Review

Road Safety in Low-Income Countries: State of Knowledge and Future Directions

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Abstract: Road safety in low-income countries (LICs) remains a major concern. Given the expected increase in traffic exposure due to the relatively rapid motorisation of transport in LICs, it is imperative to better understand the underlying mechanisms of road safety. This in turn will allow for planning cost-effective road safety improvement programs in a timely manner. With the general aim of improving road safety in LICs, this paper discusses the state of knowledge and proposes a number of future research directions developed from literature reviews and expert elicitation. Our study takes a holistic approach based on the Safe Systems framework and the framework for the UN Decade of Action for Road Safety. We focused mostly on examining the problem from traffic engineering and safety policy standpoints, but also touched upon other sectors, including public health and social sciences. We identified ten focus areas relating to (i) under-reporting; (ii) global best practices; (iii) vulnerable groups; (iv) disabilities; (v) road crash costing; (vi) vehicle safety; (vii) proactive approaches; (viii) data challenges; (ix) social/behavioural aspects; and (x) capacity building. Based on our findings, future research ought to focus on improvement of data systems, understanding the impact of and addressing non-fatal injuries, improving estimates on the economic burden, implementation research to scale up programs and transfer learnings, as well as capacity development. Our recommendations, which relate to both empirical and methodological frontiers, would lead to noteworthy improvements in the way road safety data collection and research is conducted in the context of LICs.

Keywords: road safety; low-income countries; under-reporting; best practices; vulnerable groups; injury severity; road crash costing; crash data; capacity building

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1. Introduction

Road safety is a major global health issue since large proportions of unintentional injuries are caused by traffic-related crashes. According to the Global Health Observatory, 1.35 million fatalities occur on the world's roads each year [1]. In general, although traffic-related injuries and fatalities have seen a decreasing trend during the past two decades, this reduction has not been as significant as expected [2]. This is despite several improvements in motor vehicle safety standards and features, road safety policies, and road design [2]. In fact, road transport still poses a substantial risk to human health in many regions around the world.

The problem is especially critical in low-income countries (LICs), due to several persisting shortcomings in road safety standards, vehicle safety and maintenance, and in the design and implementation of policies and safe transportation infrastructure. Figure 1 displays national wealth versus road death rate based on data provided by the WHO [1]. Research is thus needed to better understand the underlying mechanisms of road safety in LICs. This will help guide road safety policies and strategies, with the aim of reducing traffic-related injuries and fatalities. Note that we refer to LMICs to indicate low- and lower-middle income countries, while LICs refer specifically to low-income countries, as shown in Figure 1.
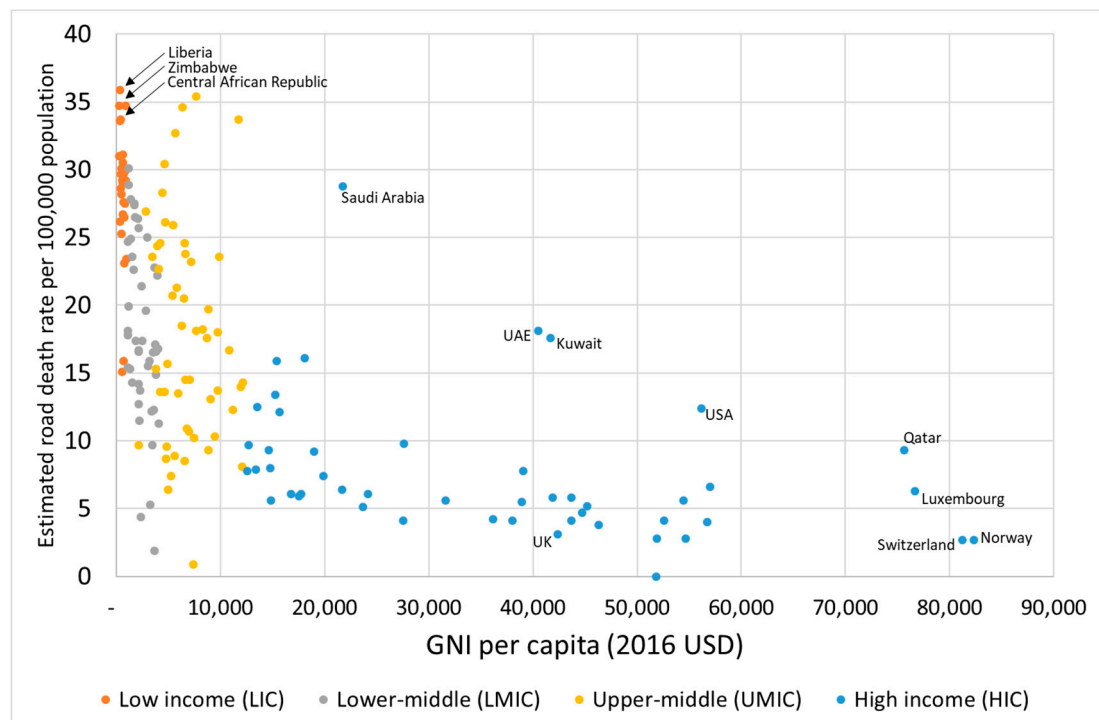

Figure 1. Comparing road traffic death rates with national wealth [1].

There are global initiatives that have sought to address such issues, many of which are coordinated through the Global Plan for the Decade of Action for Road Safety 2011–2020 [3], developed by the United Nations Road Safety Collaboration (UNRSC). Examples include the Global Road Safety Partnership (GRSP) [4], the World Bank's Global Road Safety Facility [5], the Bloomberg Philanthropies Initiative for Global Road Safety [6], and the Road Safety in 10 Countries Project [7]. These global efforts have generally focused on the practical implementation of policies and standards to improve road safety in the developing world [8].

Given these developments in the field, and the fact that we are nearing the end of the UN Decade of Action for Road Safety [3], it is important to take stock of where we are, what the state of the field is, and determine what research will be important in the future to make further progress. In line with this approach, our study aims to take a holistic approach investigating different lines of research under the broad topic of road safety in LICs with the aim of (i) analysing and summarising the current state of knowledge; and (ii) proposing a number of future research directions. We have used the Safe Systems framework and the framework for the UN Decade of Action on Road Safety to identify the domains of focus for this work [9,10]. There is a focus on the understanding of road safety engineering issues while also reaching out to other sectors.

The paper is structured as follows: Section 2 discusses our methodology. Section 3 discusses our findings and is centred on an overview of current (available) research focusing on the main road safety issues in LICs. In Section 4, we report on the results of a survey of experts in road safety in

LICs. Section 5 discusses implications and our proposed future directions, where there are several opportunities for improvements, both empirically and methodologically. We conclude with a summary in Section 6.

2. Materials and Methods

2.1. Review Framework

This article explores the state of knowledge of road safety in LICs based on a review of literature and consultation with experts in the field. The review panel was formed by an international collaboration of the Transportation Research Group at the University of Southampton (United Kingdom) and Johns Hopkins International Injury Research Unit at Johns Hopkins University (USA). With respect to quantitative results, the literature search was carried out according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [11] as explained in Section 2.3. Non-quantitative results were identified through online searches as described in Section 2.3. Expert consultation is described in Section 2.4.

2.2. Research Questions

Our research questions were as follows:

i　"what are some of the most important topics relating to road safety issues in LICs?"
ii　"what is known about these topics?"
iii　"what would be some of the most critical future research directions to be considered by researchers?"

2.3. Search Strategy, Selection of Studies, and Eligibility Criteria

We extracted the search terms from published studies (journal/conference articles and reports published by international organisations) in a preliminary search. For the review, while there was no search restriction on the publication date, articles published before 1990 were only considered for inclusion if the number of relevant results was particularly low. The search strategy aimed to limit the search to LICs by combining search results from a list of names of LICs with other relevant keywords applicable to other search topics such as vehicles and crashes, road safety measures, vehicle safety measures or vulnerable road user groups. Articles had to be peer-reviewed and published in English. Articles were screened by title and abstract for relevance, and appropriate bibliographies were also scanned for further relevant articles or reports. The search resulted in over 7000 potential articles to be screened across all the topics under consideration.

Quantitative results were specifically sought for under-reporting, and the literature search for that topic was carried out according to PRISMA guidelines, using electronic databases such as Web of Science, Scopus, PUBMED, TRID, BMC, and EMBASE. Search strings were generated by combining the list of LIC named countries and other relevant search terms such as underreport, under-report, and capture-recapture (a methodology used to address under-reporting). To be included, articles had to be related to a formal assessment of under-reporting. As the number of eligible papers in LICs was relatively few, there was no restriction on whether the assessment was for injury/fatality counts, nor any restriction on date. This in-depth search yielded many papers related to under-reporting as well as the other topics of road safety, both as part of the search results, and from bibliographies within relevant articles and reports. In this regard, further details are discussed in Section 3.1.

With respect to other topics, further relevant articles or reports, published by international organisations, were identified through online searches using appropriate keywords for each of the topics, and from discussions with experts and stakeholders. Search strings were generated by combining the list of LIC named countries, and other relevant search terms; e.g., low-income OR road accident OR traffic accident OR road crash OR traffic crash). Table 1 gives examples of the search strategy developed for this study (the example displayed having been used for searching Scopus). The strategy aims to

limit the search to LICs (see Scopus #1), and then limit the search according to the desired topics of vehicles and crashes (see Scopus #2), road safety measures (see Scopus #3), vehicle safety measures (see Scopus #4), or vulnerable road user groups (see Scopus #5). For example, from a total of 69,448 studies relating to LICs, 454 studies were found to be relevant to road crashes in LICs (see Table 1).

Table 1. Example Scopus search strategy.

Set #	Search String	Results
#1 Low-income countries	TITLE-ABS-KEY("developing country" OR "developing countries" OR Afghanistan OR Benin OR "Burkina Faso" OR Burundi OR "Central African Republic" OR Chad OR Comoros OR Congo OR Eritrea OR Ethiopia OR Gambia OR Guinea OR "Guinea-Bissau" OR Haiti OR "North Korea" OR Liberia Madagascar OR Malawi OR Mali OR Mozambique OR Nepal OR Niger OR Rwanda OR Senegal OR "Sierra Leone" OR Somalia OR Sudan OR Tanzania OR Togo OR Uganda OR Zimbabwe OR "low resource" OR "under-resourced" OR "resource poor" OR "under-developed" OR "underdeveloped" OR "developing world" OR "third world" OR LIC OR (low AND income))	69,448
#2 Vehicles and accidents or crashes	TITLE-ABS-KEY((("Motor Vehicles" OR Automobiles OR Motorcycles OR traffic OR vehicle OR vehicular OR car OR cars OR automobile OR motorcycle OR taxi OR cab OR road OR pedestrian OR pedestrians) AND (accident OR accidents OR crash OR crashes OR injury OR injuries)))	151,221
#3 Road safety measures	TITLE-ABS-KEY("road safety" OR "road safety interventions" OR speeding OR "drink driving" OR helmet OR "motorcycle helmet" OR "seat belt" OR "seatbelt" OR "child restraint" OR "distracted driving" OR "drug driving" OR "traffic calming")	49,812
#4 Vehicle safety measures	TITLE-ABS-KEY("vehicle safety" OR "vehicle safety standards" OR "advanced braking" OR "anti-lock braking" OR "electronic stability control" OR NCAP)	6,559
#5 Vulnerable road user (VRU) groups	TITLE-ABS-KEY("vulnerable road user" OR "disability" OR "disabled" OR "gender disaggregation" OR "gender")	956,942
#6 Crashes in LICs	#1 AND #2	454
#7 Road safety measures in LICs	#1 AND #3	147
#8 Vehicle safety measures in LICs	#1 AND #4	5
#9 VRU crashes in LICs	#1 AND #2 AND #5	103

2.4. Expert and Stakeholder Consultations

In the process of synthesizing findings from the literature review and identifying areas for further inquiry, we informally consulted with ten road safety experts from academia and international road safety organizations, including local experts from Bangladesh, Nepal, Uganda, Ghana, and Kenya. We asked a smaller number of experts (n = 6), who have had extensive experience working on road safety in LICs and are well versed with the global road safety landscape, to respond to a survey to provide further input on findings from the literature review. These consultations and surveys aided in the synthesis and prioritization of important areas of focus for future road safety in LICs. This questionnaire was based on three main themes regarding road safety in LICs: (i) main topics of concern; (ii) policy-making and implementation; and (iii) capacity development for road safety. Basically, with respect to each theme, respondents were asked to answer "what needs to be done, and how it can be achieved?" Before undertaking this part of our research, we obtained an approval from the University of Southampton Faculty of Engineering and Physical Sciences Ethics Committee on 03/05/2019 (ERGO II 48744). The outcomes from the survey and other discussions also provided context for topics for which there was a gap in the literature. These consultations contributed to the future research agenda set out in Section 5. Our consultation results are discussed in Section 4.

3. State of Knowledge

This section discusses our findings with respect to pertinent previous studies.

3.1. Under-Reporting of Road Crashes in LICs

Accurate knowledge of road crashes and their causes can help provide robust motives for the investment of appropriate and effective road safety interventions, and is especially important where such funds are limited [12]. Police road traffic crash data has been the traditional source of such information, although the accuracy of such data is questionable since all countries suffer from some level of under-reporting. The WHO provide estimates of the numbers of fatalities in each country, using negative binomial modelling based on the actual number of reported fatalities [1]. According to their estimates, the average number of road fatalities correctly reported to official sources is likely to be higher for higher income countries, with an average of 88% of road fatalities correctly reported in high-income countries (HICs) and 77% in middle-income countries (MICs). However, this reporting accuracy is significantly lower in LMICs (52%) and LICs (17%).

There are several underlying reasons why under-reporting may occur. A poor understanding regarding the benefits of complete and accurate road crash records means those involved may avoid contacting the police [13], preferring to negotiate with the driver [14,15]. A poorly resourced, capacity-limited police force is likely to focus on those crashes that involve more injuries, fatalities or property damage [13,16,17]. Also, the legal requirement to report road crashes to the police varies from country to country [18]. In built-up areas, victims are likely to be taken to a nearby hospital by relatives or bystanders before any police officers can attend the crash scene [13,14,17]. In rural areas, relatives and neighbours of crash victims may be deterred from travelling to hospitals due to cost implications [14]. There are further limitations due to the reliance on paper records, rather than on the types of electronic recording systems in place in higher income countries [18], especially if such original paperwork is required for subsequent judicial hearings [19].

Numerous studies have investigated how to improve the quality and accuracy of road crash data, particularly through combining police records with hospital records of patients admitted as a result of road crashes. These studies have mainly taken place in the developed world, for example in France [20–23], elsewhere in Europe [24–30], the United States [31,32], Australia and New Zealand [33–38], and China and Japan [39,40].

With respect to quantitative results relating to under-reporting, we found only four studies in LICs (from an initial list of 983 potential articles) that provide a quantitative assessment of the level of under-reporting, comparing police data with those of hospital records (see the PRISMA flow diagram in Figure 2). The four studies were all from LICs in Africa (Ethiopia, Uganda, Malawi, and Mali). Table 2 shows the location, study period, methodologies and metrics used, highlighting the inconsistencies in study designs. The study in Ethiopia [14] focuses on a 264 km stretch of two-way, two-lane road, on which traffic volumes vary from an average of 17,000–20,000 vehicles per day on the 64 km stretch near Addis Ababa, to around 3000–3500 vehicles per day on the remaining 200 km as the road approaches Hawassa. The other studies focus on regional areas (adopting a zone- or macro-level approach), considering the records at police offices and hospitals within a certain region.
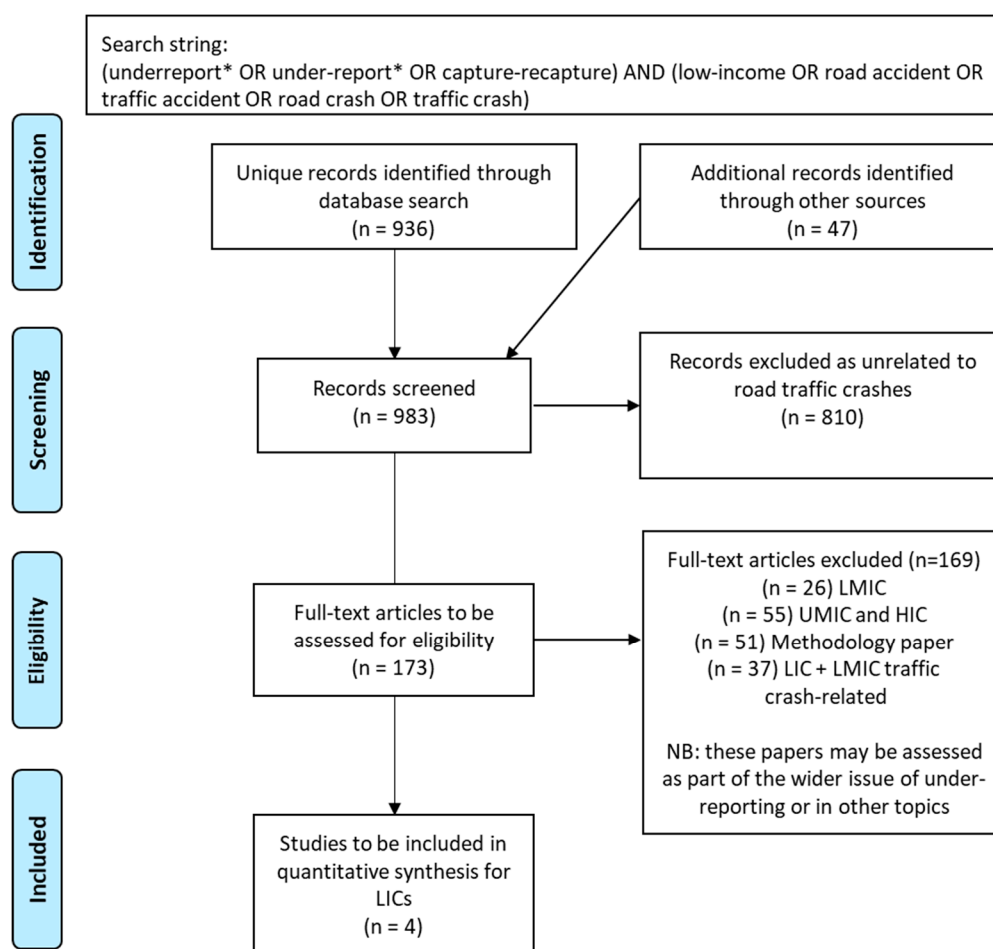
Figure 2. PRISMA flow diagram for under-reporting literature search.

The only consistent element to these four studies is the analysis methodology used: the capture-recapture method. The 'Capture-recapture' method is perhaps the most widely used method to rectify inaccuracies in road crash reporting [41]. Originally developed for use in estimating the biometrics of animal populations and subsequently applied to human populations and the injury field as discussed for example in (as discussed for example in [42]), the method involves estimating the number of cases in a defined population using multiple sources of information (e.g., linked databases), assuming that each source alone may under-count the population. While it is a useful (and relatively low-cost) tool for road crash investigators, especially in LICs where under-reporting is frequent, there are certain caveats to understand regarding its use due to population movements and dependence of data sources [43]. However, movement of population has been identified as a minor issue, for example, due to the relatively short timescales between police attending a crash scene and casualties visiting hospital [14,20], or the relative lack of migration within a study region [44]. The four studies identified here all aimed to address any bias introduced by a lack of independence by using a stratified capture-recapture technique to identify those factors that were associated with dependency of the data sources. Yet, whether stratification is satisfactory remains uncertain and the problem may not be fully addressed.

Given the limitations associated with capture-recapture methods, other techniques have been used to estimate the levels of under-reporting. Regression analysis is useful if the two-source approach used in capture-recapture is not appropriate or feasible [1,33]. A modified Poisson regression has been used in France [21], and similar approaches have been used in India [15], the United States [32], and Australia [38]. The impact of under-reporting on crash severity models has also

been investigated [45–47]. However, as previously noted, all four quantitative papers in LICs use capture-recapture.

Table 2. Summary characteristics of selected studies.

Reference	Location	Study Period	Method Used	Metric Used
Abegaz et al. [14]	Ethiopia (264 km highway)	Jun 2013–May 2014 (12 months)	Capture-recapture, two-source	Fatalities/injuries per billion vehicle km
Magoola et al. [13]	Uganda (Jinja)	March 2014–April 2014 (2 months)	Capture-recapture, two-source	Number of road traffic injuries (RTIs)
Samuel et al. [16]	Malawi (Lilongwe district)	July 2008–June 2009 (12 months)	Capture-recapture, two-source	Number of fatalities Mortality incidence (fatalities/1000 person-years)
Sango et al. [48]	Mali (Bamako district)	January 2012–April 2012 (4 months)	Capture-recapture, two-source	Number of fatalities; Number of records; Incidence per 100,000 people

The key findings of the studies reported in Table 2 are summarised in Table 3 according to the metric used and sources of data (police and/or hospital). In order to compare results of the four African studies while accounting for uncertainty, the relative accuracy of each data source was calculated in terms of confidence intervals (see Table 3). The accuracy rate is obtained by considering the main metric used in a particular study (e.g., number of fatalities, or injuries per 100,000 vehicle km), and comparing police and hospital results with those generated by the capture-recapture method. These results reveal some consistent patterns. Police records tend to account for more fatalities than hospital records, while hospitals tend to have more complete records of road crashes and injuries. However, neither set of records has a complete record of the numbers of fatalities or injuries. In general, the uncertainties around estimates relating to fatalities are larger than those obtained for injuries and crashes. The study conducted by Abegaz et al. [14], which adopts a micro-level approach, focusing on a specific roadway rather than a region, has the smallest confidence intervals. The results from Ethiopia and Mali indicate that the police records contain around 60% of the total fatalities, and hospital records seem to account for between 40% and 60% of injuries or road crash numbers.

Table 3. Accuracy rates of police and hospital records for four LICs (with associated confidence intervals).

Reference	Fatalities		Injuries		Crashes	
	Police	Hospital	Police	Hospital	Police	Hospital
Abegaz et al. [14]	59.2% (57.4–60.9%)	32.5% (31.5–33.4%)	23.7% (23.5–23.9%)	55.6% (55.2–56.0%)	n/a	n/a
Magoola et al. [13]	n/a	n/a	14.4% (13.1–16.5%)	60.4% (55.1–65.2%)	n/a	n/a
Samuel et al. [16]	37.6% (30.9–48.0%)	25.5% (21.0–32.6%)	n/a	n/a	n/a	n/a
Sango et al. [48]	57.6% (50.4–67.9%)	54.5% (47.8–64.2%)	n/a	n/a	16.8% (15.9–17.8%)	42.1% (39.9–44.6%)

3.2. Lessons Learned from Global 'Best Practice' and Its Applicability to LICs

We believe it is important to draw on the experience of successful road safety campaigns around the world. For example, Wegman [49] identifies Spain in particular as an exemplar of success in road safety practice, as the number of fatalities there has decreased by over 70% between 2000 and 2013, with neighbours Portugal close behind.

According to the Spanish Government's Traffic Directorate report on their road safety strategy [50], Spain's improved safety level in the 2000's stemmed from their adoption of the European Road Safety Strategy in 2000, followed by the increased use of in-car safety systems, the increased use of helmets

(from 73% to 99%), the increased use of seat belts (from 70% to 91%), and reduced risks from slower average speeds (reduced by 2 km/h) and a downward trend in drink-driving (the percentage of drivers who died when over the limit of 0.3 g/L fell from 35% to 29%).

The Spanish experience is one example of how a cohesive national road safety strategy may result in significant reductions in road crashes. However, as a developed country, the challenges and issues involved in improving road safety are likely to be different from those in LICs [51]. While infrastructure improvements and appropriate legislation are, to a relatively large extent, common themes appropriate to all road networks, road user behaviour may vary from one country to another. This is why one should take into account that cultural differences may lead to variation in road user behaviour in different jurisdictions. For example, the same engineering intervention may result in unequal road safety improvements even if all other factors such as traffic exposure and roadway characteristics are similar. However, we speculate that, while such variation in road user behaviour would affect the magnitude of effectiveness, it would not deter the effect of such engineering interventions entirely. Therefore, lessons can be learnt from successful interventions in developed countries. For example, the Safer Africa project [52] aims to utilise knowledge and expertise from successful European road safety projects to implement effective road safety and traffic management interventions in African countries.

In order to attempt to affect road safety positively in LICs and LMICs, 2011–2020 has been designated the World Health Organization's (WHO) 'Decade of Action for Road Safety', seeking to save millions of lives by building road safety management capacity, improving the safety of road infrastructure, further developing the safety of vehicles, enhancing the behaviour of road users and improving the post-crash response. A number of previous studies have carried out reviews of road safety interventions in LICs and LMICs, some of which are shown in Table 4 and discussed in more detail below.

Gupta et al. [53] focused on regulatory and road engineering interventions for preventing road traffic injuries and fatalities among non-motorised and motorised two-wheel (i.e., vulnerable) road users. Of the twenty-five studies in their review, only two were LIC-based. Esperato et al. [54] aimed to evaluate the cost and health impacts of road safety interventions in LMICs, identifying thirteen studies which met their criteria, none of which were based in LICs. Staton et al.'s focus [55] was to determine quantitative impacts of road safety interventions including legislation, enforcement and education campaigns. Of the eighteen studies identified, three were in LICs. Bonnet et al. [56] identified twenty-three articles relating to road safety interventions in Africa; eight were set in LICs. These studies highlight the relative dearth in quantity and quality of research output that relate specifically to the impact of road safety interventions in LICs.

With respect to best practices in LICs, the experience of Ethiopia could be mentioned, where media campaigns coupled with targeted research studies have provided a more complete picture of the impact of road safety legislation [6,57–59]. A summary of these and other research into policy interventions in LMICs is given below under the broad themes of education, enforcement and engineering.

Table 4. A sample of papers related to road safety initiatives and interventions in LICs and LMICs.

Main Themes	Location		Key Finding
General review of interventions	12 countries in Eastern and Southern Africa	Bonnet et al. [56] What interventions are required to reduce road traffic injuries in Africa? A scoping review of the literature	There is a lack of road safety interventions and some shortcomings in the associated assessments.
	LICs &LMICs	Gupta et al. [53] Regulatory and road engineering interventions for preventing road traffic injuries and fatalities among vulnerable (non-motorised and motorised two-wheel) road users in low- and middle-income countries	There is a lack of studies specifically assessing the impact of engineering interventions in LMICs. Where studies exist, there are mixed results (e.g., while fatalities declined, the number of casualties more than doubled)
	LICs & LMICs	Staton et al. [55] Road traffic injury prevention initiatives: a systematic review and meta-summary of effectiveness in low and middle income countries	A multi-faceted approach (involving education, legislative and enforcement measures) is more effective
	LMICs	Esperato et al. [54] Projecting the health and economic impact of road safety initiatives: A case study of a multi-country project	Road safety interventions in the Road Safety in 10 Countries project are likely to be cost-effective, but there is a reliance on potentially inaccurate global data sets for evidence of impacts
Legislation change	Ethiopia	Abegaz et al. [59] Effectiveness of an improved road safety policy in Ethiopia: an interrupted time series study	Revised road safety policy helped reduce motor vehicle crashes and associated fatalities. However, the overall incidence rate is still very high
Road safety education	Pakistan	Ahmad et al. [60] Teaching children road safety through storybooks: An approach to child health literacy in Pakistan	Discussions using bilingual pictorial storybooks helped primary school children better understand crash prevention
	LICs & LMICs	Li et al. [61] Children and road traffic injuries: Can't the world do better?	Validation and implementation of road safety interventions are lacking and urgently needed in LMIC
	Tanzania	Zimmerman et al. [62] Road traffic injury on rural roads in Tanzania: Measuring the effectiveness of a road safety program	The incidence of road crashes in low-volume rural settings is unacceptably high and most commonly associated with motorcycles. More research is needed to quantify the impact of various prevention strategies
	Ethiopia	Salmon and Eckersley [63] Where there's no green man: child road-safety education in Ethiopia	Road-safety education in Ethiopia is often locally inappropriate and impractical, frequently based on dominant but ineffective educational models imported from other contexts
	LICs & LMICs	Bradbury and Quimby [64] Community road safety education: an international perspective	Transferring road safety education practices from developed to developing countries is arguably unfeasible because of variations in education systems, teaching methods, traffic regulations and exposure to risk. Road safety practitioners should research and develop bespoke teaching methods and materials in the country in which they will be used
	Ghana	Blantari et al. [65] An evaluation of the effectiveness of televised road safety messages in Ghana	Televised advertisements concerning speeding and alcohol-impaired driving, targeted towards commercial drivers, were largely understood, but road safety activities would be strengthened by increasing accompanying law enforcement activities

<div align="center">**Table 4.** *Cont.*</div>

Main Themes	Location		Key Finding
Enforcement	Kenya	Bachani et al. [66] Helmet wearing in Kenya: prevalence, knowledge, attitude, practice and implications	A traffic amendment bill resulted in negligible impact on helmet use, highlighting the need for a multi-faceted strategy that includes media campaigns and widespread enforcement in addition to legislative change for improving helmet use
	Cambodia	Bachani et al. [67] Knowledge, attitudes, and practices around drinking and driving in Cambodia: 2010–2012	A multi-pronged, coordinated approach is needed to effectively address drink-driving, including social marketing and public education campaigns, and enhanced enforcement
	Nigeria & Vietnam	Stewart et al. [68] Drink driving prevention initiatives in low- and middle-income countries: challenges and progress in Nigeria and Vietnam	Interventions tailored to local conditions and needs can help reducing drinking and driving in LMICs. Effective partnerships with local governmental and nongovernmental organizations is an important aspect of future progress
	Kenya	Bachani et al. [69] Prevalence, knowledge, attitude and practice of speeding in two districts in Kenya: Thika and Naivasha	While this study demonstrates an improvement in the prevalence of speeding in two Kenyan districts over 2010-2012, it also highlights the need for further action to be taken to address the problem
	Malawi	Kraemer et al. [70] Cyclists' helmet usage and characteristics in central and southern Malawi: a cross-sectional study	Cycle helmet usage in Malawi is virtually non-existent. Future interventions should be targeted to adult and young adult males who made up 95% of observed cyclists
	LICs & LMICs	Johnson [71] Assessing a country's drink driving situation: An overview of the method used in 6 low- and middle-income countries	Situation assessments of drink-driving in six countries are now being used to develop appropriate and relevant pilot projects, taking into consideration the country's culture with respect to transportation, enforcement, health care, and alcohol consumption
Roundabout design	Ethiopia	Tulu et al. [58] Investigating pedestrian injury crashes on modern roundabouts in Addis Ababa, Ethiopia	The presence of a public transport terminal beside a roundabout is associated with increased pedestrian crashes. While the maximum gradient of an approach road is negatively associated with pedestrian safety, the provision of a raised median along an approach appears to increase pedestrian safety at roundabouts

3.2.1. Education

Educating the populace, and children in particular, about road safety and good road user behaviour can help to reduce the number and severity of crashes, particularly when used as part of a wider package of interventions [56,61,63]. For example, storybook narratives have been used in Pakistan to improve children's knowledge and attitudes towards road safety, and the relatively low-cost storybooks provided an effective and early strategy towards promoting behavioural change, particularly how to behave at the road side and when crossing. For instance, results indicated that while questions regarding where it is safe to cross were answered correctly by just over 50% of the children, this increased to over 90% correctly answering two months after the initial intervention. However, it was acknowledged that there may be a need for regular road safety education to further ensure that students retain traffic safety messages in the longer term [60], and for any impact to be effective, such measures ought to be coupled with legislative and enforcement measures [55].

Communities and families also have considerable potential to influence the young and road safety programmes need to be developed in support of formal school programmes [64]. In the wider community, research has focused on the impact of televised road safety messaging [65], which was found to be largely effective at promoting lower alcohol consumption when driving, although the language used in the messages was considered a potential barrier in a country with multiple languages spoken. In Tanzania, an education programme was developed based on an assessment of local road crashes, including targeting motorcyclists [62].

The transferral of road safety education practices from developed to developing countries can be difficult due to variations in education systems, teaching methods, traffic regulations and exposure to risk. Road safety education and awareness have been identified as the interventions which are most adapted to LICs [56]. Thus, road safety practitioners should aim to research and develop bespoke teaching methods and materials in the country in which they will be used [64].

3.2.2. Enforcement

Improving road safety through enforcement of revised legislation can also help promote road safety, particularly in the five key risk factors identified in the Global Plan for the Decade of Action for Road Safety (speed, drink driving, not wearing motorcycle helmets, not wearing seat belts, and not using child restraints in cars) [3], manuals for each of which have been published by WHO [72]. The drink-driving manual has been further developed into an assessment framework to help understand how LICs and LMICs can better adopt the guidelines [71]. Further examples of research in this area include a study in Addis Ababa in Ethiopia, where joint media and enforcement campaigns have reduced drink driving by 50% [57]. In terms of legislation, Addis Ababa has developed its first ever road safety strategy and implementation plan, and established an inter-agency road safety council chaired by the Deputy Mayor and is considering setting up a road safety fund [6]. Wider road safety policy interventions in Ethiopia were investigated using interrupted time series [59]; the revised road safety policy banned the use of mobile phones while driving, made helmet and seat belt use mandatory, and increased levels of enforcement of excessive speeding, drunk driving and carrying dangerous loads. This was found to have helped reduce motor vehicle crashes by around 19% and associated fatalities by 12% in the year following the intervention; however, the overall crash rate was still very high [57].

Helmet use, for both bicycles and motorcycles, is low throughout LICs. A study in Malawi observed zero bicyclists wearing a helmet over a four-day study period [70]. In Kenya, the low prevalence of motorcycle helmet use remained unchanged, with around 30% of motorcycle riders correctly using helmets following the introduction of a traffic amendment bill in 2012, highlighting the need for a multi-faceted strategy that includes media campaigns and widespread enforcement in addition to legislative change for improving helmet use [66]. The authors reached a similar conclusion after studying the prevalence and attitudes towards drink driving in Cambodia, as Bachani et al. [67] concluded that a multi-pronged and coordinated approach would be needed

to effectively address this issue, including social marketing and public education campaigns, and enhanced enforcement measures.

Wismans et al. [73] provide a summary of the WHO report [74] focusing on Asian countries, highlighting that while the interventions suggested have been adopted in many countries, LICs (notably Afghanistan and Nepal) tend to be lacking in such interventions.

3.2.3. Engineering

There is a lack of studies specifically assessing the impact of engineering interventions in LMICs [53], and those that are available have mixed results. Gupta et al. [53] report that the results of the three before-and-after engineering-based studies included in their review show that while fatalities declined, the number of casualties more than doubled. Other more recent research in Ethiopia has focused on reducing traffic-related pedestrian injuries at roundabouts by modelling the effects of different features of the approaches, such as the presence of guard railing and location of pedestrian crossings. The results which emerged from a crash prediction model and development of safety performance functions suggested that the number of crashes involving pedestrians was 50% higher near public transport terminals, where the spatial intensity of pedestrian-vehicle conflicts is high. A change in gradient of the approach of 1% could result in 12% increase in pedestrian crashes, as visibility is reduced and speeds are affected. However, there is less risk of pedestrian crashes where appropriate crossing facilities are provided. For instance, roundabout approaches with central refuges had 44% fewer pedestrian crashes than those without such facilities [58]. However, provision of pedestrian facilities does not imply compliant use. In Ghana, 65% of pedestrians using a zebra crossing displayed some aspect of risky behaviour such as talking, eating or drinking, using telephones, and wearing headphones [75].

The WHO's annual 'Global Status Report on Road Safety' provides an overview of progress that has been achieved in important areas such as legislation, vehicle standards and access to post-crash care. The 2018 report [1] notes that progress has not, however, occurred at a pace fast enough to compensate for the rising population and the rapid motorisation of transport taking place in many parts of the world. At this rate, they note, the Sustainable Development Goals (SDG) target 3.6 to halve road traffic deaths by 2020 will not be met.

3.3. Vulnerable Groups and Gender Disaggregation

The travel behaviour of vulnerable groups, such as the disabled, women and children, can be adversely affected by road safety issues, particularly in LICs. The injury profile of road traffic crashes in LICs differs in important ways from the profile seen in developed countries. Pedestrians, cyclists and passengers on multi-passenger transport (buses, trucks and minibuses) are at particular risk of injury. For instance, Nantulya and Reich [76,77] note that pedestrians, cyclists and passengers in buses and trucks account for around 90% of the casualties in countries in low- and middle-income regions, as opposed to high-income regions where drivers constitute the majority of victims. This large proportion of vulnerable road users in road crash statistics in LICs may be explained by a traffic mix of incompatible users, where pedestrians, cyclists and motorcyclist are forced to share road space with cars and trucks, especially where communities live within the vicinity of roads, where there is a lack of pavement along large urban streets [78], and where children are particularly vulnerable to increasing levels of motorisation [79].

Despite the prominence of vulnerable road users in LICs, they are still largely ignored in the planning, design and operation of roads [1]. Around three-quarters of the casualties and fatalities in LICs are men [80,81], and this may reflect gender disparities in access to economic opportunities and in exposure to road traffic injury risks as drivers and passengers [77]. Unfortunately, the published summary data of injury numbers is seldom disaggregated to look at patterns in factors such as gender [82]. However, as more countries are conducting household surveys, in addition to regular population censuses, more countries can now produce data disaggregated by sex for basic indicators

on population, families, health, education and work [83]. Nevertheless, even when such information is collected, it is often not tabulated and disseminated to allow for meaningful gender analysis [83].

Men and women typically adopt different journey patterns, which will differentially change their exposure to risk of involvement in road crashes [82,84]. Uteng [85] suggests that there are a number of factors influencing women's mobility in the developing world, including social and cultural norms in a patriarchal system and transport infrastructure planning and design. Typically, women are less likely to make long journeys or use slower modes, and may not use busy roads as frequently as men, thus crash statistics for men and women will tend to show different patterns [85]. The predominant mode of transport for women in rural Africa, for instance, is walking [86], while men get access and priority for the use of private vehicles [85]. When women use motorised transport, it is likely to be public transport and they are often subject to other risks while travelling [86]. While these gender differences in the use of transport is greatest in rural settings [87], in urban areas, women have less access to either individual or public means of transport than men, due to both economic and social reasons, and are hence dependent on walking or using undesirable and potentially unsafe forms of public transport [88].

In their review of 73 studies of road traffic injuries in developing countries, Odero et al. [80] note that "no study in this review attempted to investigate specific potential factors that would explain the observed gender differences. Such a study is desirable and would need to assess and correct for levels of exposure by gender." Thus, the available literature on gender disaggregation in road crashes specifically relating to LICs is sparse, indicating a clear gap in the knowledge base, and this is a topic which could merit the use of social research mechanisms such as behavioural and attitudinal surveys of these vulnerable groups, especially focussing on countries which have recently improved frequency of and access to household survey data. Car-centric transport policies coupled with increased urbanisation could lead to greater inequity in mobility [85], and further study needs to be made on how such policies affect mobility from a gender-based perspective.

3.4. Disabilities Due to Road Crashes

Disability due to road traffic crashes and injuries is a significant proportion of the burden in low-income settings, where appropriate and timely medical care is not usually available for victims. Rehabilitation care systems are sorely lacking in LICs [89,90]. It is estimated that for every road traffic death, there are an additional 20–50 more people who are injured, and often face disability [91]. According to the World Health Organization [91], around 85% of all global road deaths, 90% of the disability-adjusted life years (DALYs) lost due to crashes, and 96% of all children killed worldwide as a result of road traffic injuries occur in low-income and middle-income countries. However, definite data on the number of people who survive road crashes but live with disabilities are almost non-existent [92].

Some indicative data is available as highlighted in the WHO's report on Global Road Safety 2018 [1]. There are data available for 29 of the 175 countries listed in that report, giving details of post-crash response, which provides an estimated value for the percentage of road crash victims with permanent disability. Of these 29 countries, four are classified as LICs and four as LMICs. The range of estimates for the four LICs is quite wide, with an estimated 47% of road crash victims having permanent disabilities in Togo and 40% in the Democratic Republic of Congo, while estimates for Zimbabwe (7%) and Uganda (3%) are much lower. The range is less stark for the LMICs, with an estimate of 19% of road crash victims in Sudan, and 15% in Cambodia suffering from permanent disabilities, compared with 2.4% in Bangladesh and 1% in Palestine (West Bank and Gaza). Of the upper-middle and high-income countries for which data is provided, this metric is highest in Brazil (24%) and Romania (21%), and lowest in Qatar and France (both 1%). There are no reasons offered within that report on why these data should be so disparate, and there is no obvious pattern linking the health care availability and these disability rates.

Zafar et al. [93] carried out secondary analysis of the results of four nationally representative cluster randomized surveys in LICs (Nepal and Uganda in 2014, Rwanda in 2011 and Sierra Leone in 2012) as

part of the Surgeons Overseas Assessment of Surgical Needs, which collected information regarding demographics, injury characteristics, anatomic location of injury, healthcare seeking behaviour, and disability from injury. The authors found that among the four LICs, involvement in a road crash was reported by 1.8%–2.6% of the population. These accounted for about 12.9% of all injuries. 'Major disability' was reported by an average of 38.5% of those suffering an injury as a result of a road crash. Respondents from Sierra Leone (49.3%) and Uganda (46%) were most likely to report a disability, whereas those from Rwanda (32.8%) and Nepal (21.1%) were less likely. Patterns of injury varied between countries; however, head and extremity injuries remained the most common.

One potential problem comparing the studies above is that of inconsistent definitions. For instance, the international road safety community has not yet settled on a precise definition of 'serious' injury resulting from a road traffic crash [94]. Injury severity in some developed countries has been assessed by means of the maximum abbreviated injury scale (MAIS), i.e., the maximum score of a six-point scale ranging from 1 (minor injury) to 6 (fatal injury) [95]. However, there is no agreement on which of the central MAIS levels should be used to define serious road injuries as a policy indicator. In the Netherlands, for instance, MAIS 2+ is used to indicate a serious road crash [94], while the International Road Traffic and Accident Database (IRTAD), proposes an injury score of MAIS 3+ to define a seriously injured road casualty [12].

A number of studies (see for example [96–101]) provide means to monitor the prevalence of disabilities among populations, but it should be noted that improved health care and vehicle safety does not necessarily imply that there will be fewer disabled people as a result of road traffic crashes. If healthcare and acute care services improve in LICs and in-vehicle protection devices (e.g., airbags) become more prevalent, there are likely to be fewer fatalities resulting from crashes. However, the implication is that more people will survive with non-fatal but extensive injuries, resulting in higher numbers of disabled people [102], implying a greater need in the future for long-term care and rehabilitation facilities for those who survive road crashes, but are permanently disabled. There are obvious cost implications associated with this [96].

3.5. Economic Burden of Road Crashes

Since road crash cost estimates are difficult to obtain, there are few studies that specifically focus on road crash costing or cost-effectiveness of interventions in LICs [103]. A recent summary of the economic costs of RTIs included in the Disease Control Priorities project suggests that these costs could range between 1%–2% of a country's GNP [92]. Delays in implementing road safety measures could also impact severely on a nation's wealth and its population's wellbeing [104]. While estimates on the total costs of RTIs vary based on the methodological approaches used, one large 21-country study estimated the global cost of RTIs at US$518 billion [92,105]. Another recent analysis of the economic impact of road traffic injuries led by the World Bank's Global Road Safety Facility found that if countries were able to halve mortality and morbidity due to road traffic injuries and sustain that over 24 years, they could realize significant increases in their GDP—between 7% and 22% [106].

In addition to the above costs, it is important to note that RTIs result in a significant societal burden as well, information about which is important for evidence-based policy making. However, there is a paucity in information in the global literature about the societal costs of RTIs, especially in LMICs, and more studies are needed. This information would provide insight into the consequences of crashes for the economy and social welfare. In fact, road crash costs can be used as a comparator with other policy areas, to help decision-makers prioritise investments. While epidemiological data for crash-related disability from LICs is scarce, the costs of prolonged care, loss of income and consequences for injured parents and their dependents impose financial pressures on families, threatening sustainable livelihoods [107]. Also, the burden of care for long-term illness and disability may fall disproportionately on women and girls [108]. That said, the tangible costs such as lost productivity (indirect cost) and medical costs (direct costs) can be estimated in economic terms more easily compared to the intangible costs such as pain and suffering [109]. However, regardless of

difficulties in estimating road crash costs, accounting for economic costs of crashes is necessary to inform policy makers in prioritising and choosing the most effective countermeasures. Three main approaches used in estimating the cost of road crashes [109] are (i) the human capital approach, in which mainly tangible injury costs to individuals are aggregated at societal, regional and national levels; (ii) the willingness-to-pay approach, which derives a value of pain and suffering based on the preferred amounts that people would be prepared to pay to live in a world where risks are reduced; and (iii) the general equilibrium approach, which uses simulation models to estimate costs from a broader macroeconomic perspective, although this is, as yet, untested for injury cost modelling [92]. The human capital approach has been the most common approach used in LMICs, due to the relative simplicity and structured nature of the approach [109].

3.6. Vehicle Safety Standards and Dumping of Old Vehicles

An emerging problem for road safety in LICs is the issue of vehicle safety and technologies. While there is a dearth of literature focusing on this issue in LICs, as part of this project, we have been working to liaise with stakeholders in considering lessons learnt from the developed world in this area to understand this issue further. These stakeholders include experts from the Global New Car Assessment Programme (NCAP), and regional car assessment programs.

With respect to emerging vehicle safety features in LICs (e.g., air bags, crash avoidance systems, etc.), one should take into account risk compensation issues. A number of studies have investigated risk compensation issues mostly in the developed world [110–113]. As discussed by Winston et al. [110], road users may become less vigilant about road safety due to innovations that are designed to improve safety. For example, drivers may trade off improved safety for speedier trips [110]. With the expected change in vehicle fleet (and their safety features) in LICs, it is important to understand how the experience of developed countries in this regard could lend itself to LICs. This also highlights the importance of publicity campaigns to raise awareness among road users in LICs with respect to vehicle safety features. This is particularly necessary to educate and train drivers at the very beginning steps of moving towards advanced vehicle safety features in LICs.

With respect to dumping old vehicles in LICs, the issue has been raised by a number of organisations and research studies, which mostly focus on the environmental impact [114]. The mainly old vehicle fleet in LICs does not meet some of the basic safety standards set in developed countries, increasing the propensity of crashes. This may be exacerbated by vehicle modification, poor maintenance standards, inappropriate use (e.g., overloading) and lack of safety enforcement. In addition, when a crash occurs, drivers and passengers would sustain more severe injuries, for example, due to lack of airbags. To our knowledge, scientific studies that investigate safety implications of exporting old vehicles to LICs are non-existent. Policies may be needed to prevent developed countries from dumping vehicles of a certain age or category in LICs and to encourage scrappage in LICs (e.g., cash for clunkers).

3.7. Proactive Approaches to Road Safety

Traditional methods that help detect, prioritise and treat high crash-risk sites have been based solely on prior crash history [115]. However, crash data quality in LICs tends to be poor, at limited numbers of sites, and with high rates of under-reporting. Studies of observed unsafe road user behaviour in LMICs do exist, e.g., [116,117], but manual data collection is time consuming and costly. To overcome these constraints, it may be possible to use new forms of data collection techniques such as video data or remote sensors, and storage and manipulation techniques involving 'big data' to allow for a proactive road safety approach that can address safety deficiencies before crashes occur [118]. For instance, assessing global databases could help identify country-specific determinants of road safety [119]. More locally, it is possible to monitor and analyse road users' trajectories and identify conflicts and near misses [120]. A proactive approach to road safety should ideally complement traditional, reactive methods [121], allowing us to design improvement programs (publicity campaigns,

engineering interventions, etc.) before crashes happen. However, applying such approaches in LICs may not be straightforward, due to cost and resource constraints.

3.8. Limited Data Conditions, Omitted Variables Problem, and Unobserved Heterogeneity

A series of well-known issues often encountered in road safety analysis are related to data limitations of various types. Crash data may be limited in terms of sample size or the number of risk (contributing) factors available in the data resulting in limited data conditions, the omitted variables problem, and unobserved heterogeneity [122–124]. Note that risk factors are needed to explain the safety of a site (highway segment, jurisdiction, etc.).

When a crash data set is not large enough, the maximum likelihood estimation is prone to bias; therefore, the model estimates are biased. This problem can be addressed by employing Bayesian methods in which prior knowledge can be included in the analysis in the form of the prior distribution, leading to enhanced statistical inferences. In this regard, for instance, Heydari et al. [124] showed how it is possible to obtain reliable statistical models for crash data characterised by a small sample size. With respect to the omission of risk factors, road safety literature discusses that, when important variables that have significant explanatory power are missing from the data, road safety inferences could be misleading [122].

Unobserved heterogeneity is related to the omitted variables problem and leads to spurious road safety inferences as indicated in the crash literature [2]. Several risk factors that affect road safety at a site (intersection, road segment, neighbourhood, etc.) are often missing (being unknown or unmeasured) in crash databases, causing the unobserved heterogeneity problem. A large body of literature discusses how to overcome this problem in order to obtain reliable estimates [2,125]. However, most studies that address the abovementioned issues are conducted in the developed world. Advanced statistical methods can mitigate unobserved heterogeneity and omitted variables problems [123], and such methods should be applicable to data sets in LICs, but their use in such contexts has so far been limited.

3.9. Reaching out to Other Sectors—Social and Behavioural Aspects

Road safety education and awareness campaigns in high-income settings are often based on changing people's attitudes. Change someone's attitudes, and they will change their behaviour. This may not, however, work across all cultural contexts. For example, previous research has suggested the link between attitudes and behaviours (in a road safety context) to be weaker in Sub-Saharan African countries than in high-income European countries [126,127]. In a study across six countries, McIlroy et al. [128] found that in Kenya, road safety attitudes predicted self-reported pedestrian behaviours to a significantly lesser extent than in the UK. This cannot, however, be explained by national income or road safety statistics. Across the six countries included in their investigation, McIlroy et al. found no patterns in this respect. This strongly points to the need to conduct preliminary research in the country of interest before applying road safety interventions. Every setting has unique characteristics, and interventions should be designed with this in mind.

Culture is a significant factor in this regard. This has been explored by a variety of researchers, with mixed results. In a study of West African taxi drivers, Kouabenan [129] examined religious, mystical, and fatalistic beliefs. Road crashes were attributed more to external factors (such as poor road maintenance and the absence of pedestrian infrastructure) than to driver behaviours (such as the breaking of road laws or carelessness). Additionally, such beliefs were linked with a disregard for safety measures. A strong belief in luck, fate, or destiny, was linked with a perceived lack of need for things such as helmets or seatbelts. Similar findings have since been reported by Dixey [130], Peltzer [131], Omari and Baron-Epel [132], and Maghsoudi et al. [133]. Additionally, not only are stronger beliefs in fate or destiny related to lower engagement in self-protective behaviours, but also with active engagement in risky behaviours. Results to this effect have been found in a variety of settings, including South Africa [134], Turkey and Iran [135,136], and Cameroon [137].

Results are not, however, clear-cut. In a study in Turkey, Yıldırım [138] found religiosity to have a positive effect on self-reported traffic behaviours. Those reporting stronger religious beliefs also reported making fewer risk-taking behaviours. Similarly, McIlroy et al. [139], found stronger beliefs in the influence of God over one's life to be related to safer attitudes and pedestrian behaviours in Kenya and Bangladesh. Note that the opposite pattern was found in China, Thailand, the UK, and Vietnam. Once again, research conducted in the setting of interest is crucial for successful intervention design and implementation.

Road transport is a highly complex sociotechnical system, with influence from a wide variety of individuals and organisations at varying levels of system abstraction [140]. Although it is the end user that carries the weight of the road traffic injury and fatality burden, it is generally not the end user that makes safety intervention decisions [141]. Yet it is this group that generally shoulders the blame [142]. This is not unique to low- and middle-income countries; however, change is beginning to be seen in some high-income countries with acceptance of the 'safe system' or 'vision zero' philosophy. The approach's primary central tenet is the idea that the end user is fallible, and that the system should be designed in a way to reduce the likelihood of crashes and reduce the consequences of crashes that happen. Crucially, blame is not placed solely on the end user, rather it is shared among system actors [143]. Although this way of thinking is gaining traction in the Europe, North America, and Australia, there is as yet a complete lack of systems-level research in low-income settings [144]. To reiterate the sociotechnical perspective, road safety is not the domain of one actor or group of actors alone, but it is the concern of many entities, at many levels of the system, from the end user to the policy maker [140].

3.10. Current Capacity for Research and Practice

Capacity for research and practice in the field of road safety is one of the key issues impeding progress in this area in the context of LICs. This is a recurrent theme in all global and regional reports published to date on road safety [1,8,91,92]. Capacity is needed for research as well as planning and implementation of appropriate safety improvement programmes, and any work being done in such settings ought to embed capacity development into it [145,146], as well as consider how to overcome institutional barriers [147].

Initiatives such as the Road Traffic Injuries Research Network [148] and the UNECE programmes in developing countries, in partnership with ECLAC (Latin America and Caribbean region) and ESCAP (Asia and the Pacific region) [149] have aimed to reduce the burden of road crashes in developing countries by identifying and promoting effective, evidenced-based interventions and supporting research capacity building in road safety research in LMICs. Building on the experience gained from such initiatives, there is a need to develop formal training programs that are readily accessible by individuals residing in LMICs. Based on the literature review and through liaising with experts and stakeholders, we have identified two main areas where improving capacity is most needed.

I　　Limited trained human resources: Many LICs around the world lack adequate human resources in the various areas necessary for effective action on road safety—research, program planning and implementation, as well as monitoring and evaluation [92,149]. One main reason for this is the lack of formal training programs in these settings that are specifically targeted towards the skills necessary for effective and appropriate action on an issue as complex and multi-sectoral as road safety [150]. This limits the amount and type of research conducted locally. For example, road safety studies that focus on data derived from LICs are extremely under-represented in peer-reviewed publications [145], and when they exist, they are often far away from advanced methodological techniques adopted in studies conducted in the developed world. To this end, it is important to train practitioners and researchers residing in LICs in the different areas necessary to effect programmatic change, such as road safety management, research on risk factors for road safety, evaluation of interventions, etc. Incorporating some of these capacity building activities

in ongoing engagements and initiatives in LMICs will also have the added benefit of enhancing collaboration between HIC and LMIC researchers and practitioners.

II   Lack of data: As set out in Sections 3.1, 3.3, and 3.4, another gap identified in LICs is the limited amount of disaggregated data available for understanding the safety condition and monitoring safety improvement programs when implemented. Capacity development efforts for road safety in LMICs ought to focus on improving data systems such that there is valid, reliable, and timely data available to not only assess the safety condition, but also serve as a basis for assessing the effectiveness of programs or interventions implemented.

4. Expert Consultation Results

As described in Section 2.4, six road safety experts, with extensive experience in road safety in LICs, participated in our survey. They provided insight into those topics that were most important to consider for future research in LICs. Two main topics emerged as the most important issues: (i) data collection and management techniques and (ii) governance and legislation. The range of sub-topics and proposed solutions are reported in Table 5. The outcomes from the survey and other discussions also provided context for topics for which literature is unlikely to be available, but which helps provide the background to the future research agenda set out in Section 5.

Table 5. Expert elicitation results showing important topics for future road safety.

Topic	Potential Solutions
Data:	
Inconsistent data collection and management techniques (including under-reporting)	- Improved training and resources for police and hospital staff - Dedicated specialists in crash data reporting - Use of modern technology to ensure accuracy of reporting and efficiency of data storage - Use of multiple data sources - Public awareness raising of importance of accurate data
Under-use of road crash cost estimates	- Establish specialised team to promote road safety, and ensure cost implications are explicitly considered in road safety interventions - Disseminate cost evaluation results to reveal shortcomings in current approaches
Governance:	
Lack of integrated approach to road safety issues	- Develop and apply an integrated multi-sectoral, multi-governance framework, possibly using a systems-based approach, including feedback mechanisms and knowledge exchange - Consider how to integrate research into vulnerable road users, policy, and education
Lack of accountability of leadership	- Review and re-evaluate current governance mechanisms to improve transparency and avoid redundancy and overlapping of responsibilities - Vision Zero approach - Implement Lead Road Safety Agency to coordinate and champion road safety activities at national, municipal and local levels
Poor legislation	- Apply best practice techniques from the developed world
Poorly resourced sector	- Increased levels of trained personnel, equipment and knowledge base - Consider use of outsourcing to private sector for certain aspects of road traffic management

Respondents agreed that the complexities of road safety implementation meant that there are unlikely to be any 'quick wins', although investigating how governance could be improved and held

more accountable could initiate action to improve the impact of road safety interventions in the short term. Further responses suggested that the effective use of increased resources and awareness of global best practice could help provide rapid insight into the priority issues, particularly with respect to the safety of vulnerable road users and the expected growth of traffic in developing countries. Additionally, reviewing current practices could help inform government and other stakeholders of the key issues in their specific location, and highlight where current governance mechanisms can be improved, with the aim of achieving greater political and funding commitments from decision-makers, resulting in better legislation and enforcement.

5. Discussion: Implications and Future Directions

This section provides a discussion of our findings and their implications grouped in seven major areas. A number of topics emerged from our analysis of the State of Knowledge review above combined with discussions with experts and stakeholders, which can help form a future research agenda. These topics relate to both empirical and methodological frontiers; therefore, they will lead to noteworthy improvements in the way road safety research will be conducted in the context of LICs. Note that topics discussed below are inter-related; nevertheless, their theoretical and empirical weights vary from one topic to another.

5.1. Under-Reporting of Crashes

This is a major issue in LICs; research is needed not only to understand causes of under-reporting but also to develop methodological approaches that can better address the issue. The use of capture-recapture techniques has been shown to be a useful tool to estimate the levels of under-reporting in low-income countries, and as such could be used when authorities wish to understand the true nature of road traffic crash rates in their country. To better address the under-reporting problem, alternative statistical methods that overcome the limitations of the capture-recapture approach (discussed in Section 3.1) should be examined and/or developed. It is also advisable to carry out a review of police and hospital data availability in LICs and LMICs, in order to understand better the nature of the types of data generally available. Following such a review, a general 'toolkit' could be developed offering guidance and methodologies for the analysis of under-reporting in LICs and LMICs. Such guidance could incorporate minimum data requirements, software tools and reporting templates in order to standardise such reporting in all LICs and LMICs in the future.

5.2. Traffic Injuries Sustained in the Crash

Understanding the causes, severities, long-term implications, and costs to society of disabilities resulting from road crashes could help refine road safety policies in LICs and improve impact analysis of road safety interventions. There are inconsistencies in the metrics and methods used to assess injury severities (as discussed in Section 3.4), and further work could seek to build on any review of road safety and healthcare data recording systems suggested in Section 5.1 (under-reporting), and aim to assess the most appropriate metrics for LICs to use in analyses of disabilities. Further research could help to develop methodologies for road safety and healthcare practitioners in LICs to understand not only the trends associated with disabilities resulting from road crashes but also their impact on society and the economy. It may be appropriate to focus such future research on vulnerable groups. Also, a surprising gap in previous road safety research conducted in LICs relates to the lack of studies that aim at analysing and understanding differing injury-severity levels properly. That is, how different factors increase or decrease the likelihood of injury-severity sustained by road users. Such analyses are common in the developed world and help draw a complete picture, allowing decision makers to design cost-effective countermeasures to reduce injuries once a crash occurs. In this regard, further research is thus needed in LICs.

5.3. Road Crash Costing

There are limitations in the methods used to apply cost estimates to road crashes in LMICs [151] and in LICs in particular. Wesson et al. [152] carried out a review of economic evaluations in LMICs, finding only three studies that assessed the costs of road safety interventions, and six studies that were cost-effectiveness analyses. Only one of these papers referred specifically to LICs [153]. Similarly, Banstola and Mytton [103] only found five studies assessing cost-effectiveness in LMICs, with only two interventions showing moderate evidence of being cost-effective. More recently, Mukama et al. [154] assessed the costs of unintentional injuries to children in a Ugandan slum, noting that costs associated with road traffic crashes are higher than those for incidents occurring at a school, due to the severe nature of most road traffic injuries requiring specialised care and hence higher treatment costs. This lack of LIC-based research indicates that further research is needed to identify relevant methods of road crash cost estimations or cost-benefit analyses of road safety interventions applicable in those settings.

5.4. Characterisations of the Vehicle Fleet

With respect to the vehicle safety features and risk compensation concerns discussed in Section 3.6, further research is needed to better understand risk compensation issues in LICs to be able to take advantage of emerging safety innovations more fully. In addition, it is important to explore issues surrounding the second hand vehicle market and how countries that are heavily reliant on imported second-hand vehicles can regulate more appropriately, as well as vehicle technologies. In this regard, scientific research is needed to quantify road safety implications of dumping old vehicles in LICs.

5.5. Challenges of Data Collection and Analysis

As set out in Section 3, and identified by the expert survey, many of the issues pertinent to this study relate to the challenges of data collection, management and analysis. While it may be possible to draw on experiences of global good practice, it may also be relevant to develop specific methods and analysis techniques that apply in the LIC-context. The following sections discuss these issues in greater detail.

5.5.1. Expected Increase in Traffic Volume and Its Implications

Previous research indicates that as a country's economy grows and traffic volume (and consequently exposure) increases, road safety deteriorates. However, the relationship is not linear and varies from one jurisdiction to another [155,156]. It is important to quantify the rate of deterioration in road safety as traffic exposure increases; and consequently, investigate how we can reduce this rate. For example, using advanced statistical methods, a study conducted by Heydari et al. [157] shows how with the same set of variables available in the data one can understand variation in crash frequency as traffic exposure increases. This is important since an increase in traffic volume in LICs seems inevitable in the near future. Further research is thus needed to understand the relationship between road safety and traffic exposure in LICs. To this end, a series of safety performance functions should be developed for different road infrastructures in LICs, similar to those developed in the Highway Safety Manual 2010 [158]. Note that safety performance functions are the main ingredient for the six-step safety management process described in the Highway Safety Manual [158]. They are used to quantify road safety, to understand factors affecting safety, and to identify hazardous locations that should then be prioritised for safety improvement programs.

5.5.2. Accounting for Data-Related Limitations and Unobserved Heterogeneity

As previously discussed, in LICs, crash data tends to be lacking or when it exists, it is often limited, in terms of sample size limitations and/or the lack of risk factors available in the data. Therefore, issues discussed in Section 3.8 are often more prevalent and frequent in LICs compared to the developed world. The number of road safety studies conducted in LICs is limited, and rarely do those studies

employ rigorous road safety and statistical techniques to address the aforementioned issues properly. One aspect of future research should be to continue work in this area by developing statistical methods, especially those applicable to LIC-contexts, and help provide robust analyses of road safety data.

5.5.3. Feasibility of Proactive Approaches to Road Safety in LICs

Although we recognise challenges for implementing proactive road safety approaches in LICs, it is important to investigate how this could help mitigate crash risk propensities in LICs. Building on the successful experience of developed countries in implementing such approaches, while considering resource and cost constraints applicable to LIC-contexts, it would be possible to adapt proactive methods in LICs to optimise their benefits with a minimum cost. Initially, this could be treated as a range of feasibility studies to extend the knowledge base to LICs. Perhaps, it would be possible to focus on monitoring a limited number of road infrastructures and based on that provide valuable insights, which in turn allow for designing tailored safety improvements transferable to other similar locations within each jurisdiction. To summarise, proactive safety approaches should be considered in the future if a major improvement in road safety in LICs is expected to be achieved.

5.5.4. Alternative Approaches to Obtain Data

With respect to data issues and limitations encountered by LICs, which also relates to limited capacity in these countries, a valuable and cost-effective approach could be based on using street imagery, for example, available in Google street view or shared on social networks. Previous research has successfully taken advantage of street imagery, for example, to identify travel patterns [159]. Estimating travel patterns and/or traffic exposure by different modes of transport and/or road user types could be promising when such information is not available (e.g., when data are not collected through traditional data collection techniques). Also, automatic data collection, for example, using traffic analyser sensors has been shown to provide valuable data that allows the analyst to conduct road safety studies [160,161]. This is particularly important given the expected increase in traffic exposure in LICs since traffic exposure is known as a major determinant of road safety. Therefore, it would be interesting to investigate how this could be employed to collect relevant data and improve safety in LICs.

5.6. Social and Behavioural Approaches to Road Safety

As described in Section 3.2, the majority of road safety research is performed in high-income countries; hence, the majority of methods are biased towards these settings. As such, there is a strong requirement for research methods developed in low-income settings. This can also be said for road safety interventions. Given differences in cultures, attitudes, and behaviour constraints, it may not be the case that what has worked in Europe or America will also work in LICs. As such, interventions should be designed preferably based on research conducted in the country in which the intervention is to be implemented. Therefore, there is a clear need for more in-depth research on the social and behavioural factors that influence road safety in low-income settings. There is also a strong need to embed sociotechnical systems thinking in crash analyses, and in road transport policy, planning, and construction. This is beginning to happen in high-income countries; however, LICs are being left behind in this respect. As such, a concerted effort to apply contemporary sociotechnical systems methods to the analysis of road transport in LICs is needed. The design of road safety interventions should be based on a good understanding of the context of application and a consideration of all the factors that influence outcomes. Neither of these points are typically addressed in LICs; as such, they represent important topics for research.

5.7. How to Build Sustainable Capacity Effectively and in a Timely Manner?

Two of the future road safety challenges identified by the WHO [10] are 'Building Capacity' and 'Strengthening Data Collection', and effective training programmes could help improve both of these

aspects of road safety. As discussed in Section 3.10, limited trained human resources and a lack of data are two areas where capacity building is most warranted. Although some previous studies have investigated related issues in LICs, there is a need to continue work in this area in order to systematically identify and/or define the most cost-effective and sustainable strategies that can be in place in a timely fashion.

6. Summary

The general objective of our research was to help improve road safety in LICs, identifying and targeting the most important problems encountered by these countries and defining critical future research directions that help enhance safety effectively given the expected increase in traffic exposure in LICs. Following recent developments in the field, including the UN Decade of Action for Road Safety (2010–2020), this article contributes to the literature by reviewing the state of knowledge and recommending a future research agenda for further improvements. Our study reveals where some of the major knowledge gaps exist for those topics that have been part of the research arena for some time. To this end, not only have we conducted a literature review, but we have also liaised with international organisations, local authorities, experts and professionals, particularly where the body of literature does not exist. Thus, we have identified some of the most critical road safety concerns in LICs; consequently, we have suggested some areas of future research that could be considered to inform an agenda for future action.

Specifically, we identified ten focus areas: (i) under-reporting of road crashes in LICs; (ii) lessons learned from global best practices; (iii) vulnerable groups and gender disaggregation; (iv) disabilities due to road crashes; (v) economic burden of road crashes; (vi) vehicle safety standards and the dumping of old vehicles; (vii) proactive approaches to road safety; (viii) limited data conditions, omitted variables and unobserved heterogeneity; (ix) reaching out to other sectors, considering social and behavioural aspects; and (x) capacity limitations of road safety research. Based on our analyses, we conclude that road safety is inherently a multi-sectoral issue, where interventions will need to involve multiple strategies and stakeholders. The most successful programmes globally have been those that have integrated systems of legislation, regulation and enforcement, combining robust data collection and management systems, economic evaluation systems to inform investment decisions, significant technical and enforcement capacity, and a substantial knowledge base of the social, medical and behavioural implications of road safety interventions.

Seven major research directions were identified based on the above-mentioned focus areas. In summary, in terms of policy recommendations, given the poor resources and lack of capacity for data management available in LICs, improving the quality of data in these countries would be one of the initial steps to make any improvements, either through investing in capacity for analysis and research, or through the development of modern techniques of data collection. Raising public awareness of the importance of accurate data and the reporting of road crashes is another central issue that should be considered by governments. We also suggest investigations into data analysis techniques considering both the statistical foundations upon which such analyses are built, and the use of proactive measures to prioritise investments, all carried out with a focus on existing cost and resource limitations in LICs, and using evidence-based techniques to promote effective changes. Combining expert insights and experiences with research from LICs, LMICs, and developed countries should provide the basis for a robust approach and a future research agenda that will help improve road safety in LICs.

Author Contributions: S.H., A.H., J.T., and A.M.B. were involved in drawing the conceptual plan of the paper. S.H. and A.H. wrote the first draft of the manuscript. R.M. wrote the sections relating to social and behavioural aspects. A.M.B. and J.T. provided valuable inputs on the content of the article.

References

1. World Health Organization. *Global Status Report on Road Safety 2018*; World Health Organization: Geneva, Switzerland, 2018.

2. Mannering, F.L.; Shankar, V.; Bhat, C.R. Unobserved heterogeneity and the statistical analysis of highway accident data. *Anal. Methods Accid. Res.* **2016**, *11*, 1–16. [CrossRef]

3. World Health Organization. *Global Plan. for the Decade of Action for Road Safety 2011–2020*; World Health Organization: Geneva, Switzerland, 2011.

4. Global Road Safety Partnership. *Road Map: Strategic Plan 2015–2020*; Global Road Safety Partnership: Geneva, Switzerland, 2016.

5. World Bank. *Global Road Safety Facility Annual Report 2018*; World Bank: Washington, DC, USA, 2018.

6. Bloomberg Philanthropies Road Safety. Available online: https://www.bloomberg.org/program/public-health/road-safety/ (accessed on 24 April 2019).

7. Hyder, A.A.; Allen, K.A.; Peters, D.H.; Chandran, A.; Bishai, D. Large-scale road safety programmes in low-and middle-income countries: An opportunity to generate evidence. *Glob. Public Health* **2013**, *8*, 504–518. [CrossRef] [PubMed]

8. Hyder, A.A.; Paichadze, N.; Toroyan, T.; Peden, M.M. Monitoring the Decade of Action for Global Road Safety 2011–2020: An update. *Glob. Public Health* **2017**, *12*, 1492–1505. [CrossRef] [PubMed]

9. World Road Association Safe System Principles. Road Safety Manual. Available online: https://roadsafety.piarc.org/en/road-safety-management-safe-system-approach/safe-system-principles (accessed on 28 October 2019).

10. World Health Organization. Decade of Action for Road Safety 2011–2020. Available online: https://www.who.int/roadsafety/decade_of_action/en/ (accessed on 28 October 2019).

11. Moher, D.; Shamseer, L.; Clarke, M.; Ghersi, D.; Liberati, A.; Petticrew, M.; Shekelle, P.; Stewart, L.A.; Group, P.-P. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Syst. Rev.* **2015**, *4*, 1. [CrossRef] [PubMed]

12. IRTAD. *Reporting on Serious Road Traffic Casualties*; International Traffic Safety Data and Analysis Group: Paris, France, 2011.

13. Magoola, J.; Kobusingye, O.; Bachani, A.M.; Tumwesigye, N.M.; Kimuli, D.; Paichadze, N. Estimating road traffic injuries in Jinja district, Uganda, using the capture-recapture method. *Int. J. Inj. Contr. Saf. Promot.* **2018**, *25*, 341–346. [CrossRef] [PubMed]

14. Abegaz, T.; Berhane, Y.; Worku, A.; Assrat, A.; Assefa, A. Road traffic deaths and injuries are under-reported in Ethiopia: A capture-recapture method. *PLoS ONE* **2014**, *9*, e103001. [CrossRef] [PubMed]

15. Dandona, R.; Kumar, G.A.; Ameer, M.A.; Reddy, G.B.; Dandona, L. Under-reporting of road traffic injuries to the police: Results from two data sources in urban India. *Inj. Prev.* **2008**, *14*, 360–365. [CrossRef]

16. Samuel, J.C.; Sankhulani, E.; Qureshi, J.S.; Baloyi, P.; Thupi, C.; Lee, C.N.; Miller, W.C.; Cairns, B.A.; Charles, A.G. Under-reporting of road traffic mortality in developing countries: Application of a capture-recapture statistical model to refine mortality estimates. *PLoS ONE* **2012**, *7*, e31091. [CrossRef]

17. Bhatti, J.A.; Razzak, J.A.; Lagarde, E.; Salmi, L.R. Differences in police, ambulance, and emergency department reporting of traffic injuries on Karachi-Hala road, Pakistan. *BMC Res. Notes* **2011**, *4*, 75. [CrossRef]

18. Bonnet, E.; Nikiéma, A.; Traoré, Z.; Sidbega, S.; Ridde, V. Technological solutions for an effective health surveillance system for road traffic crashes in Burkina Faso. *Glob. Health Action* **2017**, *10*, 1295698. [CrossRef]

19. Patel, A.; Krebs, E.; Andrade, L.; Rulisa, S.; Vissoci, J.R.N.; Staton, C.A. The epidemiology of road traffic injury hotspots in Kigali, Rwanda from police data. *BMC Public Health* **2016**, *16*, 697. [CrossRef] [PubMed]

20. Amoros, E.; Martin, J.-L.; Laumon, B. Estimating non-fatal road casualties in a large French county, using the capture–recapture method. *Accid. Anal. Prev.* **2007**, *39*, 483–490. [CrossRef] [PubMed]

21. Amoros, E.; Martin, J.-L.; Laumon, B. Under-reporting of road crash casualties in France. *Accid. Anal. Prev.* **2006**, *38*, 627–635. [CrossRef] [PubMed]

22. Amoros, E.; Martin, J.-L.; Lafont, S.; Laumon, B. Actual incidences of road casualties, and their injury severity, modelled from police and hospital data, France. *Eur. J. Public Health* **2008**, *18*, 360–365. [CrossRef] [PubMed]

23. Amoros, E.; Soler, G.; Pascal, L.; Ndaiye, A.; Gadegbeku, B.; Martin, J.-L. Estimation of the number of seriously injured road users in France, 2006–2015. *Rev. Epidemiol. Sante Publique* **2018**, *66*, S334. [CrossRef]

24. Broughton, J.; Keigan, M.; Yannis, G.; Evgenikos, P.; Chaziris, A.; Papadimitriou, E.; Bos, N.M.; Hoeglinger, S.; Pérez, K.; Amoros, E.; et al. Estimation of the real number of road casualties in Europe. *Saf. Sci.* **2010**, *48*, 365–371. [CrossRef]

25. Bauer, R.; Steiner, M.; Khnelt-Leddihn, A.; Rogmans, W.; Kisser, R. Under-reporting of vulnerable road users in official EU road accident statistics—Implications for road safety and added value of EU IDB hospital data. *Inj. Prev.* **2018**, *24*, A266.

26. Chini, F.; Farchi, S.; Camilloni, L.; Borgia, P.; Antoniozzi, T.; Ciaramella, I.; Valenti, M.; Rossi, P. Road traffic injuries in one local health unit in the Lazio region: Results of a surveillance system integrating police and health data. *Int. J. Health Geogr.* **2009**, *8*, 21. [CrossRef]

27. Ferrando, J.; Plasencia, A.; Ricart, I.; Oros, M.; Borrell, C. The contribution of independent health and police sources of information to the ascertainment of traffic deaths in a European urban setting. In Proceedings of the 43rd Annual Conference of the Association for the Advancement of Automotive Medicine, Barcelona, Spain, 20–21 September 1999.

28. Reurings, M.C.B.; Stipdonk, H.L. Estimating the number of serious road injuries in The Netherlands. *Ann. Epidemiol.* **2011**, *21*, 648–653. [CrossRef]

29. Ward, H.; Lyons, R.; Thoreau, R. *Road Safety Research Report No. 69. Under-Reporting of Road Casualties—Phase 1*; Department for Transport: London, UK, 2006.

30. Yannis, G.; Papadimitriou, E.; Chaziris, A.; Broughton, J. Modeling road accident injury under-reporting in Europe. *Eur. Transp. Res. Rev.* **2014**, *6*, 425–438. [CrossRef]

31. Conderino, S.; Fung, L.; Sedlar, S.; Norton, J.M. Linkage of traffic crash and hospitalization records with limited identifiers for enhanced public health surveillance. *Accid. Anal. Prev.* **2017**, *101*, 117–123. [CrossRef] [PubMed]

32. Sciortino, S.; Vassar, M.; Radetsky, M.; Knudson, M.M. San Francisco pedestrian injury surveillance: Mapping, under-reporting, and injury severity in police and hospital records. *Accid. Anal. Prev.* **2005**, *37*, 1102–1113. [CrossRef] [PubMed]

33. Alsop, J.; Langley, J. Under-reporting of motor vehicle traffic crash victims in New Zealand. *Accid. Anal. Prev.* **2001**, *33*, 353–359. [CrossRef]

34. Meuleners, L.B.; Lee, A.H.; Cercarelli, L.R.; Legge, M. Estimating crashes involving heavy vehicles in Western Australia, 1999–2000: A capture–recapture method. *Accid. Anal. Prev.* **2006**, *38*, 170–174. [CrossRef] [PubMed]

35. Cercarelli, L.R.; Rosman, D.L.; Ryan, G.A. Comparison of accident and emergency with police road injury data. *J. Trauma* **1996**, *40*, 805–809. [CrossRef]

36. Lujic, S.; Finch, C.; Boufous, S.; Hayen, A.; Dunsmuir, W. How comparable are road traffic crash cases in hospital admissions data and police records? An examination of data linkage rates. *Aust. N. Z. J. Public Health* **2008**, *32*, 28–33. [CrossRef]

37. Rosman, D.L. The Western Australian Road Injury Database (1987–1996): Ten years of linked police, hospital and death records of road crashes and injuries. *Accid. Anal. Prev.* **2001**, *33*, 81–88. [CrossRef]

38. Watson, A.; Watson, B.; Vallmuur, K. Estimating under-reporting of road crash injuries to police using multiple linked data collections. *Accid. Anal. Prev.* **2015**, *83*, 18–25. [CrossRef]

39. Ma, S.; Li, Q.; Zhou, M.; Duan, L.; Bishai, D. Road traffic injury in China: A review of national data sources. *Traffic Inj. Prev.* **2012**, *13*, 57–63. [CrossRef]

40. Nakahara, S.; Wakai, S. Underreporting of traffic injuries involving children in Japan. *Inj. Prev.* **2001**, *7*, 242–244. [CrossRef]

41. Ahmed, A.; Sadullah, A.F.M.; Yahya, A.S. Errors in accident data, its types, causes and methods of rectification-analysis of the literature. *Accid. Anal. Prev.* **2017**, *130*, 3–21. [CrossRef] [PubMed]

42. Morrison, A.; Stone, D.H. Capture-recapture: A useful methodological tool for counting traffic related injuries? *Inj. Prev.* **2000**, *6*, 299–304. [CrossRef] [PubMed]

43. Van Hest, R.; Grant, A.; Abubakar, I. Quality assessment of capture–recapture studies in resource-limited countries. *Trop. Med. Int. Health* **2011**, *16*, 1019–1041. [CrossRef] [PubMed]

44. Carter, K.L.; Williams, G.; Tallo, V.; Sanvictores, D.; Madera, H.; Riley, I. Capture-recapture analysis of all-cause mortality data in Bohol, Philippines. *Popul. Health Metr.* **2011**, *9*, 9. [CrossRef]

45. Yamamoto, T.; Hashiji, J.; Shankar, V.N. Underreporting in traffic accident data, bias in parameters and the structure of injury severity models. *Accid. Anal. Prev.* **2008**, *40*, 1320–1329. [CrossRef]

46. Ye, F.; Lord, D. Investigation of effects of underreporting crash data on three commonly used traffic crash severity models. *Transp. Res. Rec. J. Transp. Res. Board* **2011**, *2241*, 51–58. [CrossRef]

47. Patil, S.; Geedipally, S.R.; Lord, D. Analysis of crash severities using nested logit model—Accounting for the underreporting of crashes. *Accid. Anal. Prev.* **2012**, *45*, 646–653. [CrossRef]

48. Sango, H.A.; Testa, J.; Meda, N.; Contrand, B.; Traore, M.S.; Staccini, P.; Lagarde, E. Mortality and morbidity of urban road traffic crashes in Africa: Capture-recapture estimates in Bamako, Mali, 2012. *PLoS ONE* **2016**, *11*, e0149070. [CrossRef]

49. Wegman, F. The future of road safety: A worldwide perspective. *IATSS Res.* **2017**, *40*, 66–71. [CrossRef]

50. Traffic General Directorate. *Spanish Road Safety Strategy 2011–2020*; Traffic General Directorate: Madrid, Spain, 2010.

51. Wang, C.; Quddus, M.A.; Ison, S.G. The effect of traffic and road characteristics on road safety: A review and future research direction. *Saf. Sci.* **2013**, *57*, 264–275. [CrossRef]

52. Safer Africa SaferAfrica Project. Available online: http://www.saferafrica.eu/ (accessed on 7 June 2019).

53. Bonnet, E.; Lechat, L.; Ridde, V. What interventions are required to reduce road traffic injuries in Africa? A scoping review of the literature. *PLoS ONE* **2018**, *13*, e0208195. [CrossRef] [PubMed]

54. Gupta, M.; Menon, G.R.; Devkar, G.; Thomson, H. *Regulatory and Road Engineering Interventions for Preventing Road Traffic Injuries and Fatalities among Vulnerable (NON-Motorised and Motorised Two-Wheel) Road Users in Low-and Middle-Income Countries*; EPPI-Centre, Social Science Research Unit, Institute of Education, University of London: London, UK, 2016.

55. Staton, C.; Vissoci, J.; Gong, E.Y.; Toomey, N.; Wafula, R.; Abdelgadir, J.; Zhou, Y.; Liu, C.; Pei, F.D.; Zick, B.; et al. Road traffic injury prevention initiatives: A systematic review and metasummary of effectiveness in low and middle income countries. *PLoS ONE* **2016**, *11*, e0144971.

56. Esperato, A.; Bishai, D.; Hyder, A.A. Projecting the health and economic impact of road safety initiatives: A case study of a multi-country project. *Traffic Inj. Prev.* **2012**, *13*, 82–89. [CrossRef] [PubMed]

57. Abegaz, T.; Berhane, Y.; Worku, A.; Assrat, A. Effectiveness of an improved road safety policy in Ethiopia: An interrupted time series study. *BMC Public Health* **2014**, *14*, 539. [CrossRef] [PubMed]

58. Ahmad, H.; Naeem, R.; Feroze, A.; Zia, N.; Shakoor, A.; Khan, U.R.; Mian, A.I. Teaching children road safety through storybooks: An approach to child health literacy in Pakistan. *BMC Pediatr.* **2018**, *18*, 1–8. [CrossRef] [PubMed]

59. Li, Q.; Alonge, O.; Hyder, A.A. Children and road traffic injuries: Can't the world do better? *Arch. Dis. Child.* **2016**, *101*, 1063–1070. [CrossRef]

60. Zimmerman, K.; Jinadasa, D.; Maegga, B.; Guerrero, A. Road traffic injury on rural roads in Tanzania: Measuring the effectiveness of a road safety program. *Traffic Inj. Prev.* **2015**, *16*, 456–460. [CrossRef]

61. Salmon, R.; Eckersley, W. Where there's no green man: Child road-safety education in Ethiopia. *Dev. Pract.* **2010**, *20*, 726–733. [CrossRef]

62. Bradbury, A.; Quimby, A. Community road safety education: An international perspective. *Munic. Eng.* **2008**, *161*, 137–143. [CrossRef]

63. Blantari, J.; Asiamah, G.; Appiah, N.; Mock, C. An evaluation of the effectiveness of televised road safety messages in Ghana. *Int. J. Inj. Control Saf. Promot.* **2005**, *12*, 23–29. [CrossRef]

64. Bachani, A.M.; Mogere, S.; Hyder, A.A.; Hung, Y.W.; Nyamari, J.; Akunga, D. Helmet wearing in Kenya: Prevalence, knowledge, attitude, practice and implications. *Public Health* **2017**, *144*, S23–S31. [CrossRef] [PubMed]

65. Bachani, A.M.; Risko, C.B.; Gnim, C.; Coelho, S.; Hyder, A.A. Knowledge, attitudes, and practices around drinking and driving in Cambodia: 2010–2012. *Public Health* **2017**, *144*, S32–S38. [CrossRef] [PubMed]

66. Stewart, K.; Bivans, B.; Nguyen, L.H.; Onigbogi, L. Drink driving prevention initiatives in low-and middle-income countries: Challenges and progress in Nigeria and Vietnam. In Proceedings of the 20th International Conference on Alcohol, Drugs and Traffic Safety, Brisbane, Australia, 25–28 August 2013.

67. Bachani, A.M.; Hung, Y.W.; Mogere, S.; Akungah, D.; Nyamari, J.; Stevens, K.A.; Hyder, A.A. Prevalence, knowledge, attitude and practice of speeding in two districts in Kenya: Thika and Naivasha. *Injury* **2013**, *44*, S24–S30. [CrossRef]

68. Kraemer, J.D.; Honermann, B.J.; Roffenbender, J.S. Cyclists' helmet usage and characteristics in central and southern Malawi: A cross-sectional study. *Int. J. Inj. Control Saf. Promot.* **2012**, *19*, 373–377. [CrossRef] [PubMed]

69. Johnson, M. Assessing a country's drink driving situation: An overview of the method used in 6 low-and middle-income countries. *Traffic Inj. Prev.* **2012**, *13*, 96–100. [CrossRef] [PubMed]

70. Tulu, G.S.; Haque, M.M.; Washington, S.; King, M.J. Investigating pedestrian injury crashes on modern roundabouts in Addis Ababa, Ethiopia. *Transp. Res. Rec. J. Transp. Res. Board* **2015**, *2512*, 1–10. [CrossRef]

71. John Hopkins International Injury Research Unit. *Risky Road Behaviors in Addis Ababa*; John Hopkins International Injury Research Unit: Baltimore, MD, USA, 2019.

72. UNRSC—United Nations Road Safety Collaboration Publications. Available online: https://www.who.int/roadsafety/publications/en/ (accessed on 6 June 2019).

73. Wismans, J.; Skogsmo, I.; Nilsson-Ehle, A.; Lie, A.; Thynell, M.; Lindberg, G. Commentary: Status of road safety in Asia. *Traffic Inj. Prev.* **2016**, *17*, 217–225. [CrossRef]

74. World Health Organization. *Global Status Report on Road Safety 2013*; World Health Organization: Geneva, Switzerland, 2013.

75. Ojo, T.; Adetona, C.O.; Agyemang, W.; Afukaar, F.K. Pedestrian risky behavior and safety at zebra crossings in a Ghanaian metropolitan area. *Traffic Inj. Prev.* **2019**, *20*, 216–219. [CrossRef]

76. Nantulya, V.M.; Reich, M.R. The neglected epidemic: Road traffic injuries in developing countries. *BMJ* **2002**, *324*, 1139–1141. [CrossRef]

77. Nantulya, V.M.; Reich, M.R. Equity dimensions of road traffic injuries in low-and middle-income countries. *Inj. Control Saf. Promot.* **2003**, *10*, 13–20. [CrossRef]

78. Lagarde, E. Road traffic injury is an escalating burden in Africa and deserves proportionate research efforts. *PLoS Med.* **2007**, *4*, 170. [CrossRef] [PubMed]

79. Towner, E.; Towner, J. Child injury in a changing world. *Glob. Public Health* **2009**, *4*, 402–413. [CrossRef] [PubMed]

80. Odero, W.; Garner, P.; Zwi, A. Road traffic injuries in developing countries: A comprehensive review of epidemiological studies. *Trop. Med. Int. Health* **1997**, *2*, 445–460. [CrossRef] [PubMed]

81. Peden, M.; Kobusingye, O.; Monono, M.E. Africa's roads—The deadliest in the world. *SAMJ S. Afr. Med. J.* **2013**, *103*, 228–229. [CrossRef] [PubMed]

82. Turner, J.; Fletcher, J. *TI-UP Enquiry: Gender and Road Safety*; TI-UP Resource Centre: London, UK, 2007.

83. UN DESA. *The World's Women 2015: Trends and Statistics*; UN Department of Economic and Social Affairs, Ed.; UN DESA: New York, NY, USA, 2015.

84. Damsere-Derry, J.; Palk, G.; King, M. Road accident fatality risks for "vulnerable" versus "protected" road users in northern Ghana. *Traffic Inj. Prev.* **2017**, *18*, 736–743. [CrossRef] [PubMed]

85. Uteng, T.P. *Gender and Mobility in the Developing World*; World Bank: Washington, DC, USA, 2012.

86. Remacle, E.; Sanon, C.; Aketch, S. *Safer Africa: Thematic Fact Sheet on Gender*; European Commission: Brussels, Belgium, 2018.

87. Venter, C.; Vokolkova, V.; Michalek, J. Gender, residential location, and household travel: Empirical findings from low-income urban settlements in Durban, South Africa. *Transp. Rev.* **2007**, *27*, 653–677. [CrossRef]

88. Peters, D. *Gender and Sustainable Urban Mobility*; UN Habitat: Kenya, Nairobi, 2013.

89. Hyder, A.A.; Razzak, J.A. The challenges of injuries and trauma in Pakistan: An opportunity for concerted action. *Public Health* **2013**, *127*, 699–703. [CrossRef]

90. Üzümcüoğlu, Y.; Özkan, T.; Lajunen, T.; Morandi, A.; Orsi, C.; Papadakaki, M.; Chliaoutakis, J. Life quality and rehabilitation after a road traffic crash: A literature review. *Transp. Res. Part. F Traffic Psychol. Behav.* **2016**, *40*, 1–13. [CrossRef]

91. Peden, M. *World Report on Road Traffic Injury Prevention*; World Health Organization: Geneva, Switzerland, 2004.

92. Bachani, A.M.; Peden, M.; Gururaj, G.; Norton, R.; Hyder, A.A. Road traffic injuries. In *Injury Prevention and Environmental Health. Disease Control Priorities Volume 7*; Mock, C.N., Nugent, R., Kobusingye, O., Smith, K.R., Eds.; World Bank Publications: Washington, DC, USA, 2017.

93. Zafar, S.N.; Canner, J.K.; Nagarajan, N.; Kushner, A.L.; Gupta, S.; Canner, J.K.; Tran, T.M.; Nagarajan, N.; Stewart, B.T.; Kamara, T.B.; et al. Road traffic injuries: Cross-sectional cluster randomized countrywide population data from 4 low-income countries. *Int. J. Surg.* **2018**, *52*, 237–242. [CrossRef]

94. Polinder, S.; Haagsma, J.; Bos, N.; Panneman, M.; Wolt, K.K.; Brugmans, M.; Weijermars, W.; van Beeck, E. Burden of road traffic injuries: Disability-adjusted life years in relation to hospitalization and the maximum abbreviated injury scale. *Accid. Anal. Prev.* **2015**, *80*, 193–200. [CrossRef]

95. Petrucelli, E.; States, J.D.; Hames, L.N. The abbreviated injury scale: Evolution, usage and future adaptability. *Accid. Anal. Prev.* **1981**, *13*, 29–35. [CrossRef]

96. Alemany, R.; Ayuso, M.; Guillén, M. Impact of road traffic injuries on disability rates and long-term care costs in Spain. *Accid. Anal. Prev.* **2013**, *60*, 95–102. [CrossRef] [PubMed]

97. Rissanen, R.; Berg, H.-Y.; Hasselberg, M. Quality of life following road traffic injury: A systematic literature review. *Accid. Anal. Prev.* **2017**, *108*, 308–320. [CrossRef] [PubMed]

98. Bachani, A.M.; Galiwango, E.; Kadobera, D.; Bentley, J.A.; Bishai, D.; Wegener, S.; Hyder, A.A. A new screening instrument for disability in low-income and middle-income settings: Application at the Iganga-Mayuge Demographic Surveillance System (IM-DSS), Uganda. *BMJ Open* **2014**, *4*, e005795. [CrossRef] [PubMed]

99. Bachani, A.M.; Galiwango, E.; Kadobera, D.; Bentley, J.A.; Bishai, D.; Wegener, S.; Zia, N.; Hyder, A.A. Characterizing disability at the Iganga-Mayuge Demographic Surveillance System (IM-DSS), Uganda. *Disabil. Rehabil.* **2016**, *38*, 1291–1299. [CrossRef] [PubMed]

100. Palmera-Suárez, R.; López-Cuadrado, T.; Brockhaus, S.; Fernández-Cuenca, R.; Alcalde-Cabero, E.; Galán, I. Severity of disability related to road traffic crashes in the Spanish adult population. *Accid. Anal. Prev.* **2016**, *91*, 36–42. [CrossRef] [PubMed]

101. Palmera-Suárez, R.; López-Cuadrado, T.; Fernández-Cuenca, R.; Alcalde-Cabero, E.; Galán, I. Inequalities in the risk of disability due to traffic injuries in the Spanish adult population, 2009–2010. *Injury* **2018**, *49*, 549–555. [CrossRef]

102. Lund, J.; Bjerkedal, T. Permanent impairments, disabilities and disability pensions related to accidents in Norway. *Accid. Anal. Prev.* **2001**, *33*, 19–30. [CrossRef]

103. Banstola, A.; Mytton, J. Cost-effectiveness of interventions to prevent road traffic injuries in low- and middle-income countries: A literature review. *Traffic Inj. Prev.* **2017**, *18*, 357–362. [CrossRef]

104. Martin, A.; Lagarde, E.; Salmi, L.R. Burden of road traffic injuries related to delays in implementing safety belt laws in low-and lower-middle-income countries. *Traffic Inj. Prev.* **2018**, *19*, S1–S6. [CrossRef]

105. Jacobs, G.; Aeron-Thomas, A.; Astrop, A. *Estimating Global Road Fatalities*; Transport Research Laboratory: Crowthorne, UK, 2000.

106. The World Bank. *The High Toll of Traffic Injuries: Unacceptable and Preventable*; The World Bank: Washington, DC, USA, 2017.

107. Ameratunga, S.; Hijar, M.; Norton, R. Road-traffic injuries: Confronting disparities to address a global-health problem. *Lancet* **2006**, *367*, 1533–1540. [CrossRef]

108. Aeron-Thomas, A.; Jacobs, G.D.; Sexton, B.F.; Gururaj, G.; Rahman, F. *The Involvement and Impact of Road Crashes on the Poor: Bangladesh and India Case Studies*; TRL Limited: Wokingham, UK, 2004.

109. Bishai, D.; Bachani, A.M. Injury costing frameworks. In *Injury Research: Theories, Methods and Approaches*; Li, G., Baker, S.P., Eds.; Springer: New York, NY, USA, 2012.

110. Winston, C.; Maheshri, V.; Mannering, F. An exploration of the offset hypothesis using disaggregate data: The case of airbags and antilock brakes. *J. Risk Uncertain.* **2006**, *32*, 83–99. [CrossRef]

111. Lv, J.; Lord, D.; Zhang, Y.; Chen, Z. Investigating Peltzman effects in adopting mandatory seat belt laws in the US: Evidence from non-occupant fatalities. *Transp. Policy* **2015**, *44*, 58–64. [CrossRef]

112. Nicita, A.; Benedettini, S. The costs of avoiding accidents: Selective compliance and the "Peltzman Effect" in Italy. *Int. Rev. Law Econom.* **2012**, *32*, 256–270.

113. Garbacz, C. Impact of the New Zealand seat belt law. *Econ. Inq.* **1991**, *29*, 310–316. [CrossRef]

114. Health Effects Institute. *State of Global Air 2018. A Special Report on Global Exposure to Air Pollution and Its Disease Burden*; Health Effects Institute: Boston, MA, USA, 2018.

115. Sayed, T.; Saunier, N.; Lovegrove, G.; de Leur, P. Advances in proactive road safety planning. In Proceedings of the 20th Canadian Multidisciplinary Road Safety Conference, Niagara Falls, ON, Canada, 6–9 June 2010.

116. Uzondu, C.; Jamson, S.; Lai, F. Investigating unsafe behaviours in traffic conflict situations: An observational study in Nigeria. *J. Traffic Transp. Eng.* **2019**, *6*, 482–492. [CrossRef]

117. Uzondu, C.; Jamson, S.; Lai, F. Exploratory study involving observation of traffic behaviour and conflicts in Nigeria using the Traffic Conflict Technique. *Saf. Sci.* **2018**, *110*, 273–284. [CrossRef]

118. Chang, A.; Saunier, N.; Laureshyn, A. *Proactive Methods for Road Safety Analysis*; SAE Technical Paper WP-0005; SAE International: Troy, MI, USA, 2017.

119. Dhibi, M. Road safety determinants in low and middle income countries. *Int. J. Inj. Control Saf. Promot.* **2019**, *26*, 99–107. [CrossRef] [PubMed]

120. St-Aubin, P.; Saunier, N.; Miranda-Moreno, L. Large-scale automated proactive road safety analysis using video data. *Transp. Res. Part. C Emerg. Technol.* **2015**, *58*, 363–379. [CrossRef]

121. De Leur, P.; Sayed, T. A framework to proactively consider road safety within the road planning process. *Can. J. Civ. Eng.* **2003**, *30*, 711–719. [CrossRef]

122. Mitra, S.; Washington, S. On the significance of omitted variables in intersection crash modeling. *Accid. Anal. Prev.* **2012**, *49*, 439–448. [CrossRef] [PubMed]

123. Mannering, F.L.; Bhat, C.R. Analytic methods in accident research: Methodological frontier and future directions. *Anal. Methods Accid. Res.* **2014**, *1*, 1–22. [CrossRef]

124. Heydari, S.; Miranda-Moreno, L.F.; Lord, D.; Fu, L. Bayesian methodology to estimate and update safety performance functions under limited data conditions: A sensitivity analysis. *Accid. Anal. Prev.* **2014**, *64*, 41–51. [CrossRef] [PubMed]

125. Heydari, S. A flexible discrete density random parameters model for count data: Embracing unobserved heterogeneity in highway safety analysis. *Anal. Methods Accid. Res.* **2018**, *20*, 68–80. [CrossRef]

126. Nordfjærn, T.; Şimşekoğlu, Ö.; Rundmo, T. Culture related to road traffic safety: A comparison of eight countries using two conceptualizations of culture. *Accid. Anal. Prev.* **2014**, *62*, 319–328. [CrossRef] [PubMed]

127. Nordfjærn, T.; Jrgensen, S.; Rundmo, T. A cross-cultural comparison of road traffic risk perceptions, attitudes towards traffic safety and driver behaviour. *J. Risk Res.* **2011**, *14*, 657–684. [CrossRef]

128. McIlroy, R.C.; Nam, V.H.; Bunyasi, B.; Jikyong, U.; Kokwaro, G.O.; Wu, J.; Hoque, M.S.; Plant, K.A.; Preston, J.M.; Stanton, N.A. Vulnerable road users in low-, middle-, and high-income countries: Examining the relationships between pedestrian behaviours and attitudes towards traffic safety. *Accid. Anal. Prev.* **2019**, *131*, 80–94. [CrossRef] [PubMed]

129. Kouabenan, D.R. Beliefs and the perception of risks and accidents. *Risk Anal.* **1998**, *18*, 243–252. [CrossRef]

130. Dixey, R.A. "Fatalism", accident causation and prevention: Issues for health promotion from an exploratory study in a Yoruba town, Nigeria. *Health Educ. Res.* **1999**, *14*, 197–208. [CrossRef]

131. Peltzer, K. Seatbelt use and belief in destiny in a sample of South African black and white drivers. *Psychol. Rep.* **2003**, *93*, 732–734. [CrossRef]

132. Omari, K.; Baron-Epel, O. Low rates of child restraint system use in cars may be due to fatalistic beliefs and other factors. *Transp. Res. Part. F Traffic Psychol. Behav.* **2013**, *16*, 53–59. [CrossRef]

133. Maghsoudi, A.; Boostani, D.; Rafeiee, M. Investigation of the reasons for not using helmet among motorcyclists in Kerman, Iran. *Int. J. Inj. Control Saf. Promot.* **2018**, *25*, 58–64. [CrossRef] [PubMed]

134. Peltzer, K.; Renner, W. Superstition, risk-taking and risk perception of accidents among South African taxi drivers. *Accid. Anal. Prev.* **2003**, *35*, 619–623. [CrossRef]

135. Nordfjærn, T.; Jørgensen, S.; Rundmo, T. Cultural and socio-demographic predictors of car accident involvement in Norway, Ghana, Tanzania and Uganda. *Saf. Sci.* **2012**, *50*, 1862–1872. [CrossRef]

136. Şimşekoglu, Ö.; Nordfjærn, T.; Zavareh, M.F.; Hezaveh, A.M.; Mamdoohi, A.R.; Rundmo, T. Risk perceptions, fatalism and driver behaviors in Turkey and Iran. *Saf. Sci.* **2013**, *59*, 187–192. [CrossRef]

137. Ngueutsa, R.; Kouabenan, D.R. Fatalistic beliefs, risk perception and traffic safe behaviors. *Rev. Eur. Psychol. Appliquée* **2017**, *67*, 307–316. [CrossRef]

138. Yildirim, Z. *Religiousness, Conservatism and Their Relationship with Traffic Behaviour*; Middle East Technical University: Ankara, Turkey, 2007.

139. McIlroy, R.C.; Kokwaro, G.O.; Nam, V.H.; Jikyong, U.; Wu, J.; Hoque, M.S.; Preston, J.P.; Plant, K.A.; Stanton, N.A. How do fatalistic beliefs affect the attitudes and behaviours of vulnerable road users in different countries? A cross-cultural pedestrian study. Unpublished work.

140. McIlroy, R.C.; Plant, K.A.; Hoque, M.S.; Wu, J.; Kokwaro, G.O.; Vũ, N.H.; Stanton, N.A.; Jianping, W.; Kokwaro, G.O.; Vũ, N.H.; et al. Who is responsible for global road safety? A cross-cultural comparison of Actor Maps. *Accid. Anal. Prev.* **2019**, *122*, 8–18. [CrossRef]

141. Salmon, P.M.; Read, G.J.M.; Stevens, N.J. Who is in control of road safety? A STAMP control structure analysis of the road transport system in Queensland, Australia. *Accid. Anal. Prev.* **2016**, *96*, 140–151. [CrossRef]

142. Fahlquist, J.N. Responsibility ascriptions and Vision Zero. *Accid. Anal. Prev.* **2006**, *38*, 1113–1118. [CrossRef]

143. Kristianssen, A.-C.; Andersson, R.; Belin, M.-Å.; Nilsen, P. Swedish Vision Zero policies for safety—A comparative policy content analysis. *Saf. Sci.* **2018**, *103*, 260–269. [CrossRef]

144. Jadaan, K.; Al-Braizat, E.; Al-Rafayah, S.; Gammoh, H.; Abukahlil, Y. Traffic safety in developed and developing countries: A comparative analysis. *J. Traffic Logist. Eng.* **2018**, *6*, 1–5. [CrossRef]

145. Perel, P.; Ker, K.; Ivers, R.; Blackhall, K. Road safety in low-and middle-income countries: A neglected research area. *Inj. Prev.* **2007**, *13*, 227. [CrossRef] [PubMed]

146. Bhalla, K.; Shotten, M. Building road safety institutions in low-and middle-income countries: The case of Argentina. *Health Syst. Reform* **2019**, *1–13*, 121–133. [CrossRef] [PubMed]

147. Khademi, N.; Choupani, A.-A. Investigating the road safety management capacity: Toward a lead agency reform. *IATSS Res.* **2018**, *42*, 105–120. [CrossRef]

148. Hyder, A.A.; Norton, R.; Pérez-Núñez, R.; Mojarro-Iñiguez, F.R.; Peden, M.; Kobusingye, O.; Road Traffic Injuries Research Network's Group. The Road Traffic Injuries Research Network: A decade of research capacity strengthening in low-and middle-income countries. *Health Res. Policy Syst.* **2016**, *14*, 14. [CrossRef]

149. UNECE. *Strengthening the National Road Safety Management Capacities of Selected Developing Countries and Countries with Economies in Transition*; UNECE: Geneva, Switzerland, 2014.

150. World Health Organization. *Capacity Building for Preventing Injuries and Violence: Strategic Plan 2009–2013*; World Health Organization: Geneva, Switzerland, 2008.

151. Wijnen, W.; Stipdonk, H. Social costs of road crashes: An international analysis. *Accid. Anal. Prev.* **2016**, *94*, 97–106. [CrossRef]

152. Wesson, H.K.H.; Boikhutso, N.; Bachani, A.M.; Hofman, K.J.; Hyder, A.A. The cost of injury and trauma care in low-and middle-income countries: A review of economic evidence. *Health Policy Plan.* **2013**, *29*, 795–808. [CrossRef]

153. Bishai, D.; Hyder, A.A.; Ghaffar, A.; Morrow, R.H.; Kobusingye, O. Rates of public investment for road safety in developing countries: Case studies of Uganda and Pakistan. *Health Policy Plan.* **2003**, *18*, 232–235. [CrossRef]

154. Mukama, T.; Ssemugabo, C.; Ali Halage, A.; Gibson, D.G.; Paichadze, N.; Ndejjo, R.; Sempebwa, J.; Kobusingye, O. Costs of unintentional injuries among children in an urban slum community in Kampala city, Uganda. *Int. J. Inj. Control Saf. Promot.* **2019**, *26*, 129–136. [CrossRef]

155. Hauer, E. *Observational before/after Studies in Road Safety. Estimating the Effect of Highway and Traffic Engineering Measures on Road Safety*; Emerald Group Publishing: Bingley, UK, 1997.

156. Wiebe, D.J.; Ray, S.; Maswabi, T.; Kgathi, C.; Branas, C.C. Economic development and road traffic fatalities in two neighbouring African nations. *Afr. J. Emerg. Med.* **2016**, *6*, 80–86. [CrossRef]

157. Heydari, S.; Fu, L.; Thakali, L.; Joseph, L. Benchmarking regions using a heteroskedastic grouped random parameters model with heterogeneity in mean and variance: Applications to grade crossing safety analysis. *Anal. Methods Accid. Res.* **2018**, *19*, 33–48. [CrossRef]

158. AASHTO. *Highway Safety Manual*; American Association of State Highway and Transportation Officials: Washington, DC, USA, 2010.

159. Goel, R.; Garcia, L.M.T.; Goodman, A.; Johnson, R.; Aldred, R.; Murugesan, M.; Brage, S.; Bhalla, K.; Woodcock, J. Estimating city-level travel patterns using street imagery: A case study of using Google Street View in Britain. *PLoS ONE* **2018**, *13*, e0196521. [CrossRef] [PubMed]

160. Eluru, N.; Chakour, V.; Chamberlain, M.; Miranda-Moreno, L.F. Modeling vehicle operating speed on urban roads in Montreal: A panel mixed ordered probit fractional split model. *Accid. Anal. Prev.* **2013**, *59*, 125–134. [CrossRef] [PubMed]

161. Heydari, S.; Miranda-Moreno, L.; Fu, L. Is speeding more likely during weekend night hours? Evidence from sensor-collected data in Montreal. *Can. J. Civ. Eng.* **2019**. [CrossRef]