School Area Road Safety Assessment and Improvements (SARSAI) programme reduces road traffic injuries among children in Tanzania

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ABSTRACT

Purpose To determine the impact of a paediatric road traffic injury (RTI) prevention programme in urban Sub-Saharan Africa.

Setting Dares Salaam, Republic of Tanzania.

Methods Household surveys were conducted in catchment areas around 18 primary schools in Dar es Salaam, Republic of Tanzania; the catchment areas were divided into control and intervention groups. Collected data included basic demographic information on all school-aged household members and whether or not they had been involved in an RTI in the previous 12 months, and, if so, what the characteristics of that RTI were. Based on these findings, a separate road safety engineering site analysis and consultation with the communities and other stakeholders, an injury-prevention programme was developed and implemented, consisting of infrastructure enhancements and a site-specific educational programme. The programme was initially implemented at the intervention schools. After 1 year, data were collected in the same manner. The control group received the same intervention after follow-up data were collected.

Results Data were collected on 12 957 school-aged children in the baseline period and 13 555 school-aged children in the post-intervention period, in both the control and intervention communities. There was a statistically significant reduction in RTIs in the intervention group and a non-significant increase in RTI in the control group. The greatest reduction was in motorcycle–pedestrian RTI, private vehicle–pedestrian RTI and morning RTI.

Conclusion The programme demonstrated a significant reduction in paediatric RTI after its implementation, in very specific ways. This study demonstrates that for a reasonable investment, scientifically driven injury-prevention programmes are feasible in resource-limited settings with high paediatric RTI rates.

INTRODUCTION

Globally, an estimated 5 million people are killed as a result of injuries each year. Road traffic injuries (RTIs) comprise the highest rate of death among injuries (24%) and are projected to become the seventh-leading cause of death worldwide by 2030. Historically, RTIs have not attracted research and resources to the same extent as other public health issues, despite injury-related deaths accounting for more than 1.7 times the number of mortalities from HIV, malaria and tuberculosis combined.[1] However, more recently, RTIs have become a mounting public health concern in low-income and middle-income countries (LMICs), where nearly 90% of all RTI-related deaths occur.[2–6] One study from Ghana found that between 1995 and 2010, there was a threefold increase in RTI-related mortality.[7] The escalating burden in LMICs has been attributed to rapid urbanisation, mobilisation and proliferation of motorised vehicles.[8]

The morbidity and mortality of RTIs has been shown to be highly preventable through the implementation of specific safety-promoting interventions.[9–11] Some evidence has demonstrated that speed bumps are a particularly effective intervention, with one study estimating a cost of only US$10.90 for each disability-adjusted life year (DALY) saved.[12] Reduced speed limits and more stringent enforcement have been shown to reduce vehicle speeds in a cost-effective manner, though injury reduction based on primary data appears to be lacking in the LMIC setting.[13–15] The impact of educational programmes on preventing pedestrian RTI has yet to be quantified, though in the absence of any blatant deleterious effects, some studies have suggested modest knowledge retention.[16–18] A variable paucity of reliable secondary-data sources in LMICs—such as police records, hospital registries and mortuary statistics—further adds to the challenge of delivering and evaluating evidence-based injury-prevention initiatives.[19 20] In recent years, increased RTI advocacy by WHO and others has prompted LMIC governments to initiate adoption of policies to reduce the incidence of RTIs; however, to date, only one-third of LMICs have employed basic age, weight and height-based child-restraint laws, for instance.[8]

Amend is a non-governmental organisation working in Sub-Saharan Africa (SSA) dedicated to decreasing paediatric RTI. SSA has the world's highest rate of RTIs, and the vast majority of children in the region walk to school. Children are a particularly vulnerable population among road users in LMICs.[21] Children under 5 had a 34% increase in DALYs due to RTI from 1990 to 2010 in LMICs.[22] Amend creates site-specific injury-prevention programmes based on detailed analysis of RTI characteristics in target communities, as determined from data collected in household surveys. One of Amend's programmes, School Area Road Safety Assessments and Improvements (SARSAI),[23] involves the identification of public primary schools in urban areas with high reported RTI rates among student populations and the provision of light infrastructure measures aimed at slowing traffic and separating child pedestrians from vehicles, along with site-specific road safety education. The present quasi-experimental population-based study in Tanzania compared intervention communities that received the SARSAI programme with control populations, to quantify the impact of this programme on paediatric RTI.

METHODS

Study design

The present study evaluated the impact of the SARSAI programme on RTI among school-aged children in Dar es Salaam, Tanzania. Eighteen elementary schools were identified based on reportedly high rates of RTI among pupils, and subsequently, placed into an intervention or control group. The intervention group received the SARSAI educational programme and infrastructure enhancements, while the control group received neither until after study completion. Funding was provided by the FIA Foundation.

Data on RTIs were collected through household surveys conducted in the communities surrounding the control and intervention schools, both before and after implementation of the SARSAI programme. The United Republic of Tanzania's National Institute for Medical Research approved this study. A sample size of 13 256 school-aged children was calculated to identify a significant difference in a one-third decrease in injury incidence, with 95% CI and power set at 80%. Of note, individuals were not paired, despite having paired communities, and no identifying information was collected. An RTI was defined as an individual stating that they were involved in an RTI. Severity was quantified by number of days of normal activity missed as a result of the RTI.

Selection of school districts

The research team conducted an informal community assessment, which involved interviewing school officials, including head teachers, throughout Dar es Salaam, to identify schools with testimonially high RTI. Eighteen such schools were identified using this process. Using a combination of Google Maps (Google, Mountain View, California, USA) and pupil enrolment data, schools were divided into intervention and control groups, which were subsequently matched for environmental characteristics and pupil enrolment numbers. The specific environmental features used in selecting schools included road conditions where students entered and exited the school, roads adjacent to the school and the presence of existing traffic-calming measures. In order to ensure that groups were geographically non-adjacent, the catchment areas for the intervention and control groups were not randomised.

Household surveys

Using Google Maps, the school catchment areas (districts) were defined, and an attempt was made to visit each household within the region. A household was defined as a unit that had a separate entrance from the street or a separate apartment entrance. As many areas were within informal settlements, data collectors kept track of the houses visited by marking the doorway with chalk, to maintain accuracy while ensuring participants' anonymity.

Four teams of two research assistants, with one male and one female interviewer in each team, were used to gather data. Household surveys were conducted in both English and Swahili. Verbal consent was obtained from the head of the household before any data were collected, in accordance with the institutional review board protocol, and participants were not compensated. Of note, whereas the head of the household answered the survey, the survey was exclusively about any school-aged children residing in the household. Android tablet devices were used for data collection, and data were stored using a Google Sheets cloud-based spreadsheet application. Basic demographic data were collected about each household to create the denominator for the baseline of the study. In addition, information was collected about any RTI and/or RTI-related deaths that occurred in the past 12 months to any school-aged household family member, regardless of where the incident took place. An individual was considered to have an RTI if they reported they had an RTI in the last 12 months. Information was also collected on the circumstances of the injury, health outcomes and long-term functional status, as detailed in the survey instrument in figure 1.

One group of nine school catchment areas was arbitrarily chosen to be the control group and the other nine to be the intervention group. SARSAI comprises several components that include infrastructure enhancements designed to lower vehicle speeds and separate pedestrians from traffic—such as speed bumps, rumble strips, bollards, moving school gates, zebra crossings, sidewalks and accompanying signage—as well as a road safety education programme tailored to the school and advocacy to local and national level government.

An assessment of existing infrastructure conditions and pedestrian road-use patterns was performed in the areas surrounding each school to identify suitable improvements at each site. Of note, only the principal investigator knew prior to baseline data collection which group was the intervention group. The information obtained from the baseline data collection, in conjunction with the site assessment, was used to create a comprehensive, targeted injury-prevention programme specific for the intervention group, including infrastructure improvements and an educational programme that focused on the specific findings of the baseline data. The SARSAI programme was then implemented at the nine schools in the intervention group. For details of the SARSAI components implemented at the schools involved in this study, see figure 2. For the educational programme, children were taught how to be seen by drivers, how to choose a safe place to cross the road, how to cross safely, how to walk safely along the road and how to find a safe place to play or relax.

One year later, follow-up data were collected in the same manner to test the effectiveness of the programme and compare it with community controls. The methods of data collection and management were identical for the follow-up data. The same communities were studied, but no attempt to pair individuals was made. The entire SARSAI programme was implemented in the control communities after all the follow-up data were collected.

Data analysis

Analysis was conducted using Statistical Package for the Social Sciences (SPSS) V.22.0 (IBM). Demographics were collected for the total surveyed population in order to calculate the incidence of the demographic group, as well as an injury incidence. Frequencies and means were calculated for categorical and continuous variables, respectively.

Chi-square tests of independence were used for comparing the intervention group at baseline and follow-up on counts of children with RTIs and without RTIs as well as for comparing the intervention and control group at the follow-up period on these counts of RTI and non-RTI. Note that these were two-tailed

Has the individual been injured in road traffic in the last 12 months?	○ No ○ Yes
Type of injury was sustained?	○ Cut ○ Amputation ○ Broken bone ○ Concussion/Head injury ○ Died ○ Bruise/pain ○ Burn ○ Dislocation ○ Minor injury ○ Psychological trauma
Type of Incident	○ Pedestrian ○ Rider/driver
Type of Vehicle	○ Private car ○ Taxi ○ Motorcycle ○ Mini-bus Taxi ○ Bicycle ○ Other
What time of day was the incident?	○ In the Morning ○ During the Day ○ At Sunset ○ At Night
Did this injury occur going to or from school or work?	○ No ○ Yes

Figure 1 Selected road traffic injury questions and responses.

INFRASTRUCTURE ENHANCEMENT	• A standardized assessment of school areas that looks at the behavior of children, behavior of drivers and other road users, and physical infrastructure • Identifying appropriate measures to improve safety, based on the assessment • Implementation of infrastructure improvements ○ Speed bumps ○ Bollards ○ Sidewalks ○ Signage ○ New school gates • Compensated crossing guards at peak hours
SCHOOL-BASED EDUCATION	Teach a maximum of 50 children at a time: • How to cross safely • How to be seen by drivers • How to choose safe place to cross • How to walk safely along the road • How to find a safe place to play, relax, or do business • Any community specific RTI characteristics, for example, motorcycle pedestrian injuries in the morning Training of Road Safety Instructors

Figure 2 Components of the School Area Road Safety Assessments and Improvements programme. RTI, road traffic injury.

Table 1 Demographics

	Baseline control	Baseline intervention	Post-control	Post-intervention
Male	2887	3281	3321	3333
Female	3306	3483	3372	3529
Total	6193	6764	6693	6862
Age (±SD)	9.92 (±2.31)	9.86 (±2.31)	9.77 (±2.26)	9.69 (±2.21)
Injuries	92 (1.49*)	89 (1.32*)	125 (1.87)*†	66 (0.96*)†‡

*Injury incidence per 100 person-years.
†Comparing number of road traffic injuries (RTIs) in post-control and post-intervention p<0.001.
‡Comparing number of RTIs in intervention baseline versus intervention follow-up p=0.045.

analyses without Yates correction. After collapsing to the school level (because baseline and follow-up were not matched to the same child), an analysis of covariance was used to predict the 1-year follow-up percentage of RTI incidents per school from the treatment condition, while adjusting for baseline percentage of RTI incidents at that school. Disability days were averaged and summed in total and in each age group without regard for severity.

RESULTS

Baseline data were collected from all households within each of the 18 communities from March 2015 to July 2015. Overall, households with 12 957 school-aged children (6193 control, 6764 intervention) were surveyed across the 18 schools (table 1). At baseline, 181 RTI were reported (92 control, 89 intervention) to have occurred in the past 12 months in individuals ranging from 5 to 18 years old.

In the intervention group, the SARSAI programme was fully implemented at a cost of approximately US$18 000 per school area, or US$162 000 in total. This price does not include ongoing maintenance to the infrastructure. At the two schools where crossing guard regimes were able to be put in place, that aspect of the programme is still in place 2 years later. The specific numbers of infrastructure enhancements are summarised in table 2.

Follow-up data were collected from April 2016 to July 2016 on 13 555 school-aged children (6693 control, 6862 intervention) across the 18 school districts. There were 191 injuries reported in the previous 12 months (125 control, 66 intervention).

The number of children who sustained a RTI versus those who did not was significantly lower at follow-up compared with baseline (baseline RTI vs non-RTI: 89 vs 6675; follow-up RTI vs non-RTI: 66 vs 6796; $\chi^2(1)=3.795$, $p=0.045$). Among the control group, there was no significant difference in RTI at baseline, and, after 1 year, there was a non-significant increase in RTI (baseline RTI vs non-RTI: 92 vs 6101; follow-up RTI vs non-RTI: 125 vs 6568; $\chi^2(1)=2.836$, $p=0.092$). Children with RTI compared with non-RTI at follow-up showed that those in the intervention group had significantly fewer follow-up RTIs relative to the control group (intervention RTI vs non-RTI 66 vs 6796; control RTI vs non-RTI 125 vs 6568, $\chi^2(1)=20.001$, $p<0.001$).

For further analyses, the counts of individual children were used to calculate an RTI incidence (in 100 person-years) at baseline and at follow-up for each of the 18 schools. At this school level of analysis, there was no significant difference in baseline RTI incidence between the nine schools assigned to intervention (M=1.59, SD=0.53) and the nine schools assigned to the control group (M=1.29, SD=0.63; $t(16)=1.09$, $p=0.291$). However, at follow-up, the nine schools in the intervention group had significantly lower RTI incidence (M=0.91, SD=0.46) than the nine schools in the control group (M=2.07, SD=0.78; $t(16)=3.85$, $p>0.001$). Adjusting for their baseline RTI incidence, the schools in the intervention group had a significantly lower incidence of RTI at follow-up than the schools in the control group (estimated marginal means: intervention M=0.96, SE=0.21 vs control M=2.02, SE=0.21; $F(1, 15)=11.87$, $p=0.004$). The baseline incidence of RTI was not a significant predictor of follow-up RTI incidence when adjusting for intervention condition, $F(1, 15)=1.48$, $p=0.243$.

Overall, 60.7% of injuries occurred going to school or work, but as shown in the χ^2 test in table 3, injuries going to school or work were significantly less likely after the intervention (60/6675 vs 38/6796, p=0.021) and had a non-significant increase in the control group (54/6101 vs 72/6568, p=0.273). Bruises and pain were the primary problem in half (50.0%) of RTIs overall, and while there was no significant decrease for the intervention group in broken bones, bruises/pain and cuts, the counts decreased for broken bones and bruises/pain, and there was a significant decrease in reported minor injuries. As far as modes of transportation, 93.3% of all RTIs occurred to pedestrians and just 6.7% of RTIs resulted from being a passenger. The majority of pedestrians were hit by motorcycles (53.0% at baseline). There was a non-significant decrease in the intervention group (52/6675 vs 39/6796, p=0.151). Private cars hitting pedestrians were the second most common (18.3% overall at baseline) but were significantly reduced after the intervention (19/6675 vs 4/6796, p=0.002). Half of RTIs occurred during the day (50.9%). RTIs in the morning were also common (35.6% overall) and showed a significant decrease following the intervention (44/6675 vs 22/6796, p=0.006).

Table 2 Infrastructure enhancements

Infrastructure enhancement	Total number (at nine intervention schools)
Asphalt concrete speed bumps	6
Asphalt concrete rumble strips	12
Road signs	44
Thermoplastic zebra crossings	10
Thermoplastic checkerboards on speed bumps	11
Cement concrete bollards	37
Natural earth speed bumps	10
Cement concrete slabs	11

DISCUSSION

The purpose of the present study was to evaluate improvements in infrastructure and education aimed at reducing RTI among school-aged children in Dar es Salaam, while delineating characteristics associated with RTI in this setting. Evidence from this study suggests that RTI decreased among schoolchildren in the intervention population compared with the control community during the same period. In addition, the intervention group demonstrated a reduction of RTIs from pedestrians struck by private cars, school-aged children going to/from school and overall during the morning.

A diverse array of data-collection modalities used in previous studies makes it difficult to directly compare findings from similar settings. For example, some studies looked at hospital admission records to quantify the burden of RTI, while others looked at mortuary entries.[14 24 25] Each approach highlights

Table 3 Road traffic injury (RTI) details

	Control		Intervention			χ^2 intervention baseline vs follow-up*	
	Baseline	Follow-up	Baseline	Follow-up	Total	$\chi^2(1)$	P values
RTIs	92	125	89	66	372		
Total sampled	6193	6693	6764	6862	26 512		
RTI Incidence†	1.49	1.87	1.32	0.96			
RTIs that							
Occurred going to or from school or work	54 (0.87†)	72 (1.08†)	60 (0.89†)	38 (0.55†)	224 (0.84†)	5.299	**0.021**
Injury sustained							
Broken bones	5 (0.01†)	8 (0.01†)	7 (0.10†)	6 (0.09†)	26 (0.01†)	0.092	0.763
Bruises/pain	48 (0.73†)	53 (0.79†)	48 (0.71†)	37 (0.54†)	186 (0.70†)	1.596	0.206
Cut	10 (0.16†)	30 (0.45†)	13 (0.19†)	21 (0.31†)	74 (0.28†)	1.774	0.183
Minor injury	13 (0.21†)	6 (0.09†)	13 (0.19†)	0	32 (0.12†)	13.201	**<0.001**
Other‡	16 (0.26†)	28 (0.42†)	8 (0.12†)	2 (<0.01†)	54 (0.20†)	NA§	
Characteristics							
Pedestrian injured by							
Bicycle	12 (0.02†)	24 (0.36†)	10 (0.15†)	13 (0.19†)	59 (0.22†)	0.35	0.554
Bus	4 (0.01†)	4 (<0.01†)	2 (<0.01†)	3 (<0.01†)	13 (0.05†)	NA§	
Motorcycle	35 (0.57†)	71 (1.06†)	52 (0.77†)	39 (0.57†)	197 (0.74†)	2.063	0.151
Private car	24 (0.39†)	21 (0.31†)	19 (0.28†)	4 (0.06†)	68 (0.26†)	10.017	**0.002**
Injured as a passenger	15 (0.24†)	3 (<0.01†)	1 (<0.01†)	6 (0.09†)	25 (0.09†)	NA§	
Time of day							
At night	4 (<0.01†)	5 (<0.01†)	2 (<0.01†)	1 (<0.01†)	12 (<0.01†)	NA§	
At sunset	8 (0.13†)	15 (0.23†)	8 (0.12†)	7 (0.10†)	38 (0.14†)	0.082	0.775
During the day	47 (0.76†)	72 (1.08†)	34 (0.50†)	36 (0.52†)	189 (0.71†)	0.032	0.858
In the morning	33 (0.53†)	33 (0.49†)	44 (0.65†)	22 (0.32†)	132 (0.05†)	7.691	**0.006**

*Chi-square tests of independence compare the intervention baseline and follow-up with all other children (RTIs not of that type and all non-RTIs) in the intervention baseline and follow-up.
†Per 100 person-years.
‡Injury sustained: Other includes amputations, dislocations, burns, head injury and death.
§P value not reported since individual cells were less than 5.
Statistically significant P values listed in bold.

a different aspect of the RTI problem in LMIC; however, all highlight an essentially neglected public health crisis in which children are particularly vulnerable and tend to be injured as pedestrians. Other studies that have used a population-based methodology have found strikingly similar RTI incidences. In Nepal, there was an injury incidence of 2.8/100 person-years, whereas this was found to be 3.4/100 person-years in Ghana and 3.3/100 person-years in Dar es Salaam in 2011.[26–28] Our baseline injury incidence was lower than some of these previously reported values at 1.4/100 person-years; however, the incidence still demonstrated a decrease to 0.96/100 person-years in the post-intervention group and increase to 1.9/100 person-years in the post-control group.

The SARSAI programme is focused on reducing RTI among primary school student populations in urban Africa where children are known to be at elevated risk of injury via the provision of relatively inexpensive infrastructure measures that can be rapidly installed as well as accompanying education that can be delivered quickly and inexpensively. Our study documented a statistically significant injury reduction in comparison with a community control that had a statistically significant injury incidence increase during the same study period. This is a novel finding that demonstrates the effectiveness of this programme.

In addition to demonstrating a reduction in RTI incidence, there were other findings that will shape the intervention and further research moving forward. We chose to mention them here because they are interesting, even though they did not show sufficient change to be considered in a meaningful inferential analysis. There were practically no night-time injuries in any group or RTI from minibus taxis (a common form of public transportation in Dar es Salaam). Also, while there was a non-significant reduction in the number of motorcycle-associated RTIs post-intervention (0.08/100 person-years vs 0.06/100 person-years, p=0.151), the reduction was exclusive to mornings as morning motorcycle-associated RTI reduced from 27 to 14 (0.04/100 person-years vs 0.02/100 person-years, p=0.055). There was no effect on daytime motorcycle-associated RTI with the pre-intervention and post-intervention groups both having 20 RTIs. In addition, all car-associated RTIs in the morning were eliminated (8/6675 vs 0/6769, p<0.001), whereas the daytime car-associated RTIs were only reduced by half (8/6675 vs 4/6769). While the total numbers in this aspect of analysis limit their generalisability, it suggests that the programme may be effective in reducing morning injury, but that traffic patterns or road-user characteristics during the day are not as amenable to the intervention in its current form. A larger sample size may have made these observations more relevant and allowed them to be actual findings, as opposed to interesting footnotes of the main results.

While the implications of this subgroup analysis are not entirely clear, having specific feedback on the effectiveness of different aspects of the intervention serves as an example of how data-driven injury-prevention research can become increasingly effective and efficient. This information can be used to guide future subgroup analyses and targeted intervention efforts. Additionally, more research could be conducted to identify ways to reduce motorcycle–pedestrian RTI since motorcycles are increasingly common in SSA; this is an area less responsive to the current paradigm, and evidence-based strategies are currently not available for the LMIC setting.

Several strengths of this study include its robust study design using pre/post and control/intervention comparison. This avoided any potential impact of secular trends. In addition, the collection of primary data was essential to accurately capture the impact of RTI in this community since it is well established that secondary data are unreliable in most LMICs, with one study in a similar environment noting that a police report was only filed in 50.2% of RTIs.[28]

There were several limitations to the study. The inclusion of each particular school was not done in a quantifiable manner. Since there were no primary data available, the identification of high-risk schools was through an informal interviewing process. While we were able to ensure that the two groups were similar in pupil enrolment size and infrastructure characteristics, the amount of labour it would have taken to formally quantify the extent of a large number of schools before making our selection limited this aspect of the study. This was a population-based study that used chalk to mark houses that were surveyed. It is unknown if families left or came to the community during the study period. When inquiring about RTI, it is not specified if the RTI took place within the school district, where the benefit of infrastructure enhancements would have been seen. Also, the Hawthorne effect may have contributed to an increase in the RTI of the control group since awareness may have been raised about RTI, but no intervention was administered until after data collection. Recall bias could also be a factor, given participants were asked to recall injury-specific information for the past year. It is a known phenomenon that recall is decreased in a time frame greater than 3 months from the injury in this setting.[29] The study population may not be an accurate representation of Dar es Salaam, other regions of SSA or LMIC populations in general.

While RTI rates are undergoing long-term, systemic reductions in high-income countries, they are increasing in LMICs, especially in SSA. Despite some limitations, this study is novel and important in demonstrating that site-specific infrastructural improvements paired with education can reduce RTI in school-aged children.

What is already known on the subject

- ► Road traffic injuries (RTIs) in low-income and middle-income countries (LMICs) are a major public health problem.
- ► Secondary data are unreliable in the LMIC setting.
- ► Children are vulnerable as pedestrians.

What this study adds

- ► A reduction in childhood RTI is possible in a resource-limited setting.
- ► Scientifically driven RTI prevention is feasible in a resource-limited setting.
- ► Light infrastructure improvements and education are effective when tailored to the community.

With the adoption of successful programmes like SARSAI, and its approach to data-driven refinement, an RTI reduction in schoolchildren may be possible in other settings. This will help achieve the RTI reduction goals stated in international agreements such as the 2016 United Nations Sustainable Development Goals.

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