). For example, a child's small physique limits his/her ability to see and be seen by vehicles (Koekemoer et al. 2017). Younger primary school children are typically curious and interested in exploring their environment but often still cannot fully appraise potential sources of traffic danger or negotiate complex road situations. Older primary school going children typically have a greater appreciation of road dangers but are increasingly influenced by peers in their behavior, some of which may be unsafe (Koekemoer et al. 2017). The child's developing abilities may therefore not be sufficient in hazardous traffic situations, highlighting the importance of creating safe pedestrian road environments, e.g., at high risk settings such as school crossings (Cloutier et al. 2021).

Young children need assistance crossing busy roads or intersections, especially in LICs, where traffic regulations are often ignored (Osuret et al. 2021). Children's vulnerability to RTIs and the challenges faced in crossing roads are heightened by the lack of protected pathways and other infrastructural protections and the child's developmental limitations (Rosenbloom, Haviv, et al. 2008; Ellis 2009). The development of RTI prevention interventions are therefore necessary to protect child pedestrians (Rosenbloom, Haviv, et al. 2008). These programs vary and may involve school zone modifications encompassing engineering, enforcement, and education (Poswayo et al. 2019; Namatovu et al. 2022). Some programs on other continents include low-cost infrastructure and environmental modifications to protect children on their way to school (Poswayo et al. 2019). A typical program employed among schools in many HICs is the deployment of school traffic wardens, commonly referred to as crossing guards, at crossings adjacent to schools to facilitate safe road crossing (Rosenbloom, Haviv, et al. 2008). Traffic wardens are reported to reduce pedestrian traffic violation behavior and relieve traffic congestion at intersections during peak hours (Yang et al. 2016). School traffic wardens assist children in safely navigating traffic situations in school zones and are positively related to the perceived safety of children (Rothman, Buliung, et al. 2015; Wilson et al. 2019; Amiour et al. 2022). School traffic wardens implemented at crossings also favorably influence the traffic behavior of vulnerable road users (Yang et al. 2016; Rothman et al. 2018). Studies in HICs have indicated the value of traffic wardens in promoting injury prevention by promoting supervised routes (Eyler et al. 2008; Fesperman et al. 2008). A study by Yang et al. (2016) in China indicated an 8% reduction in pedestrians' risk-taking behavior in the presence of a traffic warden (Yang et al. 2016). However, the school traffic warden benefit and compliance rates have yet to be examined in different, more challenging settings (Rothman, Perry, et al. 2015). Findings from HICs on school traffic wardens and child pedestrian safety may not apply to the Ugandan or other LIC contexts, where supportive legislative, enforcement and infrastructure is more limited or absent, leaving an evidence gap as regards their effectiveness. Furthermore, there is limited international research on the impact of school traffic warden programs on child pedestrian behavior at such crossings. In response to the child pedestrian RTI problem in Uganda and as an attempt to generate local intervention data, we designed and implemented a school traffic warden program in specific school zones. Thus, this cluster randomized trial aims to determine the effect of deploying a school traffic warden both on driver yield and child pedestrian crossing behavior.

Methods

Study area

The study was conducted in Kampala, Uganda's capital city. Kampala has the highest burden of RTIs (i.e., approximately 50% of the total number of crashes) and most public primary schools in Uganda (Uganda Bureau of Statistics 2020; Uganda Police 2023). Road transport in this area accounts for over 90% of cargo and passenger movement (United Nations 2018). Most school-going children in Kampala are aged 5–11 and under the Kampala Capital City Authority (KCCA) management (Uganda Bureau of Statistics 2023). Kampala is congested with many economic activities and busy roads with little provision for pedestrians (Kobusingye et al. 2001). Walking is dominant amid modes like private cars, commercial motorcycles locally known as "boda bodas," commercial minibuses, and cycling (Ministry of Lands, Housing and Urban Development 2011). Kampala city suffers from the challenges of poor land-use planning and is served by a relatively unregulated public transport system (United Nations 2018).

Study design

We conducted a cluster randomized trial (CRT) to determine the effect of a school traffic warden program on driver yield and child pedestrian crossing behavior in Kampala, Uganda. The 34-cluster study was implemented among public primary schools under the jurisdiction of Kampala Capital City Authority over 6 months from May to December 2022 (i.e., term II and III of the Uganda school calendar). We chose a CRT because the intervention was delivered at a group level, and the unit of randomization was the schools to avoid contamination. The intervention group received the school traffic warden program, while the control group received the standard of care, including road safety materials developed by the Uganda National Curriculum Development Center.

Selection of schools and respective crossing points

To ensure comparability, the research team assessed the 79 public primary schools and their respective crossings. We included primary schools with similar pupil enrollment populations, environmental characteristics, e.g., adjacent to tarmac roads, traffic volume (i.e., in terms of the number of vehicles and vehicle type), crossings within 600 m of the school zone, and economic status. We excluded schools located along roads under construction and those with the school traffic warden program and traffic signal treatments.

The school traffic warden program intervention

The "school traffic warden program" is a low-cost RTI prevention intervention that reduces pedestrian-motor vehicle conflict at school crossing points. This intervention addresses some behavior risk factors of child pedestrians and drivers. We implemented school traffic wardens in locations with lower traffic risks, such as straight roads that allowed visibility, with two lanes, and far from an intersection. It was posited that school traffic wardens at safe crossing points would regulate traffic and increase driver yield to pedestrians' right of way entering or crossing. Additionally, they would give children road safety tips and promote safe crossing. This intervention would, in turn, reduce the risk of pedestrian motor-vehicle collisions. A total of 17 school wardens, one for each school, were selected from 79 schools. The school crossings included were within 600 m of the school and had tarmacked roads and similar traffic and pedestrian volumes. The participating 17 school traffic wardens (all non-teaching support staff) underwent a 5-day road safety training before starting the study. The objective of the training was to build capacity among traffic wardens to support safe crossing practices for school children. The training module covered an introduction to road safety, basic concepts of causation and consequences of RTIs, personal health and safety, dress code, customer care, crashes, risks, hazards, safe crossing behavior, managing emergencies, and effective communication. A similar follow-up training was conducted after 3 months. One road safety trainer delivered the training sessions in class and at the respective school crossing sites. The primary school head teachers briefed the children to obey the warden's road safety instructions as an authority. In addition, the respective school administrations supervised the wardens daily. The traffic warden was expected to wear reflective safety gear for visibility and to ensure they were healthy are not under any medication. They always crossed children at designated crosswalks. The crossing rule emphasized safety, patience, and observance, i.e., for the child to stop, look and listen. Before crossing, children were gathered at the curb and briefed to wait for the crossing instructions. The warden would face the oncoming vehicles at a safe distance with a stop paddle and then flag them to stop with direct eye contact with the drivers. The warden would hold the stop paddle high with one arm and the other, signaling the driver to stop. We cautioned wardens on judging vehicle speed and to only flag down slow-moving vehicles at a safe breaking distance of 50–100 m to allow large numbers of children to cross. The children could only cross after the vehicles came to a complete stop. The school wardens were motivated with non-monetary incentives such as high visibility jackets, whistles, and a "lollipop" stop paddle sign. In the intervention clusters, the trained school traffic wardens were placed at a safe location to reduce the risk of crashes. All school sites in this study had partially designated crossing points adjacent to their entrances that were predetermined by the city authority directorate of engineering. We, therefore, enhanced the visibility and safety at these pedestrian crossings by placing the trained school traffic warden to support safe crossing practices for children. The school traffic warden assisted pupils in crossing at all times during peak periods (6:00 am–8:00 am; 01:00 pm–02:00 pm; 03:00–07:00 pm) over a 6-month intervention period.

Primary and secondary outcomes

The primary outcome was driver yield. This was defined as the first or following drivers from both the right and left giving the right of way to pedestrians entering or crossing at the school crossing point. We also assessed whether drivers yielded to the hand signal instructions given by the wardens as they controlled traffic at the school crossing.

The secondary outcome was safe child pedestrian crossing behavior. This outcome was informed by Rosenbloom, Ben-Eliyahu, et al. (2008) and Zareharofteh et al. (2021), who observed unsafe crossing behavior of children, like not stopping at the curb, not looking before crossing, crossing outside a crosswalk, running across the road, crossing between cars in traffic jams, and attempting to cross when a vehicle is nearing (Rosenbloom, Ben-Eliyahu, et al. 2008; Zareharofteh et al. 2021). We coded whether or not children (1) waited at the curb for the car to move off before crossing, (2) looked both ways for oncoming vehicles before crossing, determined by the head movements to the right or left, (3) crossed within the boundary of the crosswalk area, (4) walked or ran as they crossed, and (5) crossed between vehicles which was defined as an illegal behavior and a dangerous action of pedestrians even if maneuvering through slow-moving traffic or moving between cars at any point on the roadway in traffic jams. A crossing behavior index for a complete crossing maneuver was constructed to quantify this outcome. We coded safe crossing behavior if a child performed all the following behavior, i.e., waited at the curb, looked both ways for oncoming vehicles, did not run while crossing, and never crossed between vehicles. On the other hand, a child's behavior was considered unsafe if they failed to wait at the curb and/or failed to look for vehicles and/or ran and/or crossed between vehicles.

Potential confounding variables

Data were collected on potential confounding variables, including the apparent sex of the child, whether parents accompanied the child or not, time of day, vehicle type, and group crossing at baseline and follow-up.

Sample size

The number of clusters needed was determined using the formula by Rutterford et al. (2015).

$$C = 1 + \frac{\left(Z_{\alpha/2} + Z_{\beta}\right)^2 \left[\frac{P_1\left(1-P_1\right)}{n} + \frac{P_2\left(1-P_2\right)}{n} + K^2\left(P_1^2 + P_2^2\right)\right]}{\left(P_1 - P_2\right)^2}$$

Driver yield, the primary outcome, guided the calculation of the number of school clusters (**C**) needed. The proportion (p1) of driver yield in the control arm was estimated at 0.14, while the proportion (p2) in the intervention arm was 0.4 from a cross-sectional pilot study (Osuret et al. 2023). We used a type 1 error rate (Z alpha = two-sided alpha) of 0.05 for a chi-square test at a 95% confidence interval (1.96) and Z beta = statistical power of 90% (1.28). The number (n) of individuals observed per cluster was estimated at 50. The coefficient of variation (k) was taken as 0.2 because pupils from the same school tended to have similar crossing behavior (Rutterford et al. 2015; Osuret et al. 2023). Substituting in the formula gave us 17 school clusters per study arm. Therefore, data were extracted for 50 randomly selected pupils per school crossing site for 34 clusters giving a sample size of 1700 child pedestrians.

Randomization and masking

We used simple computer-generated randomization with clusters assigned in a 1:1 allocation ratio. Randomization was not stratified, and the allocation sequence was generated by a statistician not participating in the study. We masked the statisticians extracting and coding outcome data to the allocation assignment, i.e., they were neither informed about the intervention under study nor the study arm assigned. To achieve this masking, two pairs of statisticians not involved in running the trial were used to extract and code data separately from the recording. One pair separately extracted data for the intervention and the other for the control arm to minimize biasing the findings. It was also not guaranteed that a pupil recorded and observed at baseline would be the same at the endline because of the random sampling.

Data collection

Four research assistants participated in mounting Go Pro mini cameras in an elevated position in control and intervention arms unobtrusively without influencing the road user behavior. They arrived at the crossing location 15 min earlier to position the camera to record the view of the crossing point and road user interactions in the natural setting. For each crossing point, the camera captured a day's video recordings for the three peak periods (06:30–8:00; 13:00–14:00; 16:00–19:00 h) when children arrive at and from school. Upon completion of the recordings, two separate teams of statisticians extracted and coded data for the intervention and control arm into the mobile technology KoBo Toolbox software. The coding process involved generating a checklist for each recorded child and entering the observations into screens designed using KoBo Toolbox software. Information coded included child crossing behavior, driver behavior, time of observation, and characteristics of crossing location. Quality control aspects of validity were enhanced by pairing statisticians to independently check for inconsistencies, duplicate records, or incomplete data by reviewing the time stamp of the recording of the submitted data. The field supervisor JO was consulted where there were still areas of disagreement (less than 3%.), especially for blurry recordings. A different statistician listed all individuals captured in the extracted data from the video recording and used a random number generator to select 50 children for each school crossing point randomly.

Data management and statistical analysis

Video recordings were saved on hard drives, and data were submitted to a secure cloud aggregate server upon completion of extraction and coding. A daily download of all data from the server was done, followed by data cleaning. All analysis was done with Stata SE (version 14.0). We compared the proportion of driver yield and safe crossing behavior between the intervention and control arms. A multilevel mixed effect modified Poisson regression model with cluster analysis at the school level was used to assess the effect of the school traffic warden program on driver yield and safe crossing behavior. We measured the outcomes at the pupils' level and accounted for the cluster-randomized design using random intercepts at the school level (the unit of randomization) (Zou and Donner 2013; Austin et al. 2018). Prevalence ratios rather than odds ratios were estimated because of the high prevalence of the outcomes (>10%). Variables that met the 0.2 level at bivariable analysis, as well as potential confounding variables determined apriori from the literature included sex, period of the day, presence of an obstacle, group crossing, whether or not parents accompanied a child, and vehicle type, which we included in the final multiple regression analysis (Osuret et al. 2023). A level of 5% with a two-tailed test was used to signify statistical significance at 95% confidence interval. The study had individual-level data nested within clusters, and to assess the effect of a treatment variable, we fitted the model below.

Level one (individual level)

$Y_{ij} = \beta_{oj} + \beta_i \, X \text{ Treatment}_{ij} + \epsilon_{ij}$

Y_{ij} is the outcome of individual i incluster j

β_{oj} is the intercept for cluster j which varies across clusters

β_i is the fixed effect of the treatment variable

ϵ_{ij} is the individual level residual

Level two (cluster level)

$\beta_{oj} = \gamma_{00} + \gamma_{01} X \, Covariate_j + u_{oj}$

γ_{00} is the overall intercept

γ_{01} is the fixed effect of a cluster – level covariate (if included)

u_{oj} is the random effect representing the variation in intercepts across clusters

So, the full model is a combination of level one and level two equations

$Y_{ij} = \left(\gamma_{00} + \gamma_{01} X \, Covariate_j + u_{oj}\right) + \beta_1 X \, Treatment_{ij} + \epsilon_{ij}$

Ethical considerations

Makerere University School of Public Health Research and Ethics Committee/Higher Degrees and Ethics Committee (HDREC ref 066) and the Uganda National Council for Science and Technology (HS659ES) approved the study. We sought and received permission to conduct the study from Kampala Capital City Authority, primary school head teachers, and the Uganda Police. This study is registered with ClinicalTrials.gov, number NCT05407883.

Results

Overall, 34 schools were approached for participation in the study over 6 months. The final sample for data analysis was 1700 (Figure 1). Few baseline differences were noted between the intervention and control clusters (Table 1).

The prevalence of driver yield to pedestrians' right of way was higher in the intervention (73.6%) than in the control (12%). Relatedly, safe crossing behavior was higher in the intervention (72.2%) compared to the control (52.5%) Table 2.

On adjustment for potential confounders (i.e., sex, period of the day, presence of an obstacle, group cross, whether or not the child was accompanied, and vehicle type), drivers were 7.2 times as likely to yield to child pedestrians at crossings in the intervention clusters as they were in control clusters (aPR 7.2; 95% CI 4.42–11.82). The prevalence of driver yield was higher at crossings with an obstacle (aPR 1.3; 95% CI 1.01–1.56) and lower when children crossed alone than those who crossed in a group (aPR 0.7; 95% CI 0.57–0.85) (Table 3).

After adjusting for potential confounders, children in the intervention clusters were 70% more likely to have safe crossing behavior than children in the control clusters (aPR 1.7; 95% CI 1.04–2.85). The prevalence of safe crossing behavior was higher in the evening (aPR 1.4; 95% CI 1.04–1.85) and morning (aPR 1.4; 95% CI 1.06–1.75) than in the afternoon period when the younger lower primary children returned home (Table 4). For the specific child behavior, children in the intervention had a significantly higher prevalence of walking (aPR 1.2; 95% CI 1.08–1.25) (Table 5).

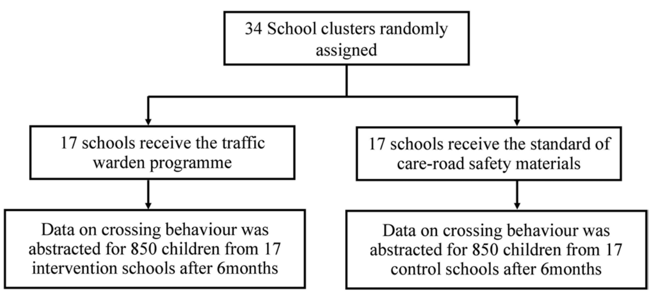

Figure 1. Trial profile.

Table 1. Comparison of baseline characteristics of the intervention and control group.

Characteristics	Intervention group ($N=850$)	Control group ($N=850$)
Sex		
Female	384 (45.2%)	429 (50.5%)
Male	466 (54.8%)	421 (49.5%)
Period		
Afternoon	77 (9.1%)	57 (6.7%)
Evening	398 (46.8%)	482 (56.7%)
Morning	375 (44.1%)	311 (36.6%)
Obstacle present		
No	676 (79.5%)	723 (85.1%)
Yes	174 (20.5%)	127 (14.9%)
Group cross		
Yes	692 (81.4%)	698 (82.1%)
No	158 (18.6%)	152 (17.9%)
Child accompanied		
Yes	136 (16%)	87 (10.2%)
No	714 (84%)	763 (89.8%)
Vehicle		
Two-wheeler	302 (35.5%)	242 (28.5%)
Four-wheeler	548 (64.5%)	608 (71.5%)

Table 2. Prevalence of driver yield and safe crossing behavior for intervention and control.

	Intervention $N=850$		Control $N=850$	
	n	Prevalence (95% CI)	n	Prevalence (95% CI)
Driver yielded	626	73.6 (70.6–76.5)	102	12.0 (10–14.4)
Safely crossed	614	72.2 (69.1–75.1)	446	52.5 (49.1–55.8)

Table 3. Prevalence ratios for driver yield.

	Crude		Adjusted	
	Prevalence ratio	95% CI	Prevalence ratio	95% CI
Study arm				
Control	Ref	Ref	Ref	Ref
Intervention	7.3	(4.37–12.03)	7.2	(4.42–11.82)
Sex				
Female	Ref	Ref	Ref	Ref
Male	1.1	(0.97–1.20)	1.0	(0.96–1.12)
Period				
Afternoon	Ref	Ref	Ref	Ref
Evening	1.1	(0.72–1.59)	1.0	(0.72–1.46)
Morning	0.9	(0.65–1.23)	1.0	(0.72–1.46)
Obstacle present				
No	Ref	Ref	Ref	Ref
Yes	1.0	(0.67–1.42)	1.3	(1.01–1.56)
Group crossing				
Group	Ref	Ref	Ref	Ref
Alone	0.6	(0.47–0.77)	0.7	(0.57–0.85)
Child accompanied				
Yes	Ref	Ref	Ref	Ref
No	0.8	(0.49–1.46)	0.8	(0.45–1.39)
Nearest vehicle				
Two wheels	Ref	Ref	Ref	Ref
Four wheels	1.1	(0.88–1.47)	1.2	(0.98–1.51)

Adjusted for clustering at the school level, sex, period of the day, presence of an obstacle, group cross, and child accompanied and vehicle.

Table 4. Prevalence ratios for child safe crossing behavior.

	Crude		Adjusted	
	Prevalence ratio	95% CI	Prevalence ratio	95% CI
Study arm				
Control	Ref	Ref	Ref	Ref
Intervention	1.7	(0.99–2.82)	1.7	(1.04–2.85)
Sex				
Female	Ref	Ref	Ref	Ref
Male	1.0	(0.91–1.11)	1.0	(0.92–1.10)
Period of day				
Afternoon	Ref	Ref	Ref	Ref
Evening	1.4	(1.00–1.85)	1.4	(1.04–1.85)
Morning	1.3	(0.94–1.70)	1.4	(1.06–1.75)
Obstacle present				
No	Ref	Ref	Ref	Ref
Yes	0.9	(0.73–1.22)	1.0	(0.77–1.31)
Group crossing				
Group	Ref	Ref	Ref	Ref
Alone	0.9	(0.83–1.05)	1.0	(0.88–1.11)
Child accompanied				
Yes	Ref	Ref	Ref	Ref
No	1.1	(0.76–1.46)	1.0	(0.72–1.30)
Nearest vehicle				
Two wheels	Ref	Ref	Ref	Ref
Four wheels	1.0	(0.93–1.19)	1.0	(0.94–1.16)

Adjusted for clustering at the school level, sex, period of the day, presence of an obstacle, group cross and child accompanied and vehicle.

Table 5. Prevalence ratios for specific child crossing behavior.

Stopped at the curb				
	Crude		Adjusted	
	Prevalence ratio	95% CI	Prevalence ratio	95% CI
Control	Ref	Ref	Ref	Ref
Intervention	1.2	(0.92–1.53)	1.2	(0.93–1.53)
Walked while crossing				
	Crude		Adjusted	
	Prevalence ratio	95% CI	Prevalence ratio	95% CI
Control	Ref	Ref	Ref	Ref
Intervention	1.1	(1.06–1.24)	1.2	(1.08–1.25)
Never crossed between vehicles.				
	Crude		Adjusted	
	Prevalence ratio	95% CI	Prevalence ratio	95% CI
Control	Ref	Ref	Ref	Ref
Intervention	1.2	(0.95–1.54)	1.2	(0.99–1.44)
Looked for oncoming vehicles				
	Crude		Adjusted	
	Prevalence ratio	95% CI	Prevalence ratio	95% CI
Control	Ref	Ref	Ref	Ref
Intervention	0.9	(0.82–0.99)	0.9	(0.84–1.00)

Discussion

The findings indicate that the school traffic warden program in Kampala was an effective strategy that promoted both driver yield to child pedestrians and safe child crossing behavior (i.e., waiting at the curb, walking while crossing, and avoiding illegal crossing between vehicles). One mechanism that might explain the higher prevalence of driver yield and safe crossing behavior in the intervention clusters is the possibility that school traffic wardens eliminate driver-pedestrian uncertainty and conflict at school crossings using their presence and red hand-held stop sign to help children cross safely (Rosenbloom, Haviv, et al. 2008). Following the established guidelines for safely crossing children from the training, the warden directed the children always to wait for them to halt the vehicles to a complete stop by raising a stop flag sign. Subsequently, the warden would use a whistle to signal the children to cross safely, ensuring the children paid close attention to the warden's signal. It could also be that these school traffic wardens, who were professionally trained and equipped with traffic signs and reflector uniforms, improved visibility and through their presence could deter negative behavior (Gutierrez et al. 2014). Other explanations for the higher safe crossing behavior could be that school traffic wardens were instrumental in supervising especially the younger, more inexperienced and vulnerable children on the road and giving practical and behavioral road safety tips such as identifying safe crossing locations (Rosenbloom, Haviv, et al. 2008). Additionally, wardens, even if not working directly under the police, may still be viewed as an authority and recognized as such by road users (Uzondu et al. 2022). There are legal provisions in the safe routes to school program in other countries for creating traffic wardens who discharge similar functions undertaken by the police in connection with traffic management, assisting pedestrians, and enforcement (Eyler et al. 2008). In the United Kingdom, wardens have authority similar to that conferred to formal traffic officials that road users recognize (Bull and Von Hagen 2014).

Our findings corroborate previous studies that generally found significant benefits of school traffic warden programs on safe road crossing behavior and knowledge improvements around road safety rules (Rosenbloom, Haviv, et al. 2008). Similar to our study, Gutierrez et al. (2014) in Florida, United States, demonstrated that increased school traffic warden presence positively influenced safe behavior, as indicated by the increased number of children using supervised routes (Gutierrez et al. 2014). However, unlike our findings that showed positive benefits, Rothman, Perry, et al. (2015) in their quasi-experiment, found no significant change in collision rate (i.e., a proxy of unsafe road behavior) following the implementation of school traffic wardens in Toronto (Rothman, Perry, et al. 2015). This finding by Rothman, Perry, et al. (2015) was explained by the deployment of school traffic wardens at higher traffic risk intersections with roadway characteristics that increase pedestrian exposure to traffic (Rothman, Perry, et al. 2015). Rothman's study, which analyzed routinely collected data across all age groups, suggested that the limited number of traffic wardens may not have effectively addressed the extent of child pedestrian safety problem, mainly because most pedestrian-motor vehicle collisions happened far from the vicinity of school crossing guard locations (Rothman, Perry, et al. 2015).

The prevalence of driver yield was lower when children crossed alone than those in a group, and this finding is consistent with other studies that reported a lower crash risk for pedestrians who crossed in a group (Ye et al. 2017; Zafri et al. 2022). Group crossing behavior by pedestrians could influence the drivers' prioritization of pedestrian right-of-way (Zafri et al. 2022). Consequently, pedestrians crossing in groups were likelier to have priority and go first before drivers at crossings. Additional research is required to understand this group cross phenomenon comprehensively.

Limitations

We relied on extracted data from video recordings and excluded variables such as age and vehicle speed because they were subjective, and their interpretation varied with this approach. In particular, we could not analyze pedestrian behavior throughout the trip, yet most crashes occur outside the school zone (Bierlaire et al. 2003). This study focused on crossings with some supportive road environment already in place, and the traffic warden is an additional road safety measure. Finally, temporal and seasonal effects were not explored due to the short study duration. Therefore, future studies should explore the level of injuries incurred by child pedestrians and include more extended observation periods and intervention time points. Strengths of this study included the cluster trial design and the large sample size. The unobtrusive recording implemented in this study allowed for a more accurate depiction of actual behavior on the road in the natural environment.

In summary, our findings suggest that the school traffic warden program is associated with increased driver yield to pedestrians and safe child pedestrian behavior (such as waiting at the curb, not running while crossing, and avoiding illegal crossing between vehicles). Given these findings, school traffic wardens play an essential role in promoting drivers to yield to pedestrians and fostering safe crossing behavior among child pedestrians. Scaling up the presence of school traffic wardens could prove valuable in complementing other road safety measures, such as pedestrian safety road infrastructure, legislation, and enforcement to protect children especially in school zones.

Author's contributions

All authors made substantial contributions to merit co-authorship. JO, OK, VN, AVN, and LA conceptualized the study. JO led the proposal writing, obtaining ethical clearance, and data collection. VN, and AVN provided technical guidance on analysis. JO drafted the work, which OK, VN, AVN, LA substantively revised. All authors approved the manuscript and took full responsibility for the conduct of the study.

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Data availability statement

All data generated or analyzed during this study are included in this published article [and its supplementary information files].

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