

Key Road Injury Prevention Interventions and Their Effectiveness in Africa: Conclusions and What Can Be Done Better

Yolaine Glèlè-Ahanhanzo¹, Bella Hounkpè Dos Santos², Alphonse Kpozehouen¹,
Donatien Daddah³, Moussiliou N. Paraiso⁴, Alain Leveque⁵

¹Multidisciplinary Research Unity for Road Crashes Prevention (ReMPART), Department of Epidemiology and Bio-Statistics, Regional Institute of Public Health, University of Abomey-Calavi, Ouidah, Benin

²Regional Direction of Health, Atlantique, Abomey-Calavi, Benin

³Regional Direction of Health, Couffo, Lokossa, Benin

⁴Health Promotion Department, Regional Institute of Public Health, Ouidah, Benin

⁵School of Public Health, Université Libre de Bruxelles, Brussels, Belgium

Email: nyglele@yahoo.fr

How to cite this paper: Glèlè-Ahanhanzo, Y., Dos Santos, B.H., Kpozehouen, A., Daddah, D., Paraiso, M.N. and Leveque, A. (2023) Key Road Injury Prevention Interventions and Their Effectiveness in Africa: Conclusions and What Can Be Done Better. *Open Journal of Preventive Medicine*, 13, 296-318. <https://doi.org/10.4236/ojpm.2023.1311020>

Received: October 16, 2023

Accepted: November 26, 2023

Published: November 29, 2023

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Abstract

Introduction: This study aimed to identify road safety interventions implemented in Africa and to analyze their effectiveness in reducing road crashes, injuries, disabilities and deaths. **Materials and Methods:** This is a systematic review including articles relating to the evaluation of road safety interventions implemented in Africa that were searched on electronic databases: PubMed, Scopus, Lissa, Google Scholar, and African Journals Online. Selection of articles and data extraction was conducted by two pairs of reviewers. Data quality was checked according to the type of study. A qualitative analysis of the data was carried out and a narrative approach was adopted to describe and synthesize the results. **Results:** A total of twenty-nine articles were selected including one cross-sectional study, seven time series, twenty-one quasi-experimental studies of which six randomised and fifteen non-randomised studies. The type of interventions evaluated was aimed at all types of users and was based on different interventions such as institutional strengthening, law enforcement, awareness raising, training or user education, vehicle maintenance and infrastructure improvements. For fourteen studies all the expected indicators had changed favourably and for twelve the indicators had partially changed. The studies that showed significant change were institutional strengthening, law enforcement, awareness raising, training, or user education interventions, development of Uber transport services, distribution of equipment, and a combination of interventions. **Conclusion:** This situation is indicative of insufficient policy investment in research but also in the field of road safety in general.

Keywords

Road Safety, Effectiveness, Prevention, Africa

1. Introduction

Road traffic injuries are a serious public health and safety problem. They are the eighth leading cause of death worldwide and the leading cause of death among young people aged 15 - 29 years. The distribution of road traffic deaths by user group varies considerably between regions and countries [1].

According to the World Health Organisation (WHO), premature deaths and disabilities due to non-communicable diseases and injuries can be largely prevented by taking low-cost, effective and proven measures. To reduce the scale of road traffic injuries, WHO recommends that countries accelerate the pace of legislative reform, improve enforcement and focus particularly on vulnerable road users, such as pedestrians, cyclists and motorcyclists. It also recommends, in its Global Plan for the Decade of Action for Road Safety 2011-2020, raising awareness of measures to prevent road traffic injuries and promoting good practices such as helmet and seatbelt use, moderate speed, abstinence from alcohol, and good visibility in traffic [2]. In order to comply with the WHO's recommendations, various measures are being implemented in countries to contribute to the common objective of reducing road deaths.

Several studies have been carried out worldwide to evaluate these different measures and have found that most of them help reduce accidents, their severity or fatalities. Very few of these studies have been conducted in Africa. To help guide priorities for road safety policy and research strategies, it is useful to learn from effective road safety interventions implemented in Africa for the prevention of road crashes, injuries, disabilities, and deaths. To this end, this study, based on a systematic review, aimed to identify road safety interventions implemented in Africa and to analyse their effectiveness in reducing road crashes, injuries, disabilities, and deaths.

2. Methods

2.1. Search Strategy and Selection Criteria

Protocol and registration: The presentation of the systematic review followed the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) grid [3], and the protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO) database under the number PROSPERO 2019 CRD42019118801 available on:

http://www.crd.york.ac.uk/PROSPERO/display_record.php?ID=CRD42019118801.

Eligibility criteria: Articles included were those relating to the evaluation of road safety interventions implemented in Africa, published in English or French

and for which full versions were available. These articles covered a range of interventions such as the adoption or revision of a law, controls or enforcement measures to prevent speeding and alcohol, the use of protective equipment (helmets, seatbelts, child restraints), user awareness, user (driver) training, school education (school modules), distribution of protective equipment, improvement of road conditions, and traffic control.

Abstracts without full articles, literature reviews, systematic reviews, meta-analyses, commentaries, and articles with unworkable data (not available in French or English) were excluded.

Information sources: Articles were searched on electronic databases: PubMed, Scopus, Lissa, Google Scholar, and African Journals Online.

Article search strategy: Articles were retrieved from 22 to 27 February 2019 using search equations tailored to each database. Two pairs of reviewers were formed to independently conduct the article selection and data extraction.

2.2. Data Analysis

Article selection: For the selection, all articles from the database search and their abstracts were imported into EndNoteX9 regardless of the language of the full text. Each reviewer examined the articles on their own and then reviewed them within the pair and between the pairs to compare the articles selected. Different steps were followed, namely the elimination of duplicates, the exclusion of abstracts and other articles that did not meet the inclusion criteria, the exclusion of articles on the basis of the title and abstract, and then on the basis of the full text.

Data extraction: For this purpose, an Excel tool was designed containing information on the title of the study, the references (journal, year, publication number), the authors, the country, the type of study, the types of road safety interventions, the users involved, the outcomes to be measured, the duration of the intervention, and the assessment of the quality of the data.

Quality of the studies: Data quality was checked according to the type of study. Different approaches were used: 1) Strengthening The Reporting of Observational Studies in Epidemiology (STROBE) indicators were checked for cross-sectional studies [4]; 2) for case-control and cohort studies the Newcastle-Ottawa Scale (NOS) scale was complemented with the STROBE indicators [4] [5]; 3) A Cochrane Risk Of Bias Assessment Tool for Non Randomized Studies of Interventions (ACROBAT-NRSi) scale [5], and the Standard Protocol Items: Recommendations for Interventional Trials (SPRIT) guidelines for non-randomised trials and quasi-experimental studies [6]; 4) the Cochrane Grading of Recommendations, Assessment, Development and Evaluations (GRADE) mechanism [7], and the Consolidated Standards Of Reporting Trials (CONSORT) guidelines for randomised studies [8]. We assigned risk of bias as recommended by Cochrane, referring to the Cochrane Handbook (low, moderate, and high risk) [9]. The risk of bias is high if several indicators of bias are present on all scales; the risk is moderate when there is a single indicator of bias on several scales. It is low when all

indicators measure low or no bias.

Type of data analysis: A qualitative analysis of the data was carried out and a narrative approach was adopted to describe and synthesise the results.

3. Results

3.1. Description of the Studies

At the end of the search, a total of 3106 articles were obtained of which 848 were from PubMed, 1262 from Scopus, 543 from AJOL, 332 from LiSSa, and 121 from Google Scholar. The selection process resulted in twenty-nine articles (Figure 1).

The extracted data were presented according to the characteristics of the studies (Table 1). Considering the type of study, twenty-one articles were quasi-experimental studies, six of which were randomised and fifteen non-randomised. One study was cross-sectional and seven were time series.

The type of intervention evaluated was varied. Two studies concerned institutional strengthening [10] [11]. Nine interventions concerned law enforcement, including two on helmet wearing [12] [13], one on seatbelt wearing [14], three

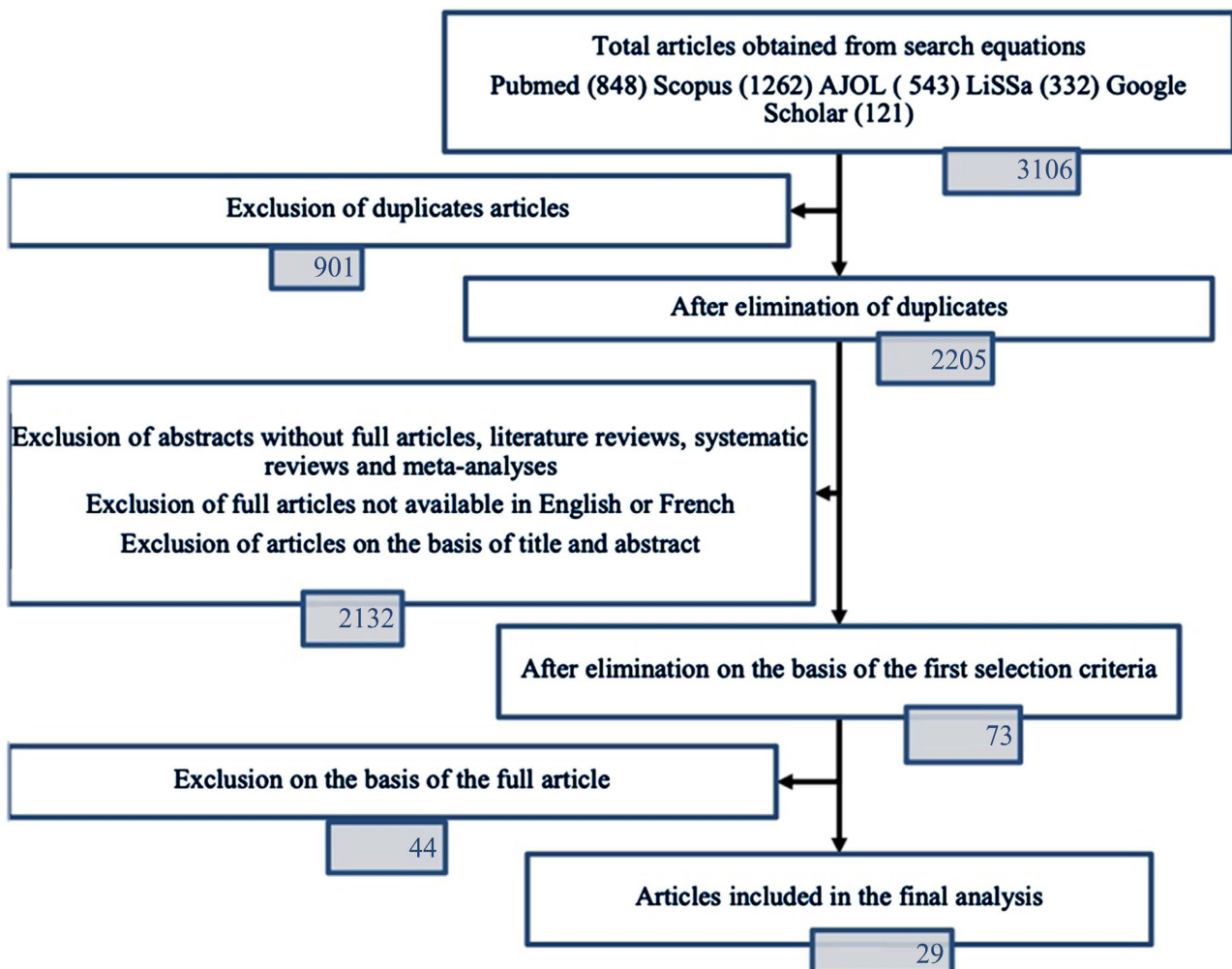


Figure 1. Flow chart showing the process of identifying and selecting studies for inclusion in the review.

Table 1. Characteristics of the articles included in the systematic review.

N°	Title	Journal	Authors	Country	Type of study	Type of intervention	Type of road users	Outputs	Implementation period	Risk of bias
1	An econometric study of the road safety impact of Nigeria's federal road safety commission	International Journal of Soft Computing 2 (2): 279-284	K. U. Nnadi et C. C. Ibe	Nigeria	Interrupted time series	Institutional strengthening	All types of users	Reduction in road traffic fatalities, injuries, crash cases	Intervention lasting three months or more	High
2	Modelling the impact of intervention measures on total accident cases in Nigeria using Box-Jenkins methodology: A case study of federal road safety commission	Cogent Engineering 2017; 4: 1345043	B. U. Oreko, C. C. Nwobi-Okoye, S. Okiy & A. C. Igboanugo	Nigeria	Interrupted time series	Institutional strengthening	All types of users	Reduction in road traffic fatalities, crash cases, severity	Intervention lasting three months or more	Moderate
3	The crash helmet legislation in Nigeria: A before-and-after study	Acrid Anal. & Pm 1980; 12: 213-216	S. E. Asogwa	Nigeria	quasi experimental no-randomized	Law enforcement	Drivers or passengers of two- or three-wheeled vehicles	Reduction in road traffic fatalities, Helmet use	Intervention lasting three months or more	High
4	The Role of Seat Belt in the Prevention of Fatalities and Determination of Fatality Index of Road Traffic Accidents in Rivers State, Nigeria	The Nigerian Health Journal 2013; 13 (4)	B. O. Akinbami	Nigeria	quasi experimental no-randomized	Law enforcement	Drivers or passengers of vehicles with more than three wheels	Reduction in road traffic fatalities, in injuries	Intervention lasting three months or more	High
5	Influence of road speed restrictions on the incidence and severity of head injuries	S Afr Med J 1973; 47 (12)	A. P. Rose-Innes & C. G. J. Le Roux	South Africa	quasi experimental no-randomized	Law enforcement	All motorised vehicle users	Reduction in injuries and severity	Intervention lasting three months or more	High
6	The Relationship between Speed Restrictions and Head Injury Admissions to Groote Schuur Hospital	S Afr Med J. 1974 Dec 14; 48 (61): 2546-8	R. A. De Villiers & J. C. De Villiers	South Africa	quasi experimental no-randomized	Law enforcement	All motorised vehicle users	Reduction in road traffic fatalities, emergency room admissions for trauma, hospital stays	Intervention lasting three months or more	High

Continued

7	The impact of alcohol and road traffic policies on crash rates in Botswana, 2004-2011: a time-series analysis	Accid Anal Prev. 2014 September; 70: 33-39.	M. Sebegu, <i>et al.</i>	Botswana	Interrupted time series	Law enforcement	All types of users	Reduction in road traffic fatalities, in crash cases	Intervention lasting three months or more	Moderate
8	Pattern of injuries from motorcycle accidents in Abia State, Nigeria: The influence of government regulation	Journal of Medical Investigations and Practice 2014; 9 (1)	O. E. Ugochukwu Ikeanyi, I. C. Nnezianya, H. I. Nwokeukwu & D. U. Inya-Agha	Nigeria	quasi experimental no-randomized	Law enforcement	Drivers or passengers of two- or three-wheeled vehicles	Reduction in road traffic fatalities, in emergency room admissions for trauma, in the severity	Intervention lasting three months or more	High
9	Impact of transportation policy on injury characteristics in a teaching hospital, Calabar, Nigeria	Int J Burn Trauma 2013; 3 (4): 214-219	I. A. Ikpeme <i>et al.</i>	Nigeria	Interrupted time series	Law enforcement	Drivers or passengers of two- or three-wheeled vehicles	Reduction in road traffic fatalities, in emergency room admissions for trauma, in the severity	Intervention lasting three months or more	High
10	Helmet wearing in Kenya: prevalence, knowledge, attitude, practice and implications	Public health 144 (2017) S23-S31	A. M. Bachani <i>et al.</i>	Kenya	quasi experimental no-randomized	Law enforcement	Drivers or passengers of two-or three-wheeled vehicles	Prevalence of helmet use before and after this legislation: KAP surrounding helmet use, and road traffic crashes and injuries among motorcyclists	Intervention repeated more than once	Moderate
11	A comparative evaluation of the impact of average speed enforcement (ASE) on passenger and minibus taxi vehicle drivers on the R61 in South Africa	J S Afr Inst Civ Eng 2016; 58 (4): 2-10	N. A. Ebot Eno Akpa, M. J. Booysen, M. Sinclair	South Africa	quasi experimental no-randomized	Law enforcement	Drivers or passengers of vehicles with more than three wheels	Reduction in travel speeds during enforcement; Reduction in crash, fatality and serious injury rates; Level of driver understanding of ASE system	Intervention lasting three months or more	Moderate

Continued

12	An interactive computer program for South African urban primary school children to learn about traffic signs and rules	African Safety Promotion Journal 2018; 16 (1)	A. Fransman, B. Richter & S. Raath	South Africa	quasi experimental no-randomized	Awareness raising, training or user education interventions	Pedestrians	Improved knowledge and behaviour regarding traffic rules, laws and protective measures	One-off intervention (less than a week)	Moderate
13	Building capacity of drivers in Nigeria to provide first aid for road crash victims	Injury Prevention 2012; 18: 62-65	A. O. Sangowawa & E. T. Owoaje	Nigeria	quasi experimental randomized	Awareness raising, training or user education interventions	Drivers or passengers of vehicles with more than three wheels	Improved knowledge and behaviour regarding traffic rules, laws and protective measures	One-off intervention (less than a week)	Low
14	Effect of First Aid Education on First Aid Knowledge and Skills of Commercial Drivers in South West Nigeria	Prehosp Disaster Med 2015 Dec; 30 (6): 579-85	A. O. Olumide, M. Asuzu & O. Kale	Nigeria	quasi experimental randomized	Awareness raising, training or user education interventions	Drivers or passengers of vehicles with more than three wheels	Improved knowledge and behaviour regarding traffic rules, laws and protective measures	One-off intervention (less than a week)	Low
15	Effect of health education on the riding habits of commercial motorcyclists in Uyo, southern Nigeria	West African journal of medicine Nov 2012; 31 (1): 39-46	O. E. Johnson et E. T. Owoaje	Nigeria	quasi experimental no-randomized	Awareness raising, training or user education interventions	Drivers or passengers of two- or three-wheeled vehicles	Reduction in crash cases, Improved knowledge and behaviour regarding traffic rules, laws and protective measures	One-off intervention (less than a week)	High
16	Effect of safety education on knowledge of and compliance with road safety signs among commercial motorcyclists in Uyo, Southern Nigeria	Ghana Med J. 2011 Sep; 45 (3): 89-96	O. E. Johnson et A. M. Adebayo	Nigeria	quasi experimental no-randomized	Awareness raising, training or user education interventions	Drivers or passengers of two- or three-wheeled vehicles	Improved knowledge and behaviour regarding traffic rules, laws and protective measures	One-off intervention (less than a week)	High
17	Effectiveness of road safety education in Nigeria using a quasi-experimental trial: Findings from the Road Safety Intervention Project	African Safety Promotion 2014; 12: 1-17.	I. P. Okafor <i>et al.</i>	Nigeria	quasi experimental randomized	Awareness raising, training or user education interventions	Drivers or passengers of vehicles with more than three wheels	Improved knowledge and behaviour regarding traffic rules, laws and protective measures	Intervention repeated more than once	Moderate

Continued

18	Heckle and Chide: Results of a randomized road safety intervention in Kenya	Journal of Public Economics 2011; 95: 1438-1446	J. Habyarimana & W. Jack	Kenya	quasi experimental randomized	Awareness raising, training or user education interventions	Drivers or passengers of vehicles with more than three wheels	Others: insurance claims data	Intervention lasting three months or more	Moderate
19	Results of a large-scale randomized behaviour change intervention on road safety in Kenya	PNAS August 25, 2015 112 (34): E4661-E4670	J. Habyarimana & W. Jack	Kenya	quasi experimental randomized	Awareness raising, training or user education interventions	Drivers or passengers of vehicles with more than three wheels	Reduction in crash cases, speeding, Others: insurance claims data	Intervention lasting three months or more	Low
20	Estimating effects of Uber ride-sharing service on road traffic-related deaths in South Africa: A quasi-experimental study	J Epidemiol Community Health 2019; 73: 263	J. Y Huang, F. Majid & M. Daku	South Africa	Interrupted time series	Development of an Uber transport service	All types of users	Reduction in road traffic fatalities	Intervention lasting three months or more	Moderate
21	Effect of free distribution of safety equipment on usage among motorcycle-taxi drivers in Tanzania: A cluster randomised controlled trial	Injury. 2014 November; 45 (11): 1681-1686.	S. A. Sumner <i>et al.</i>	Tanzania	quasi experimental randomized	Distribution of helmets and reflective vests	Drivers or passengers of two- or three-wheeled vehicles	Improved knowledge and behaviour regarding traffic rules, laws and protective measures	One-off intervention (less than a week)	Low
22	Effectiveness of an improved road safety policy in Ethiopia: an interrupted time series study	BMC Public Health 2014; 14: 539	T. Abegaz, Y. Berhane, A. Worku & A. Assrat	Ethiopia	Interrupted time series	Multi-intervention	All types of users	Reduction in road traffic fatalities, in injuries, in crash cases	Intervention lasting three months or more	Moderate
23	Effects of enforcement of the traffic act on injury severity among patients admitted at the Rift Valley Provincial General Hospital, Nakuru	East Afr Med J. 2010 Nov; 87 (11): 436-442	E. Muguku, J. Ouma & A. Yitambe	Kenya	quasi experimental no-randomized	Multi-intervention	Drivers or passengers of vehicles with more than three wheels	Reduction in road traffic fatalities, in the severity, in hospital stays	Intervention lasting three months or more	High

Continued

24	Lives saved by regulations that resulted from the Bloomberg road safety program	Accident Analysis and Prevention 2018; 113: 131-136	T. R. Miller, D. T. Levy & D. I. Swedler	Brazil China Kenya Mexico Turkey Vietnam	quasi experimental no-randomized	Multi-intervention	All types of users	Reduction in road traffic fatalities	Intervention lasting three months or more	Moderate
25	Motorcycle taxi programme increases safe riding behaviours among its drivers in Kampala, Uganda	Inj Prev 2018; 0: 1-6.	K. Muni et al	Uganda	Cross-sectional	Multi-intervention	Drivers or passengers of two- or three-wheeled vehicles	Reduction in crash cases, Improved knowledge and behaviour regarding traffic rules, laws and protective measures	Intervention lasting three months or more	High
26	School Area Road Safety Assessment and Improvements (SARSAI) programme reduces road traffic injuries among children in Tanzania	Inj Prev 2019; 25: 414-420	A. Poswayo, <i>et al.</i>	Tanzania	quasi experimental no-randomized	Multi-intervention	Pedestrians	Reduction in injuries, Reduction in crash cases	Intervention lasting three months or more	Moderate
27	Schoolbus driver performance can be improved with driver training, safety incentivisation, and vehicle roadworthy modifications	S Afr Med J 2017; 107 (3): 188-191	A. van Niekerk, R. Govender, R. Jacobs, A. B. van As	South Africa	quasi experimental no-randomized	Multi-intervention	Drivers or passengers of vehicles with more than three wheels	Reduction in speeding	Intervention lasting three months or more	Moderate
28	The effect of traffic calming on pedestrian injuries and motor vehicle collisions in two areas of the eThekweni Municipality: a before-and-after study	S Afr Med J 2013; 103 (9): 621-625	N. Nadesan-Reddy & S. Knigh	South Africa	Interrupted time series	Multi-intervention	All types of users	Reduction in road traffic fatalities, in crash cases, in the severity	Intervention lasting three months or more	Moderate
29	Urban pedestrian accidents and the efficacy of a counter-measure	Cent Afr J Med 1985 Mar; 31 (3): 62-65	S. E. Asogwa & C. N. Obionu	Nigeria	quasi experimental no-randomized	Multi-intervention	Pedestrians	Reduction in road traffic fatalities	Intervention lasting three months or more	High

on speed limits [15] [16] [17], one on alcohol and other road safety measures [18], one on banning motorbikes from the capital [19], and one on banning the use of motorbikes as a means of public transport [20]. Eight studies concerned awareness raising, training, or user education interventions [21]-[28]. One study concerned the development of an Uber transport service in South Africa [29], and one concerned the distribution of helmets and reflective vests [30]. Eight studies combined several interventions such as enforcement, monitoring, education and awareness raising, provision of equipment (helmets and hairnets), vehicle maintenance, and infrastructure improvements [31]-[38].

The users benefiting from these interventions were pedestrians (three studies), drivers or passengers of two- or three-wheeled vehicles (eight studies), drivers or passengers of vehicles with more than three wheels (nine studies), all motorised vehicle users (two studies), or all types of users (seven studies).

The expected outputs or outcomes of these studies were diverse. These included a reduction in road traffic fatalities, injuries, crash cases, or emergency room admissions for trauma. Other outputs included reductions in the severity of road crashes, hospital stays, or speeding. Some outputs were related to helmet use, improved knowledge and behaviour regarding traffic rules, laws and protective measures, or insurance claims data (Figure 2).

In the implementation, twenty-two studies involved interventions that were implemented for three months or more, while six interventions were one-offs lasting less than a week, and one intervention was repeated more than once.

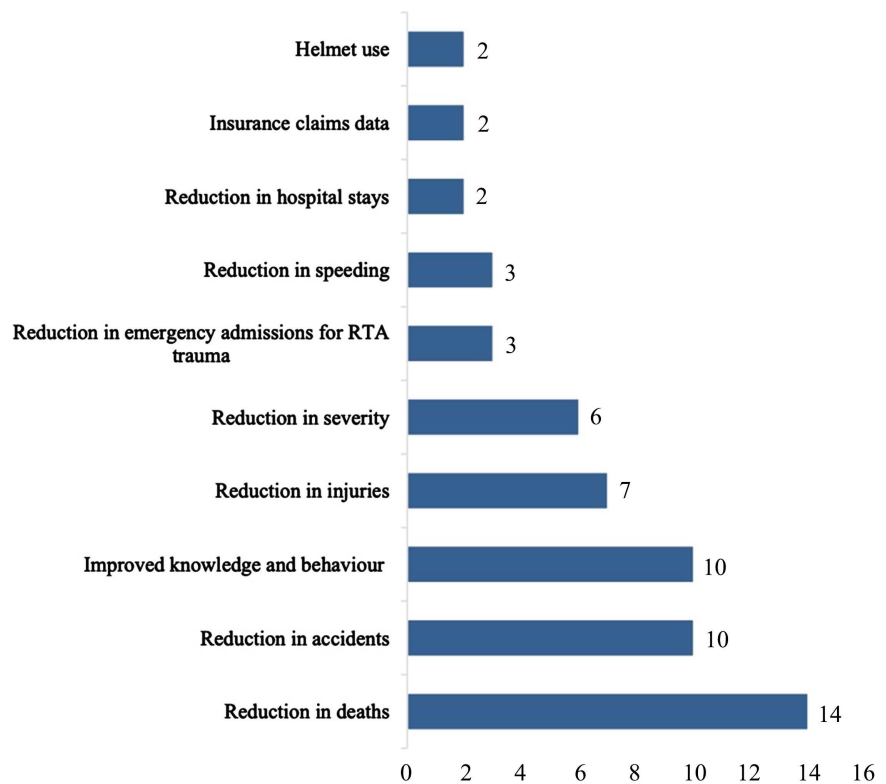


Figure 2. Different expected outputs of the evaluated interventions.

The risk of bias was assessed as high for twelve studies, moderate for thirteen, and low for four. No studies were excluded due to risk of bias.

3.2. Summary of Results

The results obtained have been presented by intervention (**Table 2**). Most of the interventions implemented showed evidence of effectiveness in terms of the results obtained. Indeed, for fourteen studies all the expected indicators had changed favourably and for eleven the indicators had partially changed. Only four studies did not show the expected main results. The studies that showed significant change were institutional strengthening [10] [11], law enforcement [15]-[20], awareness raising, training, or user education interventions [21]-[28], development of Uber transport services [29], distribution of equipment [30], and a combination of interventions [31] [33]-[38]. The studies were randomised [22] [23] [26] [27] [28] [30], non-randomised [15] [16] [17] [19] [21] [24] [25] [33] [35] [36] [38], time series [10] [11] [18] [20] [29] [31] [37], or cross-sectional studies [34]. The inconclusive studies were non-randomised [12] [13] [14] [32]. Of them, three were law enforcement studies [12] [13] [14], and one combined several interventions [32].

Countries of studies implementation: Nigeria (twelve studies), South Africa (seven studies) and Kenya (five studies) embedded more than 80% of studies selected (**Figure 3**).

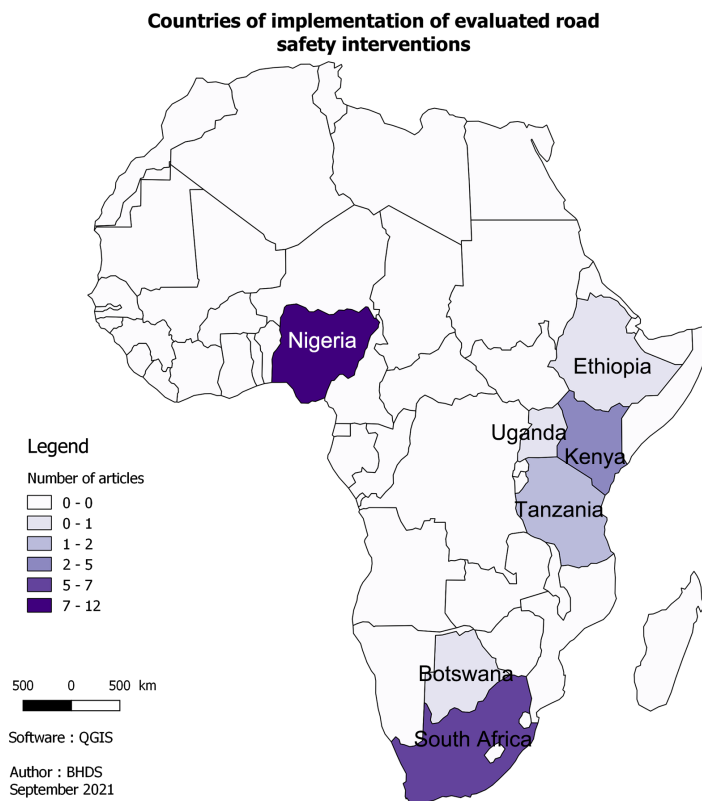


Figure 3. Countries of implementation of the evaluated interventions. Data source: GADM.org (contour and cutting of Africa). Copyright holder: BHDS.

Table 2. Interventions implemented, and results obtained.

N°	Brief description of the intervention implemented	Brief summary of the results obtained
1	<ul style="list-style-type: none"> * What: Creation of the Federal Road Safety Commission (FRSC) as an institution in charge of road safety * How: Prevention and reduction of MVA risks; education of road users * When: From 1988 	<ul style="list-style-type: none"> * Significant decrease in the average annual number of MVAs and people injured after an MVA following the creation of the FRSC * Non-significant decrease in the average annual number of post-stroke fatalities after the introduction of the FRSC
2	<ul style="list-style-type: none"> * What: Through the creation of a road safety institution: Federal Road Safety Commission (FRSC) * How: Implementation of intervention policies to reduce MVAs * When: From 1988 * 34.5% reduction in MVAs 	<ul style="list-style-type: none"> * 67.4% reduction in MVA cases per capita * 71.77% increase serious MVA not fatal MVA * 14.55% reduction in fatal MVA cases per capita * 26.54% reduction in severe MVA cases * 63.45% reduction in severe MVA cases per capita
3	<ul style="list-style-type: none"> * What: Enforcement of helmet law * How: Mandatory helmet use by motorcyclists * When: From 1 June 1976 in Anambra State 	<ul style="list-style-type: none"> * Non-significant increase in the proportion of motorcyclists who died as a result of an MVA after the intervention, * but high proportion (over 90%) of subjects wearing helmets
4	<ul style="list-style-type: none"> * What: Implementation of national road traffic regulations with seatbelt use as the main feature * When: Effective implementation from 2005 	<ul style="list-style-type: none"> * Non-significant reduction in accident cases. * Increase in the number of injuries, fatalities, total number of victims, and death index
5	<ul style="list-style-type: none"> * What: Fuel saving measures * How: Speed restrictions * When: November 1973 	<ul style="list-style-type: none"> * Significant decrease in the incidence and severity of head injuries
6	<ul style="list-style-type: none"> * What: Implementation of the law on maximum speed limits on roads * How and when: Speed limits reduced from 120 km/h to 80 km/h for rural traffic and from 60 km/h to 50 km/h for urban traffic in November 1973, then limit for urban traffic increased from 50 to 60 km/h in January 1974 	<ul style="list-style-type: none"> * Significant decrease of the total number of patients admitted for head injuries after MVA * Decrease in total number of deaths and total length of stay in hospital for patients admitted for head injuries after MVA
7	<ul style="list-style-type: none"> * What: Adoption of a law to reinforce road safety and tackle alcohol consumption * How and When: <ul style="list-style-type: none"> October 2008: Adoption of a 30% tax on alcoholic products and use of the funds collected to tackle alcohol abuse November 2010: Increase of the tax on alcoholic products to 40% April 2009: Enforcement of ROAD SAFETY regulations with sanctions and fines for several traffic offences, including driving without a licence, speeding, driving under the influence of alcohol and disobeying road signs 	<ul style="list-style-type: none"> * Significant decrease in the overall MVA rate in June 2009 and June 2010 * Significant decrease in the rate of fatal MVAs and the rate of fatal single-vehicle night-time MVAs in early 2010
8	<ul style="list-style-type: none"> * What: Ban on “commercial” motorcyclists in the state capital * When: From July 2009 	<ul style="list-style-type: none"> * “Significant” decrease in reported MVAs after the intervention * Decrease in MVAs resulting from motorbike crashes * Decrease in serious injuries and fatalities after intervention
9	<ul style="list-style-type: none"> * What: Banning motorbikes as a mode of public transport * When: From 2010 and effective application 1 year later 	<ul style="list-style-type: none"> * Significant decrease in the frequency of head injuries, open femur fractures, closed tibia fractures, and penetrating abdominal injuries, but a significant increase in spinal fractures * Significant decrease in the hospital prevalence of MVA * Significant decrease in the severity of head injuries (Revised trauma score)

Continued

- 10 * What: assessment of the impact of helmet legislation in improving helmet use in Kenya
 * How: 16 rounds of helmet observations among motorcycle drivers and passengers at six randomly selected locations and eight rounds of KAP surveys administered to motorcyclists were conducted in Thika and Naivasha.
 Analysis of trauma registry data in four public hospitals in Kenya (Thika Level 5 Hospital, Naivasha District Hospital, Kenyatta National Hospital, and Machakos Level 5 Hospital) between January 2014 and February 2015
 * When: between August 2010 and December 2014
- 11 * What: Evaluate the impact of ASE on speeding patterns (and crash rates) on the R61 and adjacent road segments in South Africa and compare the results with control routes.
 * How: Time differentiation and spatial differentiation analysis at various distances from the enforcement route and control routes
 Behavioural changes analysis
 Crash outcomes (fatalities, serious and minor injuries) analysis by comparing two years of pre- and post-installation effects of the ASE system.
 * When: June 2009 to June 2011 before enforcement, and December 2011 to December 2013 during enforcement
- 12 * What: Computerised traffic sign knowledge enhancement programme
 * How: The programme provides 41 questions (5 levels of advancement) with 4 answer options (in English). One can only continue if the correct option is chosen. Students acquire knowledge by working through the programme themselves (autodidactic)
- 13 * What: Rescue techniques, basic evacuation procedures and specific first aid skills
 * How: Didactic lectures, practical demonstrations and skill-building exercises
- 14 * What: Basic rescue and evacuation techniques, fracture/haemorrhage management, general first aid knowledge, securing the scene of an MVA, victim assessment, rapid victim assessment, important information to obtain from the victim
 * How: Didactic lectures, practical demonstrations and skill-building exercises, formation of groups of 10 - 20 drivers to facilitate participation and skill acquisition, use of the "Basic Trauma Life Support (BTLS) manual" for 2 days
- * Minor improvements in Naivasha and no effect in Thika have been observed in helmet use among motorcycle drivers and passengers after the passage of a traffic amendment bill.
 * KAP survey showed that respondents recognized the life-saving effect of wearing a helmet, but many did not always wear a helmet
 * Analysis of trauma registry data showed that helmet wearing was associated with a significant reduction in head injuries among motorcyclists (adjusted odds ratio: 0.472, 95% CI: 0.327 - 0.684)
- * Reduction in mean speed on the enforcement route and adjacent control route for passenger vehicles after the introduction of ASE
 * Little influence of ASE on improving speed compliance for minibus taxis
 * Reduction of fatalities (79.5%), serious injuries (58.5%) and minor injuries (50%)
 * Reduction of passenger vehicle crash rates on the enforcement route and its immediate vicinity
 * Lack of understanding of how the system operates by minibus taxi driver
- * Significant change in learners' knowledge of road signs after the intervention
 * Variable effect depending on the category of road signs
- * No significant increase in first aid knowledge score over the 3 periods in the intervention group
 * Significant increase in first aid competence score over the 3 periods in the intervention group
 * 75% of drivers in the intervention group who witnessed an MVA used their acquired skills
- * Significant improvement in first aid knowledge and skill score over the 3 periods in the intervention group
 * Significantly higher post-intervention first aid knowledge and skill score in the intervention group

Continued

15	<p>* What: Communication on road safety practices (explanation of the association between road behaviours and the occurrence of MVAs)</p> <p>* How: Lecture and interactive sessions (Q & A, local language)</p>	<p>* Increased proportion of drivers reporting resting after hours of driving (significant), observing speed limits (significant) and having a valid driver's licence (non-significant) in the intervention group</p> <p>* Decrease in the proportion of drivers reporting fatigue (significant), substance use (non-significant), and carrying more than one person (non-significant) in the intervention group</p> <p>* Non-significant decrease in the prevalence of MVAs in the intervention group</p>
16	<p>* What: Teaching of traffic signs</p> <p>* How: Lecture, interactive sessions, visual aids on the identification of traffic signs and the importance of obeying them</p>	<p>* Significant increase in the proportion of drivers with a good traffic sign knowledge score in the intervention group</p> <p>* Significant increase in the proportion of drivers reporting compliance with traffic signs in the intervention group</p>
17	<p>* What: Health and safety education on the following topics: the burden of MVAs and the need to prevent/control them, the importance of vision tests and driving tests as prerequisites for obtaining a driver's licence, road signs and maximum speed limits</p> <p>* How: 4 one-hour sessions over 2 months using pictures, posters, road signs and speed limits, leaflets</p>	<p>* Significant increase in the proportion of drivers with correct knowledge of driving licence requirements, adequate knowledge of road signs and adequate knowledge of maximum speed limits in the intervention group</p> <p>* Decrease in the proportion of drivers reporting compliance with speed limits in the intervention group</p>
18	<p>* What: Raising awareness among minibus passengers</p> <p>* How: Placing stickers in front of the passenger seats of minibuses used for long-distance public transport, with messages encouraging passengers to react if drivers do not respect the rules of the road and even to report them if they do not listen to the advice. This is accompanied by a lottery to reward drivers who do not remove the stickers</p>	<p>* Decrease in the number of incidents leading to insurance claims</p>
19	<p>* What: Raising awareness among minibus passengers</p> <p>* How: Setting up several experimental groups with specific messages for each group with or without lottery, pictures or other additional text</p>	<p>* Reduction in claims ranging from one quarter to one third</p> <p>* 140 fewer MVAs per year than expected and 55 lives saved</p> <p>* Cost-effectiveness of the intervention between \$13 and \$60 per DALY and between \$10 and \$45 per DALY for the most "impactful" stickers</p> <p>* Average maximum speeds and average speeds 1 - 2 km/h lower in the intervention vehicles</p> <p>* Messages promoting collective action are particularly effective, and evocative images are an important motivator.</p> <p>* No effect of the radio campaign was found</p>
20	<p>* What: Uber</p> <p>* Where and when: Johannesburg/Gauteng Province from 11 September 2013, Cape Town/Western Cape from 11/10/2013 and Durban/KwaZulu-Natal from 12/02/2014</p>	<p>* Number of weekly MVA deaths in a province with Uber were lower after the introduction of Uber than in comparison provinces without Uber</p> <p>* Absolute effects were very small (<2 deaths per year), could be due to seasonal variation</p>
21	<p>* What: Free distribution of reflective vests + brief road safety education</p> <p>* How: Distribution + communication about the beneficial effects of visibility measures (wearing reflective jackets, using daytime running lights and wearing white helmets) on reducing the risk of MVAs; places where this equipment could be purchased</p>	<p>* Significant increase in the use of reflective jackets among motorbike taxi drivers</p> <p>* No significant difference in use of white helmet and daytime running lights among motorbike taxi drivers</p>

Continued

22	<p>* What: Ban on mobile phone use while driving, driving without seatbelts and not using motorbike helmets; introduction of stiffer penalties including suspension of a driving licence for speeding, driving under the influence and dangerous loads from September 2007</p> <p>* How: regular random roadside checks for helmet/seatbelt use and phone use while driving; however, no radar or breathalyser to check for speeding and drink driving</p>	<p>* Significant reduction in the number of non-injury MVAs and fatalities (per 10,000 vehicles) by 19% and 12.4% respectively in the first year of implementation of the intervention</p> <p>* Non-significant reduction in injuries (per 10,000 vehicles) in the first year of implementation of the intervention</p>
23	<p>* What: Reduce MVAs caused by speeding, increase passenger safety, increase driver responsibility and accountability, eliminate illegal drivers, facilitate vehicle identification and limit their exploitation for other purposes, etc.</p> <p>* How: Installation of seatbelts and speed governors (80 km/h), indication of route details, painted yellow stripes for easy identification, security control of drivers (compulsory wearing of badges, uniforms while on duty), permanent employment of drivers, compulsory renewal of drivers' competence tests every 2 years, posting of each driver's photo, enforcement measures and the provision of hotlines for the public to report offenders to the police</p>	<p>* No significant change in levels of injury severity (including deaths) or patient length of stay before and after</p>
24	<p>* What: Advocacy for strengthening road safety legislation among the participants</p> <p>How: Multi-country study including Kenya</p> <p>In Kenya: Increased penalties for driving under the influence of alcohol, up to and including licence suspension in 2012, law for mandatory use of certified helmets and reflective clothing and carrying of a maximum of one passenger in 2013, increased penalties for speeding in 2013</p>	<p>* In total, 109,000 lives saved including 1637 in Brazil, 61,622 in China, 3318 in Kenya, 3221 in Mexico, 1061 lives in Turkey and 38,645 in Vietnam</p> <p>* In total, 109,000 lives were saved, 84% due to alcohol laws, 13% due to increased protection for motorcyclists, 2% due to increased fines and penalty points, and 1% due to seatbelt interventions</p>
25	<p>* What: Education, provision of motorbike taxi equipment</p> <p>* How: Multi-stage road safety training, two helmets (for driver and passenger) and vehicle maintenance, provision of hairnets to encourage helmet use by passengers</p>	<p>* Helmet use (reported or directly observed) significantly higher among SafeBoda drivers than among regular drivers</p> <p>* Self-reported prevalence of protective behaviours (possession of a driver's licence, reflective jacket, not using a phone while driving, not driving in the wrong direction, not carrying more than one passenger) significantly higher among SafeBoda drivers</p> <p>* Observed prevalence of risky behavior (phone use while driving, carrying more than one passenger) higher among SafeBoda drivers, but not significant</p> <p>* Based on roadside observation, SafeBoda drivers were significantly less likely to carry more than one passenger</p> <p>* Prevalence of MVAs significantly lower among SafeBoda drivers</p>

Continued

<p>26 * What: Slow down traffic, separate children (pedestrians) from vehicles + road safety education</p> <p>* How: Identification of public primary schools with high incidence of MVAs + infrastructure improvements (speed bumps, bollards, pavements, signage, new school gates) + traffic safety education (how to cross, how to be seen, choosing the best place to cross, how to walk alone on the road, choosing the best place to play, characteristics of MVAs)</p>	<p>* Significant decrease in prevalence of MVAs occurring on the way to school in the intervention group</p> <p>* Non-significant decrease in the frequency of pedestrian vs. motorbike collisions (most frequent type of collision) in the intervention group</p> <p>* Significant decrease in the frequency of pedestrian vs. private car collisions in the intervention group</p> <p>* Significant decrease in the frequency of minor injuries in the intervention group</p> <p>* Significant decrease in the frequency of MVAs occurring in the morning in the intervention group (however, no reduction in certain types of accidents, such as those involving motorcycles and pedestrians, or in injuries such as fractures)</p>
<p>27 * What: Contribution to making school trips in minibuses safer for children through interventions among = drivers and on the vehicle</p> <p>* How: Among the drivers (driver training for safer driving, eye tests) and on the vehicle (vehicle inspections and upgrades, implementation of a telematics tracking system)</p>	<p>* Overall, intervention group drivers recorded less speeding, hard braking (on bends) and hard acceleration than control group drivers</p> <p>* Intervention group drivers drove more at night than control group drivers</p> <p>* Significant difference in the speed on the approach to a bend</p> <p>* No reduction in hard braking</p>
<p>28 * What: Reduce speeding and excessive transit volumes on roads not designed for this purpose</p> <p>* How: Introduction of area-wide speed bumps to prevent traffic migration to other side roads, tarring of roads and construction of pavements + speed restrictions, road signs, road safety education in the primary school curriculum, employment of “lollipop men” in some schools to assist at pedestrian crossing points</p> <p>* When: Introduction of intervention from 2001</p>	<p>* Decrease in the number of collisions between pedestrians and motor vehicles (total, fatal, serious, slight, no injury) in both areas</p> <p>* Decrease in the number of collisions between motor vehicles in one of the two zones, but an increase was recorded in the second zone</p>
<p>29 * What: Make it easier for children/pupils to cross the road</p> <p>* How: Construction of a pedestrian overpass on a two-lane expressway near a military primary school + education on its use (on good pedestrian manners according to Schifferes)</p>	<p>* Increase in the number of pupils using the overpass after road safety education</p>

Institution building studies: The two studies concerned were implemented in Nigeria and assessed the influence of the creation of a road safety institution on the trend in road crashes, injuries and deaths. Both studies found a significant reduction in road crashes and injuries according to the indicators measured (average annual number for one, proportion and number per capita for the other) [10] [11]. However, while one study found a significant reduction in fatalities [11], the difference was not significant in the second study [10].

Law enforcement studies: Five of these interventions improved all the indicators predicted by the studies [15] [16] [18] [19] [20], while one improved partially indicators [17], and three were inconclusive [12] [13] [14]. The implementation of these laws resulted in a reduction in the frequency and severity of inju-

ries [13] [15]-[20], a significant decrease in the hospital prevalence of road traffic accidents (RTAs) [20], a decrease in RTAs resulting from motorbike collisions [19], a reduction in mean speed [17], an increase of subjects wearing helmets [12], a reduction of passenger vehicle crash [17], a decrease in road traffic deaths [16] [17] [18] [19], and a reduction in the total length of hospital stay for patients admitted for head injury after an RTA [16]. The laws concerned were speed limits [15] [16] [17], alcohol control [18], helmet use [12], a ban on motorbikes in the capital [19], and a ban on the use of motorbikes as a means of public transport [20]. In contrast, evaluation of the influence of helmet enforcement in Nigeria, rather than a reduction, noted an increase in the proportion of motorcyclists who died from RTAs after the intervention [12]. Furthermore, they were no improvements in helmet use among motorcycle drivers and passengers after helmets enforcement in Kenya [13], and non-significant reduction in accident cases after seat-belt enforcement in Nigeria [14]. Authors of these studies believed that the influence of other confounding factors as lack of education on the correct use of the crash helmet, or differences in population in different periods were responsible for these outcomes. Opportunity to further increase both awareness as well as enforcement of the legislation would improve outcomes of law enforcement.

Studies on awareness raising, training or user education interventions.

Four studies noted the achievement of all expected outputs [23] [25] [27] [28], and for another four, there was partial achievement [21] [22] [24] [26]. Training drivers in rescue techniques, basic evacuation procedures and specific first aid skills resulted in a significant increase in the first aid knowledge score in the intervention group [22] as well as in the first aid skill score [22] [23]. However, the knowledge score was not improved in one of the two studies that evaluated this intervention [22]. Similarly, the intervention to improve knowledge of traffic signs resulted in a significant change in learners' or drivers' knowledge after the intervention [21] [25], and a significant increase in the proportion of drivers reporting compliance with traffic signs in the group [25]. However, the effects varied according to the categories of traffic signs [21].

Communication about road safety practices led to some expected results, such as an increase in the proportion of drivers reporting resting after hours of driving or observing speed limits, and a decrease in the proportion of drivers reporting fatigue. This study did not find significant differences in the possession of a valid driver's licence, substance use, carrying more than one person, and a decrease in the prevalence of RTAs [24].

Health and safety education on various road safety topics resulted in a significant increase in the proportion of drivers with correct knowledge of licensing requirements, and adequate knowledge of road signs and maximum speed limits in the intervention group. However, the proportion of drivers reporting compliance with speed limits in the intervention group decreased [26]. The introduction of stickers in public transport vehicles led to a reduction in the number of incidents resulting in insurance claims [27] [28]. Stickers had messages en-

couraging passengers to react if the driver did not follow the rules of the road, to report it [27] [28], or messages on the possible consequences of driver misbehaviour if the driver did not listen to the advice [28]. There was also a reduction in the average maximum speed of drivers in the intervention group, a reduction in crashes (140 fewer RTAs) and fatalities (55 lives saved) [28].

Study of the development of Uber transport services. This intervention resulted in a slight reduction in weekly RTA deaths in the province with Uber in South Africa compared to provinces without Uber [29].

Equipment distribution study. Free distribution of reflective vests, combined with brief road safety education in Tanzania, led to a significant increase in the use of reflective vests among motorbike taxi drivers. However, there was no significant change in the use of white helmets and daytime running lights among motorbike taxi drivers [30].

Multi-intervention study. The combination of various interventions among public transport drivers in Kenya did not result in significant changes in injury severity levels (including fatalities) or patient hospital stays [32]. A combination of interventions to reduce the risk of accidents among schoolchildren resulted in a decrease in the prevalence of RTAs, the frequency of pedestrian-car collisions among schoolchildren, and the frequency of minor injuries in the intervention group [35] [37]. There was a non-significant decrease in the frequency of pedestrian-motorcycle collisions (the most frequent type of collision) in the intervention group [35], and in the number of motor vehicle collisions in one of the two zones, but an increase was recorded in the second zone [37]. These interventions reduced the frequency of speeding, braking, and sudden acceleration among drivers in the intervention group, but they drove more at night [36]. The construction of a footbridge and educating schoolchildren to use it in Nigeria showed a “significant” increase in the number of pupils using the footbridge to cross the road [38].

Studies evaluating the effectiveness of the enforcement of various road safety laws and the monitoring of compliance have shown reductions in fatalities in terms of lives saved [33], or reductions in fatalities per 10,000 vehicles [31]. There was also a significant reduction in the number of non-injury RTAs, but the number of injuries per 10,000 vehicles did not decrease as expected [31]. A study implementing activities to increase compliance with road safety measures and encourage helmet use resulted in improved helmet use (reported or directly observed), reduced prevalence of RTAs, speeding, carrying more than one passenger, and an increase in the proportion of subjects reporting protective behaviours [34].

4. Discussion

Very few studies have been carried out on road safety in Africa and the majority are concentrated in three countries. It can also be noted that it is mainly English-speaking countries that have published on implemented interventions. This

shows that French-speaking countries seem to be behind in terms of research and scientific publications on road safety. Studies that measured effects on the reduction of accidents, injuries, or deaths used various indicators of absolute frequencies in some cases, such as the frequency of injuries [17] [20], number of weekly deaths from RTAs [29], annual number of RTAs, injuries, or deaths [11], number of RTA cases [17] [19] [28], total number of patients admitted with head injuries after RTAs, or deaths in patients admitted with head injuries after RTAs [16]. Some studies have assessed injury severity levels [15] [19] [20] [32]. Others have determined the length of hospital stay for patients [16] [32], or the number of lives saved [28] [33]. The absolute frequency measure for judging the effectiveness of an intervention seems insufficient because it does not consider a denominator that could better compare two different periods or different contexts. This means that assessments of the effectiveness of the interventions concerned are questionable.

Some studies measured indicators that are relative frequencies such as proportions, ratios, prevalence, incidences, and others. In this group, we can mention the annual average number of RTAs, people injured or killed after an RTA [10], the number of RTAs, serious RTAs and fatal RTAs per capita [11] [14], the monthly number of RTAs, people injured or killed after an RTA per 10,000 vehicles [31], the prevalence of RTAs [34] [35], the hospital prevalence of RTAs [20], the incidence of trauma [15], the ratio of fatalities per crash involving motorcyclists [12], the median number of pedestrian-vehicle crashes per km of road per year, the median number of motorcycle-vehicle crashes per km of road per year [37], the ratio of the total number of RTAs, or fatal RTAs per volume of petrol sold [18]. These types of indicators seem more realistic as a measure of effectiveness and for comparing the same types of intervention in different contexts or time periods. Indeed, use of indicators based on ratios or relative frequencies is more relevant than the use of absolute frequencies, as the inclusion of a denominator makes it possible to standardise interpretation and comparison between before and after the intervention.

The studies of user awareness, training, or education interventions [21]-[28], the study of equipment distribution [30], and two studies combining several interventions essentially assessed outputs related to the adoption of certain behaviours [36] [38], but not effects on injury or fatality reduction. These indicators do not assess the effects of the implementation of these measures on accidents, injuries, or fatalities. The only study of an awareness intervention that looked at effects measured absolute frequencies only (reduction in RTAs and number of lives saved) [28], which is also a shortcoming.

The studies on institutional strengthening all seem to be effective, as they have noted a significant reduction in road accidents and injuries [10] [11]. The same is true for most of the enforcement studies, which have shown a reduction in the frequency and severity of injuries [15]-[20], except for the three studies on helmet and seatbelt use [12] [14]. Both of these studies showed convincing direct

effects (helmet or seatbelt use) but not a significant effect on the occurrence of injuries and fatalities. This could be explained by the existence of other accident severity factors not considered by these studies. The combination of various interventions led to a reduction in road accidents, injuries and/or deaths [31] [33] [35] [37], except for one study [32]. This observation demonstrates the value of implementing integrated and multidisciplinary interventions.

Limitations of this study: The risk of bias was assessed as high for several articles, but these were not rejected so as not to reduce the number of articles too much. Also, the interventions and the methodologies were diverse, as were the outputs, which limits the comparison of studies. However, we considered that studies that demonstrated a reduction in road traffic accidents, injuries or deaths could be retained as effective studies. Several studies measured only intermediate outcomes but not the effects of interventions on reducing road traffic injuries and fatalities, which does not confirm their effectiveness.

5. Conclusion

Few countries have conducted studies to measure the effect of road safety interventions in Africa. It is important to assess the effectiveness of interventions in order to know which ones to promote, based on their cost-effectiveness, and which ones to reorient in relation to the contexts of each country. This systematic review shows that the most effective interventions are those related to institutional strengthening, law enforcement and, above all, the combination of several interventions. Research is needed to measure the effect of awareness, education, and training interventions on the occurrence of RTAs, injuries, and deaths from RTAs. Leading road safety institutions and all stakeholders should encourage and fund research to evaluate measures implemented in countries and to conduct quasi-experimental intervention studies tailored to each context.

Acknowledgements

The research team would like to thank the authorities of the Regional Institute of Public Health. The following people who have contributed or facilitated the achievement of this research are also thanked for their contributions: Ms. Valérie DURIEUX, librarian at the Université Libre de Bruxelles, who helped to determine the main terms used in the research equations and to formulate these research equations; Prof. Katia CASTETBON who contributed to the definition of the methodology of the study and to the development of the tools for data extraction; Mr. Dosten Kpozehouen and Mr. Nicolas Gaffan who participated in the selection of articles and the extraction of data; Dr. Virginie MONGBO who guided the writing of the article.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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