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Evaluation of the effectiveness of traffic calming measures on vehicle speeds and pedestrian injury severity in Ghana.

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Abstract

Objectives: Each year, pedestrian injuries constitute over 40% of all road casualty deaths and up to 60% of all urban road casualty deaths in Ghana. This is as a result of the overwhelming dependence on walking as a mode of transport in an environment where there is high vehicular speeds, and inadequate pedestrian facilities. The objectives of this research were to establish (1) the impact of traffic calming measures on vehicle speeds and (2) the association between traffic calming measures and pedestrians' injury severity in built-up areas in Ghana.

Method: Vehicle speeds were unobtrusively measured in 38 selected settlements comprising 19 “with” and 19 “without” traffic calming schemes. The study design used in this research was a matched case-control. A regression analysis compared case and control casualties using a conditional logistic regression.

Results: Generally, the mean vehicle speeds and the proportion of vehicles exceeding the 50 km/hour speed limit were significantly lower in settlements which have traffic calming measures compared with towns without any traffic calming measures. Additionally, the proportion of motorists who exceeded the speed limit was 30% or less in settlements which have traffic calming devices whilst the proportion who exceeded the speed limit was 60% or more in towns without any traffic calming measures. The odds of pedestrian fatality was significantly higher in settlements which have **no** traffic calming devices compared to those which have, OR=1.98; (95% CI=1.09 to 4.43). The protective effects of a traffic calming scheme which has a speed table was notably higher than where there were no speed tables.

Conclusion: It was clearly evident that traffic calming devices reduce vehicular speeds and for that matter, the incidence and severity of pedestrian injuries in built-up areas in Ghana. However, the fact that they are deployed on arterial roads is increasingly becoming a road safety concern. Given the emerging safety challenges associated with speed calming measures, we recommend their use to be restricted to residential streets but not on arterial roads. Long term solutions for improving pedestrian safety proposed herein include by-passing settlements along the highways to

reduce pedestrians' exposure to traffic collisions, adopting a modern way of enforcement such as evidence-based laser monitoring in conjunction with a punishment regime which utilizes the demerit points system.

Keywords

traffic calming measures; demerit points; enforcement; pedestrian injuries; speeding; by-pass

BACKGROUND

Pedestrian injuries are a growing public health problem in Low and Middle Income Countries (LMIC). In Ghana, over 40% of all road injury casualties are pedestrians. High pedestrian injury rates have also been reported in many LMICs. Crash statistics show that pedestrian fatalities constitute over 60% of all urban road user deaths in Ghana (Building & Road Research Institute 2016) and some LMICs (Donroe et al. 2008, Khayesi 1997). Conversely, many High Income Countries (HICs) generally have less than 15% of their traffic crash victims being pedestrians (Retting et al. 2003, WHO 2009, Zhu et al. 2008).

The unfavorable disparities in pedestrians' injury rates between LMICs and HICs have arisen largely because LMICs do not usually formulate appropriate rules to protect road users, particularly pedestrians. If they do, the good will to enforce these laws associated with motorization is lacking. For instance, while pedestrian facilities like sidewalks, pedestrians' paths and bridges and the practice of motorists yielding for pedestrians at crosswalks, are available to promote walking in HICs, these facilities are generally lacking in Ghana and many LMICs. Therefore, pedestrians and fast moving vehicles share the same road space to the detriment of pedestrians. In many African countries, over 80% of students walk to schools (Koekemoer et al. 2017). In Ghana, road reservations in settlements have been encroached upon in many cities. Residents use these spaces mainly for roadside trading. Sometimes roadside hawking activities do spread to the road shoulders which are in most cases the only spaces available for pedestrians to walk on. Speeding is an important risk factor for pedestrians' injuries. For example, the fatality risk for pedestrians will increase by 4.5 times when the striking speed of a vehicle increases from 50 km/hour to 65km/hour (WHO 2018). Nevertheless, speeding is pervasive in Ghana to the extent that over 90% of motorists exceed the posted speed limits in this country (Damsere-Derry et al. 2008, Derry et al. 2007). Pedestrians are therefore exposed to road injuries. Between 2002 and 2006 for instance, police crash data showed that the probability of pedestrians' death to be attributed to excessive speeding in Ghana was 65% (Damsere-Derry et al. 2010).

In the HICs, multifaceted prevention techniques by first separating vulnerable road users such as pedestrians from fast moving vehicles by providing the requisite pedestrians' infrastructure and enforcing traffic regulations using deterrent-based techniques have collectively worked to promote pedestrians' safety in those countries. According to the deterrent theory, criminal behaviors (in this case breaking speeding regulation) can be prevented by threatening potential offenders with punishment that produces pain or loss which outweigh any pleasure, reward or gain associated with the criminal act (Robinson 2010). The deterrent theory has three main elements namely *certainty*, *celerity* and *severity*.

According to this theory, for any road safety countermeasure to work, motorists should perceive that the probability of being detected, apprehended and punished is high (*certainty of detection, apprehension, and punishment*), swiftness (*celerity*) of the punishment and *severity* of punishment. Evaluation of road safety interventions in the U.S. indicate that deterrence theory is the underpinning reason for the success of the speed limit law (Ritchey, Nicholson-Crotty 2011). The demerit point system is an example of a deterrence based-theory of enforcement used in many HICs to discourage speeding motorist. Under this system, each individual is given 10 to 30 points depending on the jurisdiction. When a motorist commits any traffic offence, some points are deducted from his total points until the individual's points are exhausted, then, he will be suspended from driving a vehicle for a period of time. In Queensland, Australia for example when a motorist is caught travelling above the speed limit but less than 13 km/hour, he is fined AUD 162 and loses 1 demerit point but will be fined AUD 1,137 and loses 8 demerit points when traveling more than 40 km/hour above the speed limit (Queensland Government 2017). This punishment is for first time offenders. Recidivism of the speeding behavior usually attracts severer punishments.

Conversely, in Ghana the concept of deterrence theory is not much grounded in road safety matters. This is largely because the police whose duty it is to initiate enforcement is alleged to have been compromised (Adu Gyamfi 2015, Starrfmonline.com 2015). Therefore, in an effort to combat speed related pedestrian injuries in Ghana various traffic calming devices have been installed in many towns and hazardous road locations. Speed calmers such as bumps and humps force motorists to significantly reduce their speeds so as to avoid sudden vertical accelerations (Lav et al. 2017). The treated sections which had the traffic calming measures we evaluated in this report were usually a combination of many speed reducing interventions including; speed limit sign, carriageway narrowing, roadline marking, rubberized delineators, studs, speed humps, speed tables and speed bumps. These devices have been constituted to form traffic calming schemes in settlements along arterial roads in Ghana. There can be between a combination of two and five different types of traffic calming devices per location. But the focus of this report is on speed tables, speed humps and speed bumps which have become the predominant speed calming measures in Ghana.

Evaluation of a few traffic calming devices in Ghana showed a significant decline in pedestrian injuries and severity (Afukaar 2003, Afukaar, Damsere-Derry 2010). The effectiveness of traffic calming devices are also reported elsewhere (Jones et al. 2005, Tester et al. 2004). According to Tester et al., (2004), installation of speed humps in residential neighborhoods in Oakland, California, in the United States, significantly reduced child-pedestrians injury by 53%. Elsewhere, these physical speed reducers are restricted to local and residential neighborhoods. However, in Ghana, their use are not limited to local streets but also on arterial and trunk roads which is increasingly becoming a road safety challenge.

The effectiveness of speed calming devices in reducing vehicular speeds and for that matter pedestrian injuries has been widely approved as the state-of-the art traffic calming countermeasures in Ghana. This is largely due to the ineffective enforcement of the speed law in Ghana by the police. Travelling along major roads in this country reveals how desperate residents are demanding for traffic calming devices in their towns due to excessive speeding. During electioneering era, inscriptions such as '*No speed humps, No votes*'

slogans are posted on bill boards as communities' appeal to road authorities (politicians) for traffic calming devices. Sometimes, when their demands for traffic calming devices are not forthcoming, resulting in pedestrian accidents, residents take the law into their own hands to build 'illegal' speed calming measures (Ultimatefmonline.com 2018). The caveat of using illegal speed calming devices is that they can cause pavement distress (Abdel-Wahed, Hashim 2017, Bekheet 2014) as well as trigger spinal injury and road accident injuries or death (David Kodjo 2016, Myjoyonline.com 2016). In particular, self-community built speed calmers pose mobility and safety problems.

This article evaluates the effectiveness of speed calming devices and recommends alternatives as well as long term speed control measures to improve pedestrian injury prevention strategies.

Objectives

The objectives of this study are to establish the: (1) impact of traffic calming measures on vehicle speeds and (2) association between traffic calming measures and pedestrians' injury severity in built-up areas in Ghana.

METHODOLOGY

Data sources

This research used two main sources of data; primary source and secondary source. The primary data were vehicle speed data obtained from the field. Vehicle speeds were obtained on 11,329 vehicles in 38 settlements located across the country. A radar speed gun was used to unobtrusively measure vehicle speeds in a snapshot fashion. At each location, vehicle speeds were measured for two hours on high traffic volume roads and three hours on low volume roads. The method for speed measurement have been described in detail in an earlier report (Derry et al. 2007).

The secondary data used in this report were obtained from the Building & Road Research Institute's (BRRRI) accident data bank. These data are collated from police accident report. Like many datasets, there is some underreporting of accident data in Ghana (Salifu, Ackaah 2012). Severely injured or fatal accidents are however less likely to be underreported because the victims or their relatives might need police report to claim their insurance entitlements. Classifications of the road injury severity is based on a thirty-day timeframe. For instance, if a casualty dies within thirty days of a collision or is hospitalized for at least 24-hours within thirty days after a road crash, the injury severity is classified as fatal and hospitalized injuries respectively.

Site selection

We conducted a matched case-control study using small-medium settlements situated on selected trunk roads in Ghana. The mean inhabitants per location was about 4,800. There were 38 settlements studied. Nineteen (19) of the settlements had some traffic calming measures while the other 19 had no traffic calming measures. There was however, a variation of population from the least of 211 inhabitants at Akrade on the Tema-Akosombo highway

to the highest of about 27,000 population at Odumase (Konongo) on the Accra-Kumasi Highway. Perhaps, the best alternative to measuring pedestrian exposure is traffic volumes. However, these data are currently unavailable in Ghana. Each settlement had the 50 km/hour speed limit signs. The highways investigated were the major arterial roads in Ghana namely; national (N), inter-regional (IR) and regional (R) highways (roads). Characteristically, these roads are predominantly single carriageways. Although in most cases, there were no perfect matches of settlements, attempts were made to find settlements with comparable populations. Settlements which have a population difference of less than 1,000 residents were assumed to have comparable exposure. In essence, efforts were made in the field to pair towns which have traffic calming measures with settlements without these interventions based on populations. Case casualties were injured pedestrians in settlements with speed calming devices whilst controls were casualties found in settlements with no traffic calming devices.

Analysis

After the field data collection, frequency matching with respect to age and gender of the pedestrian casualties was carried out. Since the traffic calming measures were installed at different times at different locations, traffic crash data for the same time periods were retrieved and used. All the settlements had a speed limit of 50km/hour.

Injury severity was the dependent variable in the analysis. This variable was binary i.e., fatal versus non-fatal. Having a traffic calming measure or not in settlements was our principal predictor variable which is also dichotomous. We used traffic crash data from the BRRI databank with the guidance of strip maps in such a manner that pedestrian injuries for road sections on the arterial roads of each settlement were delineated from other sections of the road. Other co-variables studied included; time of day of crash, age and gender of traffic injury casualties and the mean vehicle speeds in the settlements.

The numerical variables among the covariates were casualty age (discrete) and vehicle speeds (continuous) which were stratified into three and two levels respectively. The classification of age was as follows; 0 – 17 years as children, 18 – 59 years as the active adult population (reference); and 60 or more years as the elderly. Similarly, prevailing mean vehicle speeds were dichotomized into speeds up to 50km/hour, as the reference, and mean speed greater than 50km/hour for comparison.

The logistic regression model

Statistical analyses were conducted using the STATA software (Windows Version 13, College Station, TX). We used the Standard Logistic Regression (SLR) analyses to obtain the unadjusted Odds Ratios and a multivariable conditional logistic regression to estimate the adjusted Odds Ratios.

The logistic regression function describing the logistic model is in the form:

$$f(z) = \frac{1}{1 + e^{-z}} \quad (1)$$

The conditional logistic model for matched analysis is given as:

$$\text{logit } P(X) = \alpha + \beta E + \sum \gamma_{1i} + \sum \gamma_{2i} V_{2i} + E \sum \delta_j W_j \quad (2)$$

Where α is a constant, E is the exposure variable (status of traffic calming devices), β is the coefficient of the exposure variable, γ_{1i} are coefficients of the dummy variables, W_j denotes potential confounders, γ_{2i} are the coefficients of the potential confounders not involved in the matching, and δ_j are the coefficients of the product interaction variables if present (Kleinbaum, Klein 2010).

Study Period

The vehicle speeds were measured in 2011. Six year accident data (i.e., 2006–2011) for the settlements were obtained analyzed.

Ethical Approval

The study used a publicly available dataset at the Building & Road Research Institute without any identifiers and was therefore exempted from ethical approval reviews by the Committee on Human Research and Ethics of the Kwame Nkrumah University of Science & Technology (KNUST).

RESULTS

Distribution of vehicle speeds

In total, free flowing speeds were measured on 11,329 vehicles in built-up areas with a speed gun and the results displayed in Tables 1. Typically, the mean speeds in settlements and the proportion of vehicles exceeding the speed limits were considerably lower in settlements with traffic calming devices compared with locations without any traffic calming schemes. For example, among settlements which have traffic calming devices, the observed mean speeds were most often less than the posted speed limit of 50 km/hour e.g., Kubease (43 km/hour), Anyinam (41 km/hour), Bokro (43 km/hour) and Kpong (37 km/hour). There were however a small number of settlements which have traffic calming schemes and yet recorded mean vehicle speeds far greater than the posted speed of 50 km/hour as in Kikam (63 km/hour), Bechem (66 km/hour), Anomabu (68 km/hour) and Biriwa (75km/hour). It was evident that generally, traffic calming schemes which included speed tables recorded mean speeds less than the 50 km/hour and low excessive speeds ranging between 0% and 30%. Apegusu was an exception to this finding in that excessive speeding (in terms of vehicles travelling above the posted speed limit of 50 km/hour) still hover around 70% despite the inclusion of speed tables in the calming scheme. Notably, traffic calming schemes without speed tables were associated with mean speeds far greater than the 50 km/hour limit and higher proportion of motorists travelling above the speed limit. For example, Bechem, Ntonso, Denase, Anomabu and Biriwa were among settlements in which over 80% of vehicles were travelling above the posted speed limits though there were some traffic calming measures in place. Two reasons accounted for this situation: first, the speeding countermeasures in these towns did not include speed tables and second, most of the installations had worn out due to continuous usage without any maintenance.

In contrast, among settlements which have no traffic calming measures as presented in Table 1, the mean vehicular speeds were generally in excess of the posted speed limit of 50 km/hour varying from the least of 55km/hour at Abofuor on the Kumasi-Techiman highway to the highest of 86 km/hour at Atwedie on the Kumasi-Accra highway.

Travelling higher than the speed limits were generally greater in such towns without any traffic calming devices compared with those with traffic calming measures. Among the settlements without any traffic calming schemes, excessive speeds ranged between the least of 60% at Abofuor to the highest of 100% at Egyirikrom and Sanfo Aduam both on the Yamoransa-Kumasi highway and Supomu Dunkwa on the Cape Coast-Takoradi highway as shown in Table 1.

Pedestrian casualty injury analysis

There were 201 pedestrian casualties reported by the police in the selected settlements over the study period of which 33% was fatal, 53% was either slightly injured and their treatment required no elaborate hospitalization or seriously injured requiring at least a 24-hour hospitalization whilst 14% was apparently, not injured. Casualty injury classes were dichotomized into two levels; fatal and non-fatal- for the SLR and the multivariable conditional logistic regression analysis.

As shown in Table 2, seventy-six (76) pedestrian casualties constituting (38%) of the pedestrians' casualties occurred in settlements which have traffic calming schemes whilst 124 number casualties representing 62% of the total pedestrian casualties in the study coincided with settlements which have no traffic calming schemes. The SLR and multivariable conditional logistic regression analysis results are displayed in Table 2.

Association between pedestrian injuries and traffic calming measures

Pedestrians' injury severity were significantly associated with traffic calming measures. After accounting for time of day, pedestrians' gender and age, the adjusted Odds Ratio (OR) for pedestrian fatalities in settlements was 1.78 times higher in settlements without traffic calming measures compared with settlements which have traffic calming schemes (OR=1.78; 95% CI: 1.09–4.43). Comparing traffic calming schemes which have no speed tables with those which have speed tables revealed that the latter were more protective than the former. The odds of pedestrian fatality in settlements which have no speed tables in their traffic calming schemes were 3-fold higher than the odds of pedestrians' death in towns which have speed tables in their calming schemes.

DISCUSSION

Travelling above the speed limit in built-up areas is a common practice in Ghana. This research shows that between 60% and 100% of drivers typically travel above the mandatory 50 km/hour speed limit in settlements in Ghana when there are no traffic calming devices. By implication, pedestrians' lives are endangered by speeding vehicles in towns along the major trunk roads. It was evident in the study that traffic calming schemes are capable of controlling vehicle speeds and consequently, reducing the incidence and severity of pedestrian-vehicle collisions along major inter-urban highways in Ghana. If a pedestrian is

involved in a crash in settlements which have no traffic calming devices, it is twice as likely to result in a fatality compared with crashes in towns where traffic calming schemes were present. Among settlements which have traffic calming schemes, the protective effects were particularly pronounced if the traffic calming scheme contained speed tables. The protective effects apparently waned off when the calming scheme is 5 years old without any maintenance. As Bishai and Hyder (2006) indicated, some traffic calming measures e.g., speed humps could perform on the road up to 10 years. We recommend that any calming scheme which does not have speed humps or speed table should be replaced periodically say, every five years. The use of the traffic calming measures should however be restricted to residential streets and not on the urban arterial roads.

It is worthy to note that Ghana inherited the road system from the colonial British regime and the main focus of road construction during that time was to link settlements as a way of opening up the country for development. Vehicle speeds and traffic volumes were notably low then. Several years later, traffic volumes on roads have increased, vehicle technology has improved tremendously and cars now travel much faster than before. Yet, this tradition of high speed roads passing through settlements has not changed in Ghana. New roads are virtually, superimposed on old road alignments. Research has however, shown a greater association between pedestrian injuries especially involving children and high traffic volumes (Christie 2000, Donroe et al. 2008, Roberts et al. 1995). Roberts et al., (1995) for example, noted in their study that the risk of pedestrian injuries at locations with highest traffic volumes was 14 times greater than the least volume sites. In spite of this, until recently, the installation of traffic calming devices was an afterthought in Ghana because they were provided only when residents demanded that traffic countermeasures should be provided to slow down vehicles passing through their towns, usually, after a couple of residents had died through vehicular-pedestrian collisions.

It was observed that, installation of traffic calming schemes i.e., speed bumps, tables and humps does not entirely eradicate excessive speeding in settlements or preclude the occurrence of pedestrian injuries especially when the schemes do not include speed tables. Rather, the incidence and severity of pedestrian injuries are ameliorated when traffic calming devices are installed. In the wake of pedestrians' exposure, long term pedestrian safety strategies are proposed: Firstly, there is a need to by-pass settlements along arterial roads (Derry et al. 2007). This will considerably reduce the traffic volumes and improve the general livability in these settlements. This is because vehicles which are bound for farther destinations particularly when the occupants have nothing doing in these towns, travelers may use the by-passes and free settlements of speeding vehicles. This will also pave the way for reasonable speeds for motorists. Otherwise, travelling on traffic calming devices (i.e., speed bumps, tables and humps) has become monotonous and irritating as there are a number of built-up areas along the major roads.

There is a great deal of pedestrian activities in Ghana, therefore, the new paradigm of road construction should be pedestrian focused encouraging the provision of requisite pedestrian infrastructure (Damsere-Derry et al. 2017). Inclusion of sidewalks, crosswalks, paths and pedestrian bridges will improve upon the livability of towns along the major highways in

this country. City authorities should ensure that these facilities when provided are not taken over by hawkers but used mainly for walking.

It is not clear as whether the magnitude of motorists travelling above the speed limit in Ghana is as a result that motorists regard the speed limits as inappropriate or that they just have the desire to break the traffic rules because of weak enforcement. For compliance of speed limit to be high, a majority of the motorists must perceive the rule to be legitimate and appropriate so that drivers can comply with them voluntarily. Otherwise large numbers of drivers may disregard the limit to such an extent that enforcement may be problematic (Transportation Research Board 1998).

Evidenced-based enforcement which utilizes deterrent theory should be adopted. For motorists to comply with speed limits there should be a high perceived risk of *certainty of apprehension and punishment*, *celerity* of punishment and *severity* of punishment. In Queensland, Australia for example, first time speeding offender travelling 40 km/hour above the speed limit loses 8 demerit points and pays a fine of AUD 1,137 (Queensland Government 2017). This system of punishment will have a much more deterrent effect particularly among commercial drivers whose livelihoods depend on driving a motor vehicle. This punishment regime will require providing police with state-of-the-art equipment for speed enforcement. The police should however change their corrupt behavior (Adu Gyamfi 2015, Myjoyonline.com 2016) and dedicate these resources to enforcement.

Traffic calming devices have been proven to significantly reduce vehicle speeds and consequently, improve upon pedestrians' safety in Ghana. However, the fact that they are being deployed on the arterial roads is increasingly becoming a road safety concern. The vast majority of vehicles traversing these settlements on trunk roads are bound for destinations farther away. Therefore, the tradition of routing major roads through towns have to be reviewed. If detours were provided in future road constructions, much of the traffic may use these by-passes thereby minimizing the number of potential speed limit violators and ultimately prevent a greater proportion of potential vehicle-pedestrian collisions which might arise.

Enforcement technique which uses the demerit points should also be adopted for long term speed control in Ghana.

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References:

- Abdel-Wahed TA, Hashim IH. Effect of speed hump characteristics on pavement condition. *Journal of Traffic and Transportation Engineering (English Edition)*. 2017;4(1):103–110.
- Adu Gyamfi A. IEA Research: Office of the Prez 2nd most corrupt institution in Ghana. Accra: peacefmonline.com; 2015.

- Afukaar FK. Speed control in developing countries: issues, challenges and opportunities in reducing road traffic injuries. *Injury Control and Safety Promotion*. 2003;10(1–2):77–81. [PubMed: 12772489]
- Afukaar FK, Damsere-Derry J. Evaluation of speed humps on pedestrian injuries in Ghana. *Injury Prevention*. 2010;16(Suppl 1):A205–A206.
- Bekheet W. Short term performance and effect of speed humps on pavement condition of Alexandria Governorate roads. *Alexandria Engineering Journal*. 2014;53(4):855–861.
- Bishai DM, Hyder AA. Modeling the cost effectiveness of injury interventions in lower and middle income countries: opportunities and challenges. *Cost Effectiveness and Resource Allocation*. 2006;4(1):2. [PubMed: 16423285]
- Building & Road Research Institute. Road Traffic Crashes in Ghana, Statistics 2015. (National Road Safety Commission), Ministry of Transport;2016.
- Christie N. The high risk child pedestrian: socio-economic and environmental factors in their accidents. PR 117. *Journal TRL*. 2000:33.
- Damsere-Derry J, Afukaar FK, Donkor P, Mock C. Assessment of vehicle speeds on different categories of roadways in Ghana. *International Journal of Injury Control and Safety Promotion*. 2008;15(2):83–91. [PubMed: 18642165]
- Damsere-Derry J, Ebel B, Mock C, Afukaar F, Donkor P. Pedestrians injury patterns in Ghana. *Accident Analysis & Prevention*. 2010;42:1080–1088. [PubMed: 20441816]
- Damsere-Derry J, Palk G, King M. Road accident fatality risks for “vulnerable” versus “protected” road users in northern Ghana. *Traffic Injury Prevention*. 2017;18(7):736–743. [PubMed: 28296466]
- Kodjo David. 5 die, 53 injured in accident. *Ghanaian Times*; 2016.
- Derry JD, Afukaar FK, Donkor P, Mock C. Study of Vehicle Speeds on a Major Highway in Ghana: Implication for monitoring and control. *Traffic Injury Prevention*. 2007;8(2):142–146. [PubMed: 17497517]
- Donroe J, Tincopa M, Gilman RH, Brugge D, Moore DA. Pedestrian road traffic injuries in urban Peruvian children and adolescents: case control analyses of personal and environmental risk factors. *PLoS One*. 2008;3(9):e3166. [PubMed: 18781206]
- Jones SJ, Lyons RA, John A, Palmer S. Traffic calming policy can reduce inequalities in child pedestrian injuries: database study. *Injury Prevention*. 2005;11(3):152–156. [PubMed: 15933407]
- Khayesi M. Livable streets for pedestrians in Nairobi: the challenge of road traffic accidents. *World Transport Policy and Practice*. 1997;3:4–7.
- Kleinbaum DG, Klein M. *Logistic Regression: A Self-Learning Text*. New York: Springer New York; 2010.
- Koekemoer K, Van Gesselien M, Van Niekerk A, Govender R, Van As AB. Child pedestrian safety knowledge, behaviour and road injury in Cape Town, South Africa. *Accident Analysis & Prevention*. 2017;99:202–209. [PubMed: 27960100]
- Lav AH, Bilgin E, Lav AH. A fundamental experimental approach for optimal design of speed bumps. *Accident Analysis & Prevention*. 2017.
- [Myjoyonline.com](http://myjoyonline.com). Speed ramps to cause spinal injury-Minister. *GhanaWeb Health News*; 2016.
- Queensland Government. Speeding fines and demerit points In: *Roads DoTaM*, ed. Queensland, Australia 2017.
- Retting RA, Ferguson SA, McCartt AT. A review of evidence-based traffic engineering measures designed to reduce pedestrian–motor vehicle crashes. *American Journal of Public Health*. 2003;93(9):1456–1463. [PubMed: 12948963]
- Ritchey M, Nicholson-Crotty S. Deterrence Theory and the implementation of speed limits in the American States. *Policy Studies Journal*. 2011;39(2):329–346.
- Roberts I, Norton R, Jackson R, Dunn R, Hassall I. Effect of environmental factors on risk of injury of child pedestrians by motor vehicles: a case-control study. *BMJ*. 1995;310(6972):91–94. [PubMed: 7833733]
- Deterrence Robinson M.. *Encyclopedia of Victimology and Crime Prevention*. SAGE Publications, Inc Thousand Oaks, CA: SAGE Publications, Inc.; 2010.

- Salifu M, Ackaah W. Under-reporting of road traffic crash data in Ghana. *International Journal of Injury Control and Safety Promotion*. 2012;19(4):331–339. [PubMed: 22035060]
- [Starrfmonline.com](#). Image of police at a low ebb-Short. 2015.
- Tester JM, Rutherford GW, Wald Z, Rutherford MW. A matched case–control study evaluating the effectiveness of speed humps in reducing child pedestrian injuries. *American Journal of Public Health*. 2004;94(4):646–650. [PubMed: 15054019]
- Transportation Research Board. Managing Speed: Review of current practice for setting and enforcing speed limits. Washington, D.C.: Transportation Research Board;1998 Special Report 254
- [Ultimatefmonline.com](#). Frustrated Kegyina residents construct speed ramps to stop deaths. Ghanaweb; 2018.
- WHO. Global Status Report on Road Safety: Time for Action. Geneva 2009.
- WHO. Road traffic injuries. Facts sheet 2018; Facts sheet. Available at: <https://www.who.int/news-room/fact-sheets/detail/road-traffic-injuries>. Accessed 7th December, 2018, 2018.
- Zhu M, Cummings P, Chu H, Xiang H. Urban and rural variation in walking patterns and pedestrian crashes. *Injury Prevention*. 2008;14(6):377–380. [PubMed: 19074243]

Table 1:

Vehicle speed distribution in settlements with and without traffic calming measures

Location	Road Section	Status of Speed Tables	Observation	Mean Speed	% > 50 km/hour
<i>List of settlements with speed calming devices</i>					
Kubease	Accra-Kumasi	Present	362	42.7	30.5
Anyinam	Accra-Kumasi	Present	417	40.7	0.0
Ejisu	Accra-Kumasi	Present	264	44.5	23.3
Frankadua	Adome - Ho	Present	160	48.9	32.1
Apeguso	Adome - Ho	Present	121	56.5	72.1
Kpong	Tema - Akosombo	Present	240	37.4	9.1
Kuluedor	Tema - Aflao	Present	303	41.5	19.6
Dahwenya	Tema - Aflao	Present	178	37.9	22.4
Awutu-Breku	Accra - Cape Coast	Present	210	36.2	7.1
Anomabu	Accra - Cape Coast	Absent	312	67.8	85.4
Biriwa	Accra - Cape Coast	Absent	213	74.5	93.0
Gomoa-Fete	Accra - Cape Coast	Absent	183	57.7	56.4
Bokro	Takoradi - Elubo	Present	315	43.1	8.3
Ewusie Joe	Takoradi - Elubo	Present	213	45.6	25.0
Kikam	Takoradi - Elubo	Absent	329	63.3	73.7
Ntonso	Kumasi - Mampong	Absent	211	60.3	80.0
Ahenkro (Offinso)	Kumasi - Techiman	Present	190	51	46.2
Bechem	Kumasi - Sunyani	Absent	207	66.4	89.3
Denase	Kumasi - Techiman	Absent	219	61.1	88.6
<i>List of settlements without speed calming devices</i>					
Atwedie	Accra - Kumasi	N/A	525	86	96.1
Odumasi	Accra - Kumasi	N/A	360	64.1	80.3
Akrade	Tema - Akosombo	N/A	490	63.8	87.2
Ayensudo	Cape Coast - Takoradi	N/A	511	71.8	92.0
Supomu Dunkwa	Cape Coast - Takoradi	N/A	463	74.7	100.0
Essiama	Takoradi - Elubo	N/A	272	58.7	68.2
Abofuor	Kumasi - Techiman	N/A	343	55.4	59.5
Aboaso	Kumasi - Mampong	N/A	230	60.6	81.0
Sanfo Aduam	Yamoransa - Kumasi	N/A	347	73.7	100
Fomena	Yamoransa - Kumasi	N/A	311	58	81.8
Kojo Nkwanta	Yamoransa - Kumasi	N/A	360	64.3	93.3
Apagya	Yamoransa - Kumasi	N/A	419	64.7	88.9
Andoe	Yamoransa - Kumasi	N/A	266	67.5	75.0
Edumfa	Yamoransa - Kumasi	N/A	409	64.9	86.0
Abeka	Yamoransa - Kumasi	N/A	233	69.2	93.9
Egyirikrom	Yamoransa - Kumasi	N/A	216	80.1	100.0
Atobiase (Adanse)	Yamoransa - Kumasi	N/A	315	59.7	76.9
Sepaase	Kumasi - Bibiani	N/A	314	57.9	78.3

Location	Road Section	Status of Speed Tables	Observation	Mean Speed	% > 50 km/hour
Anyinamso	Kumasi - Bibiani	N/A	298	79	93.0

N/A = Not applicable

Table 2:

Impact of traffic calming on pedestrian traffic casualty severity in Ghana

Variable	No. of injuries (%)	Odds Ratios		
		Crude	Adjusted	95% CI
<i>Speed calming measures</i>				
Present (Referent)	76 (38%)	1.00	1.00	
Absent	124 (62%)	1.95	1.78	1.09 to 4.43 [*]
<i>Speed Table</i>				
Present (Referent)	15 (36%)	1.00		
Absent	46 (64%)	3.41		0.54 to 6.51
<i>Gender</i>				
Female (Referent)	74 (37%)	1.00		
Male	126 (63%)	1.12		1.08 to 2.46
<i>Mean speed</i>				
Less or =50 km/hour	67 (34%)	1.00		
Greater than 50 km/hour	133 (66%)	2.30		1.21 to 3.21
<i>Age (years)</i>				
18 to 59	103 (53%)	1.00		
Less or equal to 17	78 (38)	1.24		1.17 to 2.36
Greater than 60	17 (9%)	2.74		2.13 to 7.77
<i>Time of Day</i>				
Daytime (6:00 am to 5:59 pm)	125 (63%)	1.00	1.00	
Nighttime (6:00 pm to 5:59 am)	75 (37%)	3.35	2.43	1.48 to 6.12 [*]

Note

* 95% Confidence Intervals for adjusted variables