THE ROAD SAFETY FUND

Road safety in Zambia

Investment case

Road safety in Zambia

Road traffic accidents cost the Zambian economy

ZMK 16.7 billion

(US$0.91 billion) every year, equivalent to

4.7 percent

of Zambia's GDP.

More than

2,100 Zambians

died due to road traffic accidents in 2021.

If current trends continue, road traffic accidents in Zambia will result in

115,000 preventable deaths

over the next 30 years.

Over the same period, more than **486,000** individuals would become permanently disabled and an additional **7.3 million** individuals would suffer injuries.

By investing in the interventions modelled, Zambia can avert more than **50,000** deaths, prevent more than **130,000** permanent disabilities and save **ZMK 234 billion (US$12.8 billion)** in economic costs.

Acknowledgements

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Abbreviations

BAC	Blood Alcohol Concentration
GBD	Global Burden of Disease
GDP	Gross Domestic Product
IHME	Institute for Health Metrics and Evaluation
LMIC	Low- and middle-income countries
MoTC	Ministry of Transport and Communications
NFRA	National Road Fund Agency
NMT	Non-motorised Transport
NMTS	Non-Motorized Transport Strategy
ROI	Return on investment
RTA	Road traffic accident
RTSA	Road Traffic Safety Agency
UNEP	United Nations Environment Programme
US$	United States Dollar
VSLY	Value of a statistical life year
ZMK	Zambian Kwacha

Contents

Executive summary

Road traffic accidents rank eighth among global causes of death. Traffic-related deaths and injuries contribute immense burdens to the global economy [1]. Ample evidence exists to support the efficacy of road traffic prevention strategies, but few studies have linked intervention-specific risk reductions to their respective implementation costs. Scarcer still are studies investigating national economic losses from road traffic accidents in countries in the Sub-Saharan African region. The urban population in Zambia is expanding, thus investment in infrastructure is needed and pedestrian safety investments should be evaluated with cost-benefit analysis to support intervention choices. This report presents the findings of the case for investing in road traffic safety measures in Zambia, a stated priority of the Government of Zambia. It measures the costs and benefits of implementing five road safety interventions. They are:

This report provides an estimate of the economic costs of current road traffic injuries in Zambia, with an emphasis on pedestrian injury. It offers evidence for selecting the above set of cost-effective interventions to reduce pedestrian injury and estimates the costs and benefits of implementing them. The health and economic benefits of these interventions are forecast for a period of 30 years at two coverage levels (50 and 80 percent).

Our analysis shows that road traffic accidents are a substantial burden on the Zambian economy and the health and well-being of the population.

The burden of road traffic accidents

Road traffic accidents cost the Zambian economy ZMK 16.7 billion (US$0.91 billion) every year, the equivalent of 4.7 percent of Zambia's GDP.

Road traffic accidents cause a tremendous loss of life. If no further investments are made in improving road safety and current trends continue, over the next 30 years over 115,000 preventable deaths could occur.

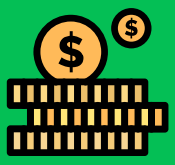
For those who survive a road traffic accident, injuries can be debilitating and long-lasting. If current trends continue, over 486,000 individuals would become permanently disabled from road traffic accidents, and an additional 7.3 million individuals would suffer injuries.

A safer and more prosperous future is possible by investing in road traffic safety interventions. Zambia has already begun taking steps to reduce the health and economic burden of road traffic accidents by developing its *Non-motorized Transport Strategy* [2] to guide implementation of high-quality interventions and improve access through sustainable methods of transportation, such as walking, cycling, and public transit. Several of the priority interventions identified in Zambia's non-motorized transit strategy are included in this analysis.

By investing in the five interventions scaled to an 80 percent coverage level, over the next 30 years, Zambia can:

Why invest in road safety?

Avert more than 50,000 deaths and prevent more than 130,000 permanent disabilities. This is the equivalent of approximately 1,600 lives saved and 4,300 permanent disabilities averted every year.



Save ZMK 234 billion (US$12.8 billion) in economic costs. That is equivalent to annual savings of ZMK 7.8 billion (US$0.42 billion).

Deliver a positive return-on-investment. All five interventions have a positive return-on-investment over 30 years. By investing in road safety measures, Zambia can expect a return-on-investment of 2.3:1 over 5 years, and 9.6:1 over 30 years.

Introduction

Road traffic accidents (RTAs) are responsible for 1.35 million fatalities per year globally, ranking first as a cause of death among those aged 15 to 29 and eighth among all age groups [1]. People living in low- and middle-income countries (LMICs) are three times as likely to die in in road accidents than those in high-income countries [1]. Ninety percent of global road traffic fatalities and injuries occur in LMICs despite these countries' smaller share of motor vehicle owners [1], [3]. Africa has the greatest burden of pedestrian and cyclist road traffic fatalities of all WHO regions1 and Zambia is no exception to this pattern. According to the Zambian Annual Crash Statistics report, 2,163 individuals died in RTAs in 2021 and the majority of fatalities were among pedestrians and cyclists [4], [5].

The economic costs attributable to RTAs are substantial. Estimates suggest road injuries and fatalities will cause a global economic loss of US$1.3 trillion between 2015 and 2030 [6]. The Sustainable Development Goals (SDGs) spotlight road safety by setting an early 2020 target: halve the number of deaths and injuries incurred from RTAs. Progress was poor despite global prioritization and as a result, the revised SDGs now aim to reach the same target by 2030 [7]. Data from the past five years show that progress towards this goal is slow. Reductions in road traffic injuries were insubstantial and came primarily from high-income settings [8]. In Zambia, after four consecutive years of reductions in road traffic accident fatalities from 2016 through 2020, fatalities in 2021 represent an alarming 28 percent increase in the number of deaths [4], [5].

Road safety can be improved through evidence-based actions. The World Bank recommends governments adopt a synergistic approach. Speed control, safer drivers, safer vehicles, road and roadside design, post-crash care, and road safety management comprise the World Bank's six "Safe System" components; a combination of these components is recommended to reduce both the occurrence and fatality of accidents [3]. Indeed, Australia achieved a 16 percent reduction in RTA mortality rates after implementing three of the six components: speed limits, drunk-driving laws, and road safety features [9]. Zambia and other LMICs can maximize long-term benefits by investing in RTA prevention strategies now. Safe road features incorporated into urbanization and development agendas will not only save lives but also facilitate a more equitable urban environment.

To support Zambia in pursuing a safer and healthier future this report includes the results of an investment case for interventions to improve road traffic safety. Investment cases quantify the direct and indirect benefits of implementing interventions, in health and monetary terms, and weigh this against the costs of implementation. By quantifying the overall economic gains that can be achieved by allocating more resources to the most cost-effective interventions, the goal of this investment case is to help to optimize responses and mobilize investment for improving the safety of Zambia's roads.

Road traffic safety in Zambia: Context and status

As of 2021, Zambia has a population of over 18.9 million and a GDP per capita of US$1,121 [10]. Zambia's road network consists of nearly 68,000 kilometers of roads, of which only about 15 percent are paved [11].

In 2020, there were 28,484 recorded road traffic crashes in Zambia. Of these, 5 percent were fatal, 10 percent considered serious, 20 percent resulted in slight injury, and 65 percent resulted in 'damages only' (not involving bodily harm). Almost half (46 percent) of these fatalities from road traffic accidents were pedestrians in Zambia in 2020. Motor vehicle drivers and passengers accounted for 35 percent of the remaining fatalities, followed by bicyclists at 14 percent, and motorcyclists at 5 percent [5]. In 2021, 2,163 Zambians were killed in RTAs and more than 14,000 were injured [4].

Although the majority (76 percent) of all 2020 road traffic accidents in Zambia were on urban roads, the majority of all fatalities occurred on inter-district roads (59 percent) [5]. Between 2011–2020, Zambia experienced a 124 percent increase in registered motor vehicles, with an average of 52,000 additional vehicles registered every year [5]. As the urban population and number of registered motor vehicles grows, improving the safety of roadways will become increasingly important and impactful.

Because the incidence and severity of RTAs can be prevented by a range of measures, policymakers must consider the national context in order to optimize road safety investments. Contextual considerations may include the most common type of road users, geographic and temporal trends in crash rates, existing road safety laws, and rural-urban disparities in accident rates. For example, over half of traffic fatalities in Vietnam occur among motorcyclists, making a strong case for enforcing helmet laws in this setting [12]. In contrast, most road traffic fatalities in Zambia involve pedestrians, and the majority of these pedestrian deaths are caused by crossing roads unsafely [13]. Data from the Zambian context thus indicate great life-saving potential from an investment in safe road crossings. National data exist regarding the most common causes of RTAs in Zambia. Zambia's most recent Annual Crash Statistics report from 2020 shows that over 87 percent of all accidents were due to human error. The vast majority of human errors (92 percent) were made by drivers [5]. The most frequently cited driver error was excessive speeding followed closely by failure to keep to the side of the road and misjudging clearance distance [5]. One interpretation of these data is that most Zambian accidents could be prevented through effective speed control interventions. Accidents caused by animals, obstructions, weather, road and motor vehicle deficits, and other causes comprised the remaining 13 percent of all accidents recorded in 2020 [5].

National road safety legislation, strategy and coordination

Road safety has been recognised as a priority in the country and has been included in previous national development plans. Goal 7.9 of the Zambian National Development Plan 2017–2021 included improved transport systems and infrastructure as a key outcome, recognising the opportunity to improve socio-economic development across the country. Under *Strategy 3: construction and rehabilitation of road network, road revenue and safety enhancement* was included as a key programme [14]. The Zambian National Development Plan 2022–2026 also includes improving transportation by road as a means to achieve an industrialized and diversified economy [15].

In 2002, Zambia passed three Acts of Parliament: the Road Traffic Act No. 11 of 2002, the Public Roads Act No. 12, and National Road Fund Act No. 13 [16]. The Road Traffic Act established the Road Transport and Safety Agency (RTSA) in 2002 under the Ministry of Transport and Communications (MoTC), which became operational in 2006. The RTSA has several key functions including registering motor vehicles, implementing international protocols and treaties on road transport, conducting and coordinating road safety programmes, and implementing policies on transport, traffic management and road safety [17]. The Road Development Agency was established through the Public Roads Act and is responsible for the construction and maintenance public roads in the country, as well as oversight of key infrastructure projects such as the National Road Tolling Programme [18]. The National Road Fund established the National Road Fund Agency (NRFA) which has key responsibilities in mobilising and managing financial resources for the road sector [16].

Zambia has developed several policies to address non-motorised transport (NMT) and the burden of RTA. In 2016, Zambia adopted the National Transport Policy which voiced government support for the development of NMT. The National Road Safety Policy Strategy and Action Plan 2017–2020 calls for the development and inclusion of footpaths, cycle paths and protected crossing, and ensuring that all road designs meet the needs of all users. However, many of the policy measures were not implemented. Zambia has also developed a Non-Motorised Transport Strategy (NMTS) in 2019, in collaboration with the United Nations Environment Programme (UNEP) [2]. Increased investment to improve road safety, including the interventions modelled in this investment case, can help Zambia achieve its targets for an improved NMT environment in Zambian cities including by reducing fatalities of pedestrians and cyclists. By ensuring a safer environment, this can also aid Zambia reach its targets on increasing NMT and improved air quality.

Zambia has also implemented several initiatives to improve road safety in the country. The most recent RTSA report in 2019, identifies children as the most vulnerable road users due to their exposure to various traffic conditions as unsupervised pedestrians travelling to school, but also as passengers with little or no control over the driver of the vehicle. With this in mind, the RTSA Education and Publicity Unit conducts several programmes to reduce these risks including: Road Safety Clubs/Traffic Warden Schemes, Road Safety Sensitization at Schools, Sensitization at Intercity Bus Terminus and Road Safety School Park [13]. In 2020, the Agency visited 20 schools sensitizing more than 4,100 learners and delivered more than 125,000 copies of Road Safety books for schools [5].

The RTSA also conducts various awareness raising activities targeting the general population including sensitizing road users on their transport to annual traditional ceremonies, facilitating participation at the Choova Cycling Contest and engaging in various activities during United Nations (UN) Road Safety Week and Road Safety Wee [13]. In 2020, RTSA also conducted road safety sensitization to passengers and drivers at Inter-City Bus Terminus, reaching more than 8,000 buses and more than 244,000 passengers [5].

Box 1: Improving safety for students in Lusaka [1]

In 2017, Amend and FedEx implemented a project to improve safety surrounding Justin Kabwe Primary School in Lusaka, Zambia. The location of the school sees 4,700 vehicles pass the entrance, 900 people walk along the road next to the school and 200 people cross the road during each peak hour. Dangerous conditions surrounding the school resulted in four children being injured. The project introduced a raised pedestrian crossing, footpaths, a school zone warning and reduced operating speeds of passing vehicles, which saw a significant improvement in its safety rating. Access roads to the schools improved from one- and two- star to five-star safety excellence score and the main entrance intersection improved from a one to five-star rating per the IRAP Star Rating for Schools app.

Financing

In the 2022 budget, ZMK 4.92 billion was allocated to road infrastructure – reflecting a decrease since the 2020 budget which saw an allocation of ZMK 10.5 billion [19], [20].

According to the NFRA 2020 Annual Report, the Road Fund received a total of ZMK 8.87 billion, which included ZMK 5,099 from local funding including road user charges, and ZMK 3,771 from external funding (such as loans and grants from the Ministry of Finance). In 2020, a total of ZMK 1.6 billion was collected in toll revenue alone, representing a 28 percent increase since 2019 despite the COVID-19 pandemic [21].

The status of key interventions

To identify and select priority interventions for inclusion in the investment case, we considered availably of evidence, strength of evidence, gaps in national coverage, and priorities outlined through consultations with country partners. The availability and strength of evidence was assessed through a review of peer-reviewed literature on cost-effectiveness of any road safety intervention aimed at reducing the frequency and severity of RTAs, first in Zambia, then globally where evidence was lacking. Intervention options were also informed by the proposals made in section 6 of the 2019 Zambia Crash Statistics report [21], priorities outlined by the Zambia Non-Motorized Transport Strategy (NMTS), and recommendations included the WHO Save LIVES Road Safety Technical Package [2], [22]. Vulnerable road users (pedestrians and cyclists) were indicated as priority populations in national reports and from consultation with national partners.

The five interventions selected for further economic and health impact evaluations in Zambia were: speed bumps, road crossings, roadside paths, post-crash prehospital care, and alcohol breath testing. In alignment with the recommendation of a multi-sectoral approach to road safety, our five interventions span four of the World Bank's six Safe System components: safe speeds, safe roads and roadsides, effective post-crash care, and safe road management, respectively. Three of the five interventions (speed bumps, road crossings, and roadside paths) benefit these road users and neatly align with urban development plans in a rapidly urbanizing nation. Alcohol breath testing and post-crash pre-hospital care reach urban and rural populations while speed bumps, road crossings and roadside paths primarily affect those in urban areas. Post-crash prehospital care is the only intervention to address road safety through the health care system. Random alcohol breath testing was chosen because the existing literature suggests promising cost-effectiveness outcomes; moreover, this intervention does not require significant changes to the built environment.

The following section provides detail on the efficacy of each intervention and current levels of implementation. Estimates for baseline coverage and other modeling assumptions are detailed in the methodology section.

Speed bumps

Exceeding the speed limit is a major risk factor for both RTA incidence and severity of injury. Over 16 percent of Zambian RTAs in 2020 were caused by excessive speed [5]. Estimates suggest that every km/hour increase in average traffic speed leads to a 3 percent increase in accidents that result in injury [23]. Speed bumps are well-suited to reduce average vehicle speeds in urban areas, where most of Zambia's crashes occur. Because the national speed bump count is unknown, qualitative assessments and budget allocations highlighted in the NMTS were taken into consideration along with the Road Development Agency's most recent road network estimates to arrive at a baseline coverage estimate of 10 percent, or 2,087 speed bumps [2], [24]. Following the National Association of City Transportation Officials' recommendation of six speed bumps per 1 km of urban roads, 100 percent coverage in Zambia equates to approximately 20,000 speed bumps within the urban road network [25].

Crossings

The most frequently cited pedestrian error leading to accidents in Zambia is careless crossing of roadways [13]. More than three-quarters of these accidents occur in urban areas [2], [13]. Qualitative data from Zambian NMTS indicate that formal pedestrian/cyclist crossings are either rare or nonexistent in many Zambian cities [2]. Increasing mid-block road crossing coverage is included in the NMTS, which offers two designs for consideration.

Roadside paths

Most people move around Lusaka by walking yet the city lacks designated roadside paths in many areas [2]. A major goal outlined in Zambia's 2019 NMTS is to increase the coverage of roadside paths in both rural and urban settings. Roadside paths can contribute to a safer environment for pedestrians and cyclists, two categories of road users who are at high risk of death from RTAs in Zambia. Special consideration of these vulnerable groups is one of the two main recommendations of the Zambian Road Transport and Safety Agency's 2020 report [5]. Roadside paths not only have measurable impacts on risk of traffic accidents but also align with national equity and social justice goals by way of increased accessibility for persons with disabilities [2].

Post-crash prehospital care

In Zambia, the majority (59 percent) of road traffic facilitates in 2020 were from accidents in rural areas, despite RTAs occurring less frequently in rural areas than in urban settings (24 and 76 percent of all recorded accidents in 2020, respectively) [5]. Approximately half of all global traffic fatalities occur within the first 30 minutes following a crash; intervening within this window provides an opportunity to avoid loss of life [13]. Further, improvements in access to post-crash prehospital care could potentially reduce the incidence of severe outcomes and disabilities from RTAs [26]. A review of various post-crash care systems among LMICs found that these systems can reduce RTA fatalities by 25 percent [27]. Still, ambulatory coverage in sub-Saharan Africa remains inadequate and under-examined. The high costs associated with increasing emergency medical service fleets has inspired creative, less costly alternatives to address acute critical care needs of crash survivors immediately after an accident occurs. A research team operating in Kampala, Uganda delivered a training course for basic trauma care to laypersons (cab drivers, police officers) which produced encouraging results: 97 percent of participants reported using skills from the course at six months follow-up [28].

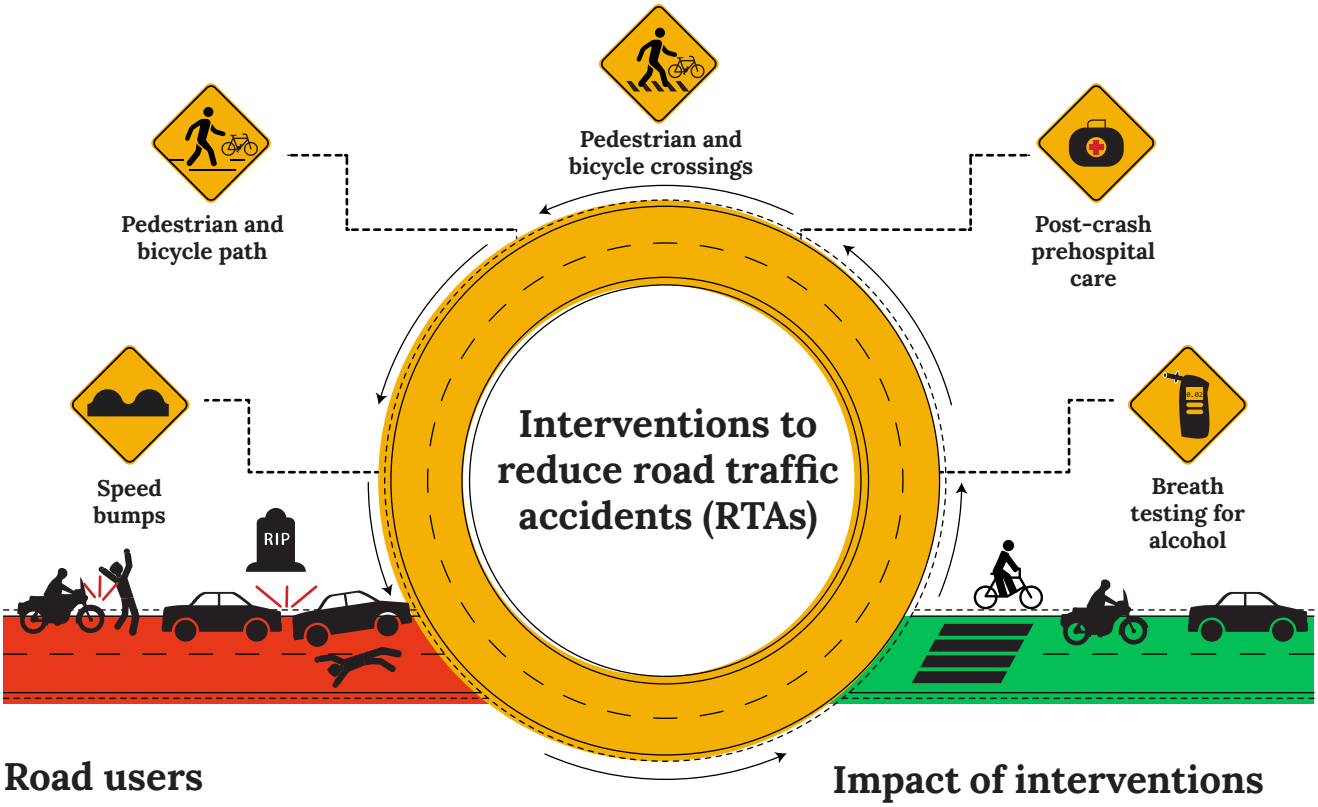
Random alcohol breath-testing

Driver error was the most frequently cited cause of all RTAs recorded in 2020 in Zambia [5]. Any level of blood alcohol concentration (BAC) in a driver's system is associated with a 5-fold increase in relative risk of accident occurrence when compared to zero BAC [23]. In 2020, about 0.19 percent of RTAs attributed to driver error was due to alcohol and drug use. However, a well research study in sub-Saharan Africa found that in total, about 34 percent of RTAs in Zambia can be attributed to alcohol intoxication [29]. One key way of preventing this risk factor for RTAs is through random breath-testing. Random breath-testing interventions are supported by a large body of evidence. Indeed, randomized breath testing is considered one of the most cost-effective road safety strategies with consistent reductions in road traffic crash rates across various countries and settings [23]. The World Bank reports cost-benefit ratios of these interventions of 1:56 [23]. International estimates suggest that breath testing consistently reduces the incidence of alcohol-related road accidents by about 20 percent from baseline in both short- and long-term implementation timelines [23], [30]. For current coverage of this intervention we adopt the regional estimate for Eastern Sub-Saharan Africa (5 percent) – a low baseline compared to other regions [29].

Methodology

An investment case model developed by RTI International was used to estimate the health and economic burden of RTAs and the impact of implementing or expanding road safety measures. The tool was built with Microsoft Office Excel 2013, and is compatible with later versions (2016, 2019 and 365). Users without a Microsoft Office license will not be able to adapt input data. The investment case team utilized Zambian data wherever available and relied on peer reviewed literature and global databases where country-sourced data were unavailable. The total number of fatal and non-fatal RTAs were obtained from the Global Burden of Disease database and other key input parameters were from literature reviews managed in Zotero software.

Figure 1: Road traffic users, outcomes, and interventions



Road users

- Pedestrians
- Bicyclists
- Motorcyclists
- Occupants of motor vehicles
- Others

Impact of interventions

- Avert deaths and prevent permanent disabilities
- Save in economic costs
- Deliver a positive return-on-investment

Road traffic accident outcomes

- Death
- Permanent disability
- Severe injury
- Moderate injury
- Minor injury

The investment case estimates the health and economic burden of RTAs for five types of road traffic users: pedestrians, bicyclists, motorcyclists, occupants of motor vehicles, and other road users. When these road users are involved in RTAs, they may experience one of five possible outcomes: death, permanent disability, severe injury, moderate injury, or minor injury. The investment case identifies and models the impact of five evidence-based interventions to reduce RTAs among road users. **Figure 1** illustrates the types of road users, outcomes resulting from RTAs, and interventions to reduce RTAs. The next section describes the methodology in more detail. A summary of data sources used in the investment case is shown in **Table 1**.

Table 1: Summary of investment case data sources

Population parameters		
Zambia population	2020 Zambian population	UN Population Division [31]
Annual population growth	2.8 percent annual population growth forecast (2011-2035)	Zambia Census Projections [32]
Mortality and morbidity parameters		
Number of RTA cases	Number of deaths and injuries from RTA	IHME GBD [8]
Incidence rate of RTA	5-year average of RTA incidence and mortality rate	IHME GBD [8]
Cost parameters		
Hospitalisation cost	Average healthcare cost of injuries based on injury type	Umo et al. (2022) [33]
Duration of hospitalisation	Average duration of hospital stay (25 days for severe injuries; 10 days for moderate injuries; 5 days for minor injuries)	Lee et al. (2016) [34]
Duration of injury	Duration of injury before remission (53 days for severe injuries; 35 days for moderate injuries)	Geraerds et al. (2019) [35]
Diminished productivity	Effect size for diminished productivity attributable to injuries (30 percent for severe injuries; 15 percent for moderate injuries)	Chantith et al. (2021) [36]
Daily wages	Estimated from mean monthly wage for Zambia	International Labour Organisation (ILO) [37]
Labour force participation rate	Labour force participation rate used to adjust income loss	ILO [37]
Intervention parameters		
Cost of the RTA intervention	Cost of the RTA interventions	Literature
Effectiveness of RTA intervention	Effectiveness of RTA interventions	Literature
Others		
Inflation rate	Annual rate of inflation	IMF [38]
Discount rate	Discount rate used in estimating net present value	Analyst's choice
Value of Statistical Life Year	Used in estimating the economic value of deaths	Robinson et al. (2019) [39]
Disability weights	Weight of 0.63 (severe traumatic brain injury) used in estimating the economic value of permanent disability	Salomon et al. (2015) [40]

Current health burden

Mortality and morbidity data was sourced from the Institute for Health Metrics and Evaluation (IHME) Global Burden of Disease (GBD) database [8]. GBD data is disaggregated by sex and five-year age groups and are categorised by road user types: pedestrians, bicyclist, motorcyclists, motor vehicle occupants, and other road users. The GBD database categorizes morbidity data into four broad categories (mild, moderate, severe, and permanent), each severity group includes a range of injuries coded according to the International Classification of Diseases, Eleventh Revision (ICD-11) and Injury Severity Score [41], [42].

We estimated the burden of road traffic injuries for a 30-year period (2020–2050). The annual number of road traffic injuries was determined by applying 5-year average incidence rates obtained from the IHME GBD database to the projected annual population of Zambia. We determined annual population in Zambia by using the 2011–2035 population growth forecast of 2.8 percent per annum, and assumed the same growth rate through the year 2050 [32]. The 2020 population in Zambia, disaggregated by age and sex, was obtained from the United Nations Population Division [31].

We estimated the direct and indirect costs of fatal and non-fatal RTAs. Direct costs include healthcare costs while indirect costs include the economic value of fatalities and permanent disabilities and productivity costs associated with severe, moderate, and minor injuries. To arrive at total costs, direct and indirect costs from each RTA were added together.

Direct costs

Direct medical costs are the cost of health care goods and services consumed due to RTAs. Without Zambia-specific data available detailing the cost of RTA-related healthcare expenditures, we relied on the best estimates we could obtain in alignment with the ICD-11 injury definitions and the GBD's broader injury categories. We identified estimates of medical costs of RTAs by injury for Papua New Guinea, which – like Zambia – is classified as a lower-middle income country [33]. The Papua New Guinea values were deflated to 2020 local currency unit estimates and then converted to Zambia kwacha (ZMK) before converting to US dollars (US$). Consumer price index data and exchange rates were drawn from the World Bank. The estimated medical costs for each type of injury are presented in **Table 2** below.

Table 2: Medical costs of road traffic injuries, by injury type (ZMK and US$)

Type of injury	Cost in ZMK	Cost in US$ [33]
Minor injury	69,539	3,791.68
Moderate injury	67,317	3,670.53[i]
Severe injury	75,294	4,105.50
Permanent disability	70,210	3,828.25
Death	40,530	2,209.97

[i]Multiple ICD-11 injuries are contained within the four injury categories; the cost estimate for moderate injuries is slightly lower than that of minor injuries – this is due to the variation in cost of ICD-11 injuries within each category.

Indirect costs

Economic cost of years of life lost due to mortality

The economic value of RTA deaths is calculated as the number of potential years of life lost due to RTAs multiplied by the economic value of a life year. The number of potential years of life lost denotes the difference between the age at death and average life expectancy. All future costs are discounted at a rate of 3 percent per year to obtain the net present value (NPV). All future economic costs associated with RTA fatalities are assigned to the year in which the death occurred and are discounted at a rate of 3 percent per year to obtain the net present value (NPV). The formula for calculating the NPV of the economic cost of premature deaths is:

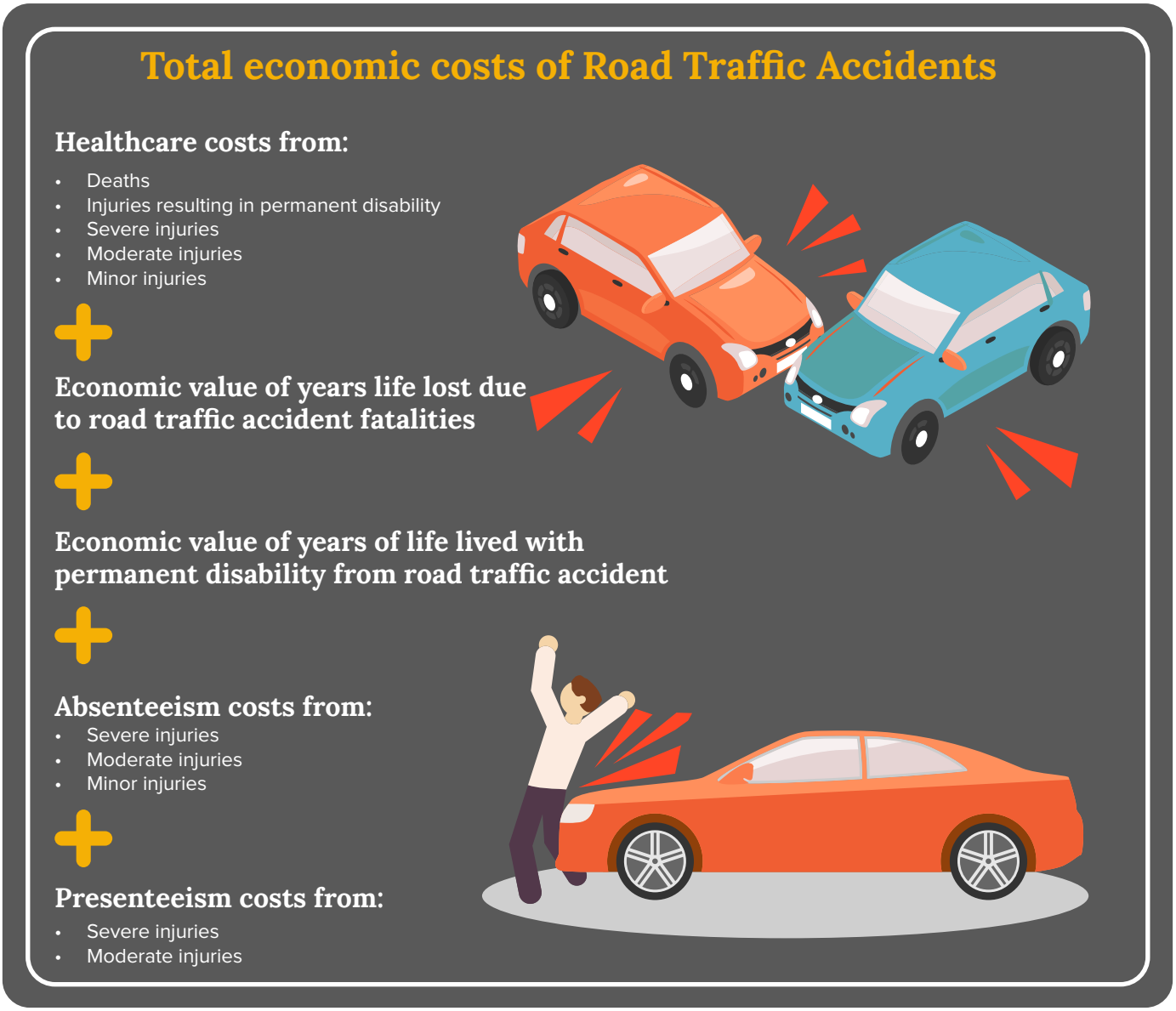
$$\sum_{k} DL_k = \left[ND_k \sum_{i=1}^{e} \frac{Y_i}{(1+r)^i} \right] (1)$$

Where $\sum_k DL_k$ represents the economic cost of premature death, ND_k is the number of deaths in each age group ("k"), and $\sum_{i=1}^{e} \frac{Y_i}{(1+r)^i}$ is the net present value of the economic value of mortality. This incorporates Y_i which is the value of a statistical life year (VSLY) [39], where i stands for each year of life lost due to premature death until year "e" (life expectancy at age of death), and "r" is the discount rate.

We utilize VSLY as the economic value of a life year. The VSLY is an estimate of the economic value of reduced mortality risk and represents individuals' willingness to exchange money for a small change in their own risk of mortality. VSLY is widely accepted for use in valuing mortality and morbidities in low-and-middle-income countries (LMICs) [43]–[45].

Economic cost of years of life lived with permanent disability

Figure 2: Approach for calculating economic costs of Road Traffic Accidents



For injuries resulting in permanent disabilities, we incorporated the disability weight for a major injury with long-term consequences (severe traumatic brain injury) from the Global Burden of Disease study [40]. We multiplied the disability weight by the VSLY to arrive at the economic cost of a year lived with permanent disability. For permanent disabilities, we adapted equation (1) by changing the number of deaths to the number of road traffic injuries resulting in permanent disability and by applying a disability weight to the VSLY estimate. The disability weight (0.64) adjusts the VSLY estimate for mortality to reflect the economic value of permanent disability and is estimated as [1-disability weight]×VSLY [39]. We assume that permanent disabilities include both physical and intellectual disabilities.

Absenteeism

When individuals are hospitalized due to RTAs, they are unable to work, resulting in lost income. We refer to these lost days of work due to hospitalization as absenteeism. The model takes the estimate of average number of days in hospital for each injury severity from the literature and uses these to estimate productivity loss due to absenteeism [46]. We calculated the value of absenteeism due to these hospitalizations using the average daily wage and the labour market participation rate by age and sex from the International Labour Organisation (ILO) [37].

Presenteeism

Even after individuals are released from the hospital, they may experience impairments resulting from their injuries that can limit their work function even after they have returned to their job. This period of diminished productivity is referred to as presenteeism. Existing literature on the magnitude and duration of diminished productivity from injuries on a country-specific level is sparse, and most injuries addressed fall into the severe category [36]. Chantith et al. found that severe injuries reduced workplace productivity by 30 percent [36]. To estimate diminished productivity due to moderate injuries, we assume half the magnitude of reduced productivity for severe injuries to arrive at 15 percent [36]. The duration of diminished workplace productivity (presenteeism) has been estimated at 35 days for moderate injuries [35]. Maintaining the above assumption of a 50 percent difference in moderate and severe injuries' impact on productivity, we extrapolate the duration of reduced workplace productivity for severe injuries as 50 percent more than that of moderate injuries to arrive at 53 days. Minor injuries (e.g., minor strains and dislocations, superficial wounds, contusions) were assumed to have no effect on workplace productivity.

Total cost of road traffic accidents

To estimate the total cost of road traffic injuries we add together direct and indirect costs, disaggregated by road user and injury type using the logic shown in **Figure 2**.

Interventions to reduce the cost of road traffic injuries

To determine the impact of the selected interventions on the cost of RTAs, we approximated the number of accidents that could be prevented by each intervention. These calculations take into account 2019 reports on causes of traffic accidents in Zambia along with the type of road users involved. We linked interventions and cause of accidents as follows: excessive speeding is affected by speed bumps, walking on the side of the road is affected by roadside paths, crossing the road is affected by road crossings, insufficient emergency care is affected by post-accident prehospital care, and drunk driving is affected by alcohol breath-testing. **Table 3** shows the road users which stand to benefit from each intervention. The attributable risk fractions were taken from existing literature and represent the degree of reduction in road traffic accidents that can be achieved by each intervention, disaggregated by road users.

Table 3: Causes of road traffic injuries

Cause of Injury (intervention)	Attributable Risk	Applied to Road Users (o)					Source
		Pedestrians	Bicyclists	Motorcyclists	Motor Vehicles	Other	
Speeding (speed bumps)	40%	o	o	o	o	o	Zambia Annual Crash Statistics (2019) [13]
Walking on side of road (lack of roadside paths)	19%	o	o				Fisa et al. (2019) [47]
Unsafely crossing the road (lack of crossing infrastructure)	30%	o	o				Fisa et al. (2019) [47]
Insufficient Emergency Care (post-crash prehospital care)	45%	o	o	o	o	o	Kobusingye et al. (2006) [48]
Drunk driving	34%	o	o	o	o	o	Ralaidovy et al. (2018) [29]

We assume that the proportion of bicyclist injuries caused by crossing the road or cycling along the road is the same as that for pedestrians. The basis of this assumption comes from evidence which suggests a high level of shared-use paths by both pedestrians, cyclists, joggers, and other non-motorized road users [49]. High-quality pedestrian paths and crossings are suggested to be more cost-efficient when developed to incorporate bicyclists [50].

Where estimates of effectiveness and cost-effectiveness are unavailable in LMICs, we relied on the best available estimate from high-income countries. Unit costs for all interventions except crossings were obtained from LMICs in Africa; crossing costs were obtained from the United States [51]. **Table 4** provides the summary of the cost-effectiveness of the proposed interventions for RTA reduction drawn from high-quality literature sources, as indicated.

Table 4: Cost-effectiveness of interventions

Intervention	Cost effectiveness	Effectiveness in reducing injuries and fatalities	Source
Speeding (speed bumps)	Treating the most dangerous intersections (responsible for 25 percent of deaths) cost US$70 per death averted, US$1.89 per life-year saved, and US$6.17–9.01 per DALY averted in Sub-Saharan Africa [52].	35 percent reduction in all injuries and 55 percent reduction in fatalities among pedestrians. We assume that the effect size for pedestrians is the same for bicyclists.	Turner et al. (2021) [3]; Afukaar (2003) [53]
Walking on side of road (lack of roadside paths)	Cost benefit ratio (CBR) for a combined sidewalk and bicyclist path was 0.82 in Norway [54].	40 percent reduction in injuries and 35 percent reduction in fatalities among bicyclists. 40 percent reduction in injuries and 50 percent reduction in fatalities among pedestrians.	Peden et al. 2004 [23] and iRAP toolkit [55]
Unsafely crossing the road (lack of crossing infrastructure)	The CBR for grade separated crossing for pedestrians and bicyclists was 2.04 in Norway [54].	39 percent reduction in injuries and fatalities among bicyclists. 49 percent reduction in injuries and fatalities among pedestrians.	Erke and Elvik (2007) [54]
Insufficient Emergency Care (post-crash prehospital care)	The projected cost of scaling up post-accident prehospital care was US$0.12 per capita and US$25–75 per life year saved in Uganda [28].	Proper implementation of prehospital care reduces fatalities by 25 percent.	Henry and Reingold (2012) [27]
Drunk driving	Cost per healthy life year gained of US$45,058 over 100 years in eastern Sub-Saharan Africa [29].	Reduces alcohol-related non-fatal and fatal RTAs by 15 percent and 25 percent	Ralaidovy et al. (2018) [29]

We estimate the number of fatal and non-fatal road traffic injuries averted due to the implementation and scale up of identified interventions. The health impact was estimated individually for each intervention. For example, if 49 percent of pedestrian road traffic injuries occur due to lack of crossings and implementing crossings reduces road traffic injuries by 25 percent, then the intervention will reduce 25 percent of injuries among the 49 percent of pedestrian road traffic injuries attributable to a lack of crossing. We used this approach across all proposed interventions. Interventions that target specific road users (paths and crossings) will reduce the incidence of road traffic injuries among pedestrians and bicyclists only. The post-accident prehospital care intervention is likewise limited in that it reduces motor vehicle user fatalities, but not injuries.

Intervention coverage

Each of the five interventions requires an estimate of the current level of coverage as well as an estimate of coverage that constitutes full implementation.

Speed Bumps: For speed bumps, the current level of coverage is unclear [2]. The U.S. National Association for City Transportation Officials recommends 6-7 speed bumps per km as the standard target spacing of speed bumps in urban roadways [25]. In the context of existing road networks in Zambia, full coverage for this recommendation translates to 20,868 total speed bumps [25]. Drawing on the qualitative urban road assessments in Zambia's NMTS [2] we estimate baseline coverage is at 10 percent in Zambia (2,087 existing speed bumps).

Crossings: Of the two models of mid-block road crossing options included in the NMTS, our model assumes the raised design option is preferred as the design is higher quality (leading to conservative cost-benefit ratios) and because better cost-effectiveness data exist for this design. Comprehensive crossing coverage follows the Global Designing Cities recommendation of 5 per km minimum for urban roads [56]. Using qualitative reports from the NMTS along with 2020 national estimates for total kilometers of paved urban and feeder roads, we assume current crossing coverage levels in Zambia are at 10 percent (1,392 crossings) [24].

Roadside paths: The cost of incorporating roadside paths depends on the path's material, width, and design. The Zambia NMTS recommends specific dimensions. The NMTS provides qualitative descriptions of Lusaka's urban roadways and suggests using "km of roads with pathways" as a performance indicator moving forward. Current national coverage levels are unclear. The model assumes a baseline coverage of 25 percent, or 716 km of urban roadside paths [57].

Post-crash prehospital care: The investment case uses a training program implemented in Kampala, Uganda to improve post-crash prehospital care coverage as a model for Zambia [28]. Upfront costs for the one-day training program are based on a cohort of 307 trainees; its impact and scalability was estimated at a per-capita basis by Jayaraman et al. using local injury data [28]. In addition to the assumption that these costs are translatable from Uganda to Zambia, we assume that 5 percent of the Zambian population is already covered by organized post-crash hospital care.

Alcohol breath testing: We were not able to identify estimates of current coverage for alcohol breath testing in Zambia. Instead, we adopt the regional estimate for Eastern Sub-Saharan Africa (5 percent) – a low baseline compared to other regions [29].

Our coverage estimates are higher than some identified estimates in the literature – we assume there has been some progress in the development of non-motorised traffic infrastructure since the publication of the estimates. For instance, according to a 2006 International Road Assessment Programme (iRAP) report, less than 10 percent of roads with speed limits greater than 40km/h have footpaths in sub-Saharan Africa [58], [59]. For roadside paths, we use a higher coverage estimate of 25 percent.

We modelled the cost and effectiveness of scaling all five identified interventions at 50 percent and 80 percent coverage. We chose two scale-up levels to understand the level of investment necessary to reach or exceed the United Nation's Decade of Action for Road Safety target of reducing road traffic injuries by 50 percent [60]. Some interventions are scaled to population levels (post-crash

prehospital trauma care) while some are scaled to the road network length in Zambia (speed bumps, crossings, paths). We assume that on average each kilometer of paved road in urban and feeder roads should have six speed bumps and five crossings, based on recommendations from the National Association of City Transportation Officials [25], [56]. The target number of speed bumps and crossings for each scaling option were calculated based on the current length (in kilometers) of existing paved urban roads which has been summarized by the Zambian Highway Management System [24].

Intervention costs

We obtained costs from published sources and estimated the intervention costs at current coverage levels and for projected scale-up targets (**Table 5**). We assumed a 10 percent annual maintenance cost for the paths and crossings. All costs were converted to ZMK, inflated to 2020 values, and then converted to US$. We estimated intervention costs to cover our study time horizon (2020–2050) and present future costs in 2020 US$ using a 3 percent discount rate. Costs were also presented as a share of GDP and per capita costs. We utilised an average 2020 exchange rate of ZMK 18.34 = US$1 (World Bank 2020). We determined the length of paved urban and community roads in Zambia to be 3,478 kilometers using data provided by the National Road Development Agency [24].

Table 5: Cost and coverage levels of interventions

Interventions	Baseline coverage (%)	Baseline coverage (number)	Unit cost	Sources
Speed bumps	10%	2,087 speed bumps	US$1,492 per speed bump at US$149 per year	Bishai and Hyder (2006) [52]
Roadside paths	25%	870 km of paths	US$14,206 per km	Road Safety Performance Review Uganda, RDA Annual Report (2019) [24], [61]
Road crossings	10%	1,739 crossings	US$9,024 per crossing	Global Designing Cities Initiative (2016) and Bushell et al (2013) [51], [56]
Post-crash prehospital care	5%	919,198 people reached	US$0.24 per capita	Jayaraman et al. (2009) [28]
Alcohol breath-testing law enforcement	10%	1,838,396 people reached	US$0.03 per capita	Ralaidovy at al. (2018) [29]

Economic returns

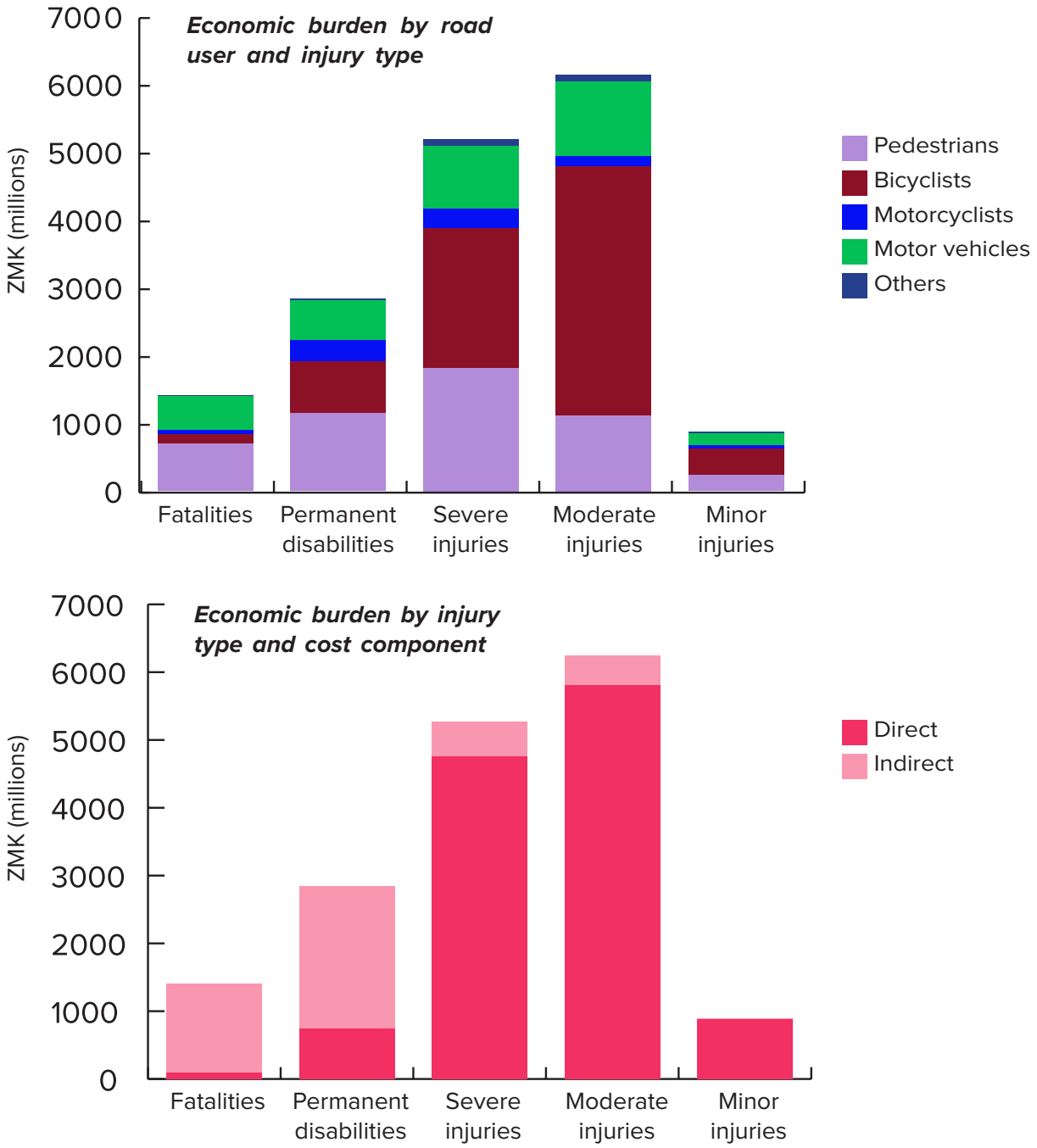
We estimated the benefit cost ratios (BCRs) and returns on investment (ROIs) for the five interventions for two projected coverage levels. We estimated the net present value (NPV) of future economic costs and intervention costs using a 3 percent discount rate. We calculate the BCR by dividing the discounted net gains by the discounted intervention cost. For ROIs, we subtracted the discounted intervention cost from the discounted net gains and divide by the discounted intervention cost. While these measurements are profitability estimates, BCRs estimate the expected benefit per investment (focus on top line) and ROIs estimate the net gain expected per investment (focus on bottom line). ROIs are presented as percentages.

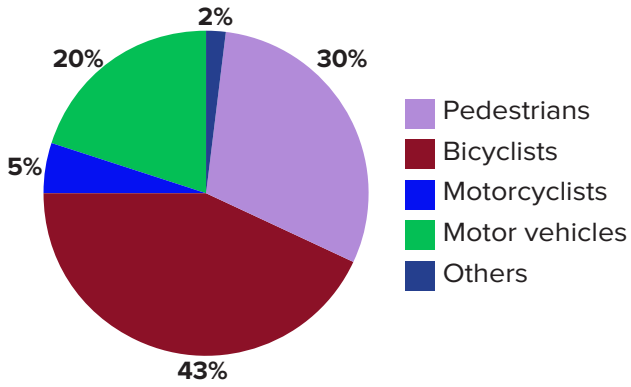
Results

Economic burden of road traffic injuries

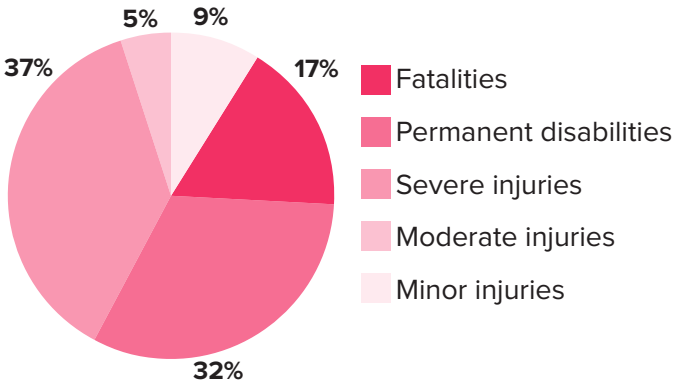
If current implementation levels of road traffic safety interventions continue without additional investment, over 115,000 preventable road traffic related deaths would occur over the next 30 years (2020–2050). Moreover, 486,348 individuals would become permanently disabled, and an additional 7.3 million would suffer injuries. These accidents would result in accumulated economic losses of about ZMK 4.99 billion (US$27.3 billion). This equates to an average cost of ZMK 16.7 billion (US$0.91 million) incurred from preventable RTAs each year. The annual economic burden of RTAs is equivalent to 4.7 percent of Zambia's GDP.

Figure 3: Economic burden of road traffic injuries





Share of economic burden by road user



Share of economic burden by injury severity

Pedestrians and bicyclists suffer the highest burden of RTA injuries and therefore bear the majority (73 percent) of the economic burden of RTA injuries (**Figure 3**). Among pedestrians, the greatest share of annual costs come from severe injuries (ZMK 1,814 million [US$99 million]), followed by permanent disabilities (ZMK 1,150 million [US$2.7 million]). Of all road users, bicyclists make up the greatest annual cost for moderate injuries (ZMK 3,670 million [US$200 million]). Among fatalities and permanent disabilities, the indirect costs (i.e., economic value of years of life lost and years lived with permanent disability) contribute the highest economic burden whereas direct (healthcare) costs make up the largest share of economic burden for severe, moderate, and minor injuries. Intervention cost and health impact at different scale up targets.

Intervention cost and health impact at different scale up targets

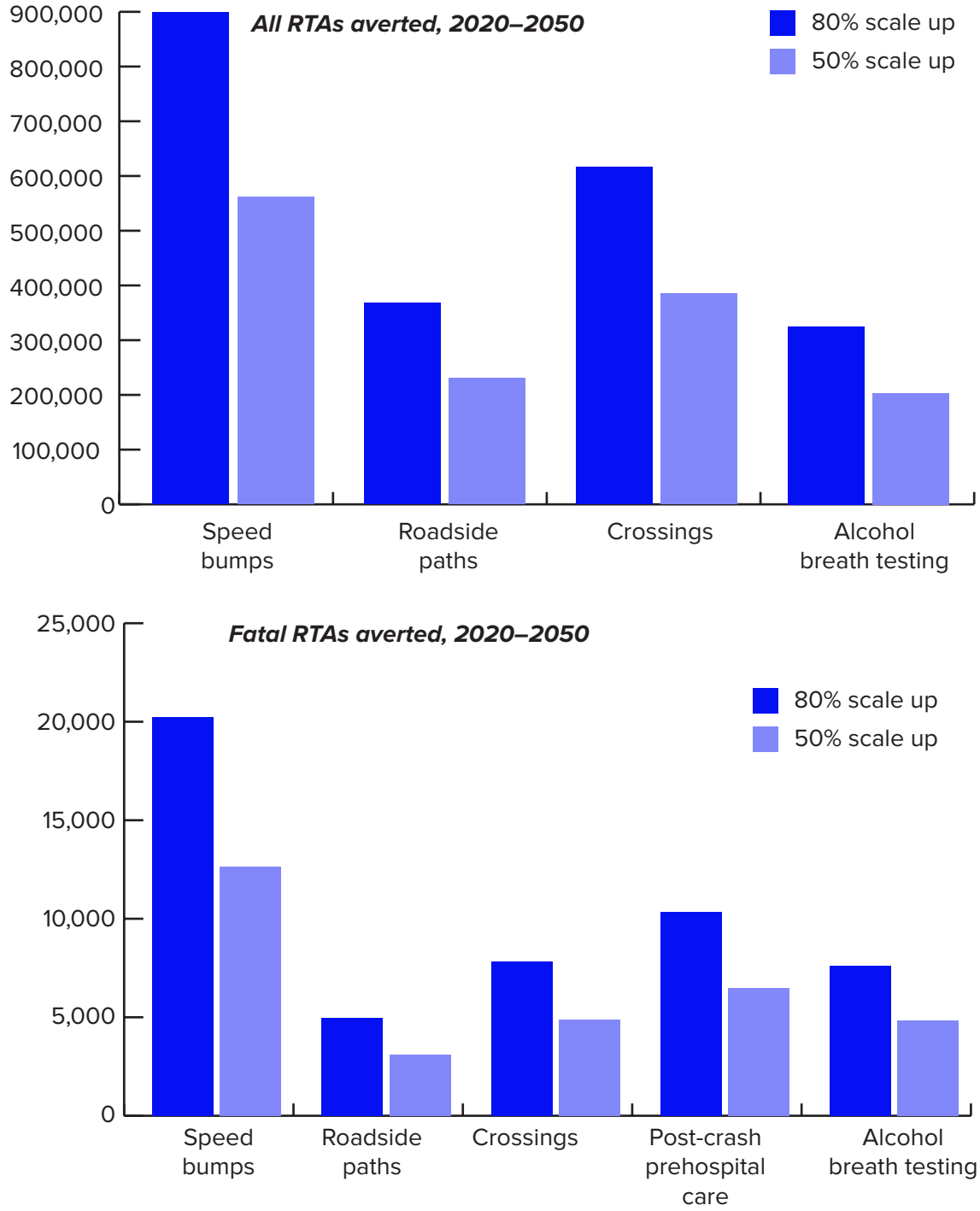
Scaling up all proposed interventions to 80 percent coverage would cost ZMK 771.8 million (US$42.08 million) per annum and ZMK 42 (US$2.29) per capita (**Table 6**). Pedestrian crossings, followed by post-crash prehospital care and roadside paths are the costliest interventions on a per capita basis. The costs used for crossings and roadside paths conservatively assumes that Zambia will select high-grade infrastructure designs. At 50 percent scale up, costs will be lower but fewer accidents would be prevented. The cost of all interventions at 50 percent scale up would be about ZMK 431.37 million (US$23.52 million) per year, on average. The cost of implementing infrastructure interventions, especially those that affect pedestrian and bicyclists, can be significantly reduced (by 50 to 65 percent) if these interventions are included as part of road construction initiatives [62], [63].

Table 6: Average annual implementation cost of interventions (2020 ZMK)

Interventions	Annual cost at 80% scale		Annual cost at 50% scale	
	Cost (millions)	Per capita cost	Cost (millions)	Per capita cost
Speed bumps	77.68	4.23	44.39	2.41
Roadside paths*	111.48	6.06	50.66	2.76
Crossings*	450.77	24.52	257.58	14.01
Post-crash prehospital care	118.11	6.42	70.86	3.85
Alcohol breath-testing	13.78	0.75	7.87	0.43
Total (all interventions)	771.82	41.98	431.37	23.46

*Interventions share the same cost for pedestrians and cyclists but have different health impacts

Figure 4: Future accidents averted



Scaling the interventions to 80 percent coverage would result in significant health savings: over 50,000 deaths and more than 130,000 permanent disabilities could be prevented between now and 2050. At this coverage level, an additional 2 million minor, moderate, and severe injuries could be averted (**Table 7**). This represents a reduction of nearly one quarter (24 percent) of the injuries that would be expected if current levels of intervention implementation remain unchanged. Post-crash prehospital care only impacts one of five injury severities (fatalities), it ranks second-only to speed bumps in the number of fatalities averted (**Figure 4**).

The majority of reductions in fatal and non-fatal RTAs come from scaling up speed bump coverage – this intervention accounts for over 40 percent of future RTAs averted, regardless of the chosen scale up option. Bicyclists account for 42 percent and 62 percent of averted severe and moderate injuries from speed bumps, respectively. Pedestrians make up the greatest share of permanent disabilities prevented by speed bumps, crossings, and roadside paths when compared to the impact of these interventions on other road users. Two interventions – roadside paths and crossings – are limited in the road users they impact. Despite this, the averted RTAs for these interventions (368,048 and 616,547, respectively, at 80 percent scale) are greater than averted RTAs for random alcohol breath testing and post-crash prehospital care (325,100 and 10,355, respectively, at 80 percent scale). Post-crash prehospital care is also limited in its impact in that it only reduces the number of fatal RTAs. An 80 percent reduction in fatalities among motor vehicle drivers can be achieved through scaling up post-crash prehospital care.

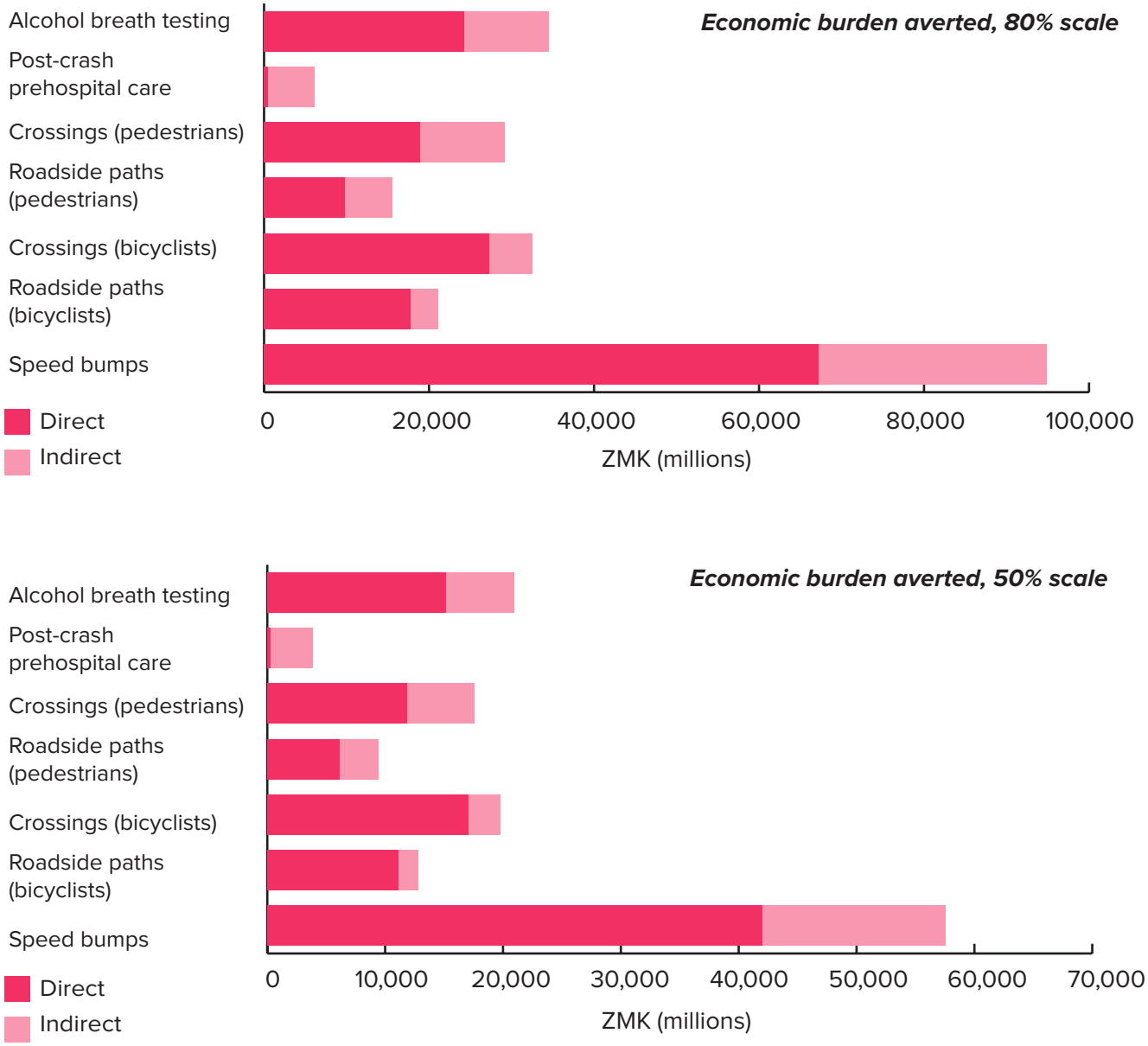
Table 7: Number of fatal and non-fatal road traffic injuries averted, 2020–2050

80% Scale						
Interventions	**Fatalities**	**Permanent disabilities**	**Severe injuries**	**Moderate injuries**	**Minor injuries**	**Total**
Speed bumps	20,251	54,471	321,977	437,792	64,659	899,149
Roadside paths	4,980	20,185	131,167	186,407	25,309	368,048
Crossings	7,838	35,986	226,030	303,961	42,731	616,547
Post-crash prehospital care	10,355	-	-	-	-	10,355
Alcohol Breath Testing	7,755	19,668	116,257	158,074	23,346	325,100
Total	**51,179**	**130,310**	**795,432**	**1,086,234**	**156,046**	**2,219,200**

50% Scale						
Interventions	**Fatalities**	**Permanent disabilities**	**Severe injuries**	**Moderate injuries**	**Minor injuries**	**Total**
Speed bumps	12,657	34,044	201,236	273,620	40,412	561,968
Roadside paths	3,112	12,615	81,980	116,504	15,818	230,030
Crossings	4,899	22,491	141,269	189,976	26,707	385,342
Post-crash prehospital care	6,472	-	-	-	-	6,472
Alcohol Breath Testing	4,847	12,292	72,661	98,796	14,591	203,188
Total	**31,987**	**81,443**	**497,145**	**678,896**	**97,529**	**1,387,000**

At 80 percent scale, the five interventions save about ZMK 234 billion (US$12.8 billion) in economic costs over 30 years (**Figure 5**). Of all five interventions, speed bumps prevent the most costs: ZMK 95 billion (US$5 billion). The average annual cost savings accumulated by implementing the full intervention package at 80 percent scale is ZMK 7.8 billion (US$425 million).

Figure 5: 30-year economic savings



Return on Investment

We estimate results for two scale-up levels based on global targets for the reduction/elimination of RTA injuries and fatalities. While the 80 percent target involves higher implementation costs, the returns on investing are substantial enough to suggest that these are good investments (**Table 8**). At 80 percent scale, every US$1 invested in random alcohol breath testing would bring US$80.4 in returns. Speed bumps are expected to have the highest returns (ROI 39.2), followed by roadside paths (ROI 10.3), crossings (ROI 4.3), and post-crash prehospital care (ROI 1.6). Extending the impact of the intervention for post-crash prehospital care towards reduction in injury severity would improve the economic returns from the intervention [26].

Table 8: Return-on-investment Ratios (US$)

Coverage	5 years 80% scale	5 years 50% scale	30 years 80% scale	30 years 50% scale
Intervention	ROI	ROI	ROI	ROI
Speed bumps	43.2	39.6	39.2	41.7
Roadside paths	1.1	1.1	10.3	13.8
Crossings	0.6	0.5	4.3	4.5
Post-crash prehospital care	5.0	4.5	1.6	1.7
Alcohol breath testing	74.8	67.5	80.4	85.5
Total	**2.3**	**2.1**	**9.6**	**10.5**

As has been noted in the literature, ROIs are sensitive to the discount rate, the costing of interventions, assumptions regarding the magnitude of the impact, and the duration over which benefits are calculated [64], [65]. Our primary analysis assumes a 3 percent discount rate.

Scaling the alcohol breath testing intervention to 50 percent would provide slightly greater returns than scaling to 80 percent; still, it is important to note that a substantially higher number of potential lives could be saved – and injuries averted if the intervention reaches 80 percent coverage.

Summary

The economic cost of RTAs in Zambia is substantial, with an annual burden amounting to 4.7 percent of Zambia's GDP. Maintaining the status quo would result in over 7.8 million injuries and 115,000 deaths over the next 30 years. Scaling up the proposed interventions would result in considerable reductions in RTA injuries and deaths. By intervention, the greatest number of lives can be saved with an 80 percent scale-up of speed bump coverage (20,251 lives) over the next 30 years. Scaling up speed bumps will likewise prevent the greatest amount of anticipated economic costs incurred from road traffic RTAs. While breath-testing coverage is the best choice in terms of cost-effectiveness ratios (ROI 80.4 at 80 percent scale), it should be noted that the scale of impact is only half of what could be achieved in the same time frame from an investment in speed bumps (325,100 lives). The infrastructure-based interventions that target NMT users (paths and crossings) are the most expensive to implement, but they target road users with the highest burden (pedestrians and bicyclists) and the cost of implementation can be significantly reduced if interventions are included as part of ongoing or planned road construction projects [62], [63].

Limitations

Our estimates come with some limitations. The conservative nature of our estimation approach does not account for possible and substantial spillover effects from preventing RTAs for different age groups and by gender. Examples of these may include administrative cost savings for government agencies including law enforcement and sanitation, prevention of changes in household economics due to fatalities and injuries, and increased accessibility of urban environments. Data gaps including lack of data on the state of road infrastructure in Zambia and many LMICs are important limitations to the extent we can know the current and future role of infrastructural maintenance on RTAs. These are potential areas for future studies. We made an attempt to address some of these gaps and where national data were unavailable, we relied on best available estimates from jurisdictions similar to Zambia in terms of economic status. However, this approach may not adequately capture all aspects of the Zambian context.

Similarly, due to a lack of data, other costs associated with road traffic accidents were not included in the modelling and therefore the economic burden may be underestimated. For example, the model was not able to include the costs associated with damages to public infrastructure caused by road traffic accidents including repairs to vehicles, road infrastructure and property damage. The cost of emergency service responses, including police presence at the scene, road closures and vehicle recovery is also not included. Road traffic accidents can also result in administrative costs where claims are involved especially when disputes are brought to court. Whilst this would also contribute to the economic burden, methodological concerns prevent this from being included in these estimates. Finally, the economic costs of hosting funerals where road traffic accidents have resulted in fatalities is also not included due to insufficient data. As such, the conservative nature of the estimation approach should be recognized, noting that the economic burden may be underestimated as a result.

Conclusion and recommendations

By investing now in the five cost-effective road traffic safety measures modelled in the investment case, Zambia would not only reduce RTA injuries and fatalities, it would also reduce hardships among Zambians who would be less vulnerable to RTA related healthcare expenditures and disability. The investment case offers compelling and useful economic and social arguments to implement road traffic safety measures, improve population health, and grow the economy.

Based on the findings of the investment case, these key actions for Zambia are recommended to be pursued simultaneously:

Recommendations

1. **Strengthen intersectoral collaboration and coordination**
2. **Raise awareness and public support through education and campaigns**
3. **Invest in interventions to promote road safety, including the interventions modelled in the investment case**
4. **Improve research and data management systems**

1 Strengthen intersectoral collaboration and coordination

Zambia faces a high burden from road traffic accidents. Fortunately, road traffic injuries can be prevented, but this requires a multisectoral approach. To effectively improve road safety, Zambia should promote involvement from a range of sectors across government and society including health, transport, environment, education, police, communication, media, local governments and civil society amongst others. A national coordination mechanism (NCM) is an effective tool for mobilising a whole-of-government and whole-of-society response and promoting coordination across ministries, sectors and key stakeholders.

The establishment of an NCM, as called for in Zambia's 2017–2021 National Health in All Policies Strategic Framework to facilitate implementation of the Health in All Policies Framework and in the Investment Case for NCDs in Zambia, could also facilitate a whole-of-government approach to road safety. The NCM, once established, could serve as a key mechanism for the Government of Zambia to clarify roles and responsibilities of various sectors, strengthen policy coherence, and effectively cost, finance and operationalise strategies and programmes.

2 Raise awareness and public support through education and campaigns

Education initiatives and campaigns can help garner public support for road safety measures as well as improve public awareness and knowledge. Education initiatives and campaigns should be conducted both to inform policymakers, practitioners and the public on the importance of addressing RTAs, but also to increase awareness of risk factor and prevention measures and change behaviours and attitudes [22].

Zambia has made commendable progress by implementing several education and awareness raising initiatives to improve road safety. This includes Road Safety Sensitization at Schools, and media announcements on radio and print media as part of UN Road Safety Week [13].

According to Zambia's most recent Annual Crash Statistics, more than 87 percent of all accidents were due to human error, and the majority of human errors were made by drivers. The most frequently cited driver error was "failure to keep near the side [of the road]" followed closely by "excessive speed" [13]. Zambia can consider implementing additional education initiatives and campaigns on the dangers of failing to keep near the side of the road and excessive speed, as well as raising awareness of other key safety measures such as the importance of wearing seatbelts, child restrains and helmets. Zambia can also consider implementing awareness campaigns on the danger of drink driving alongside the modelled intervention on alcohol breath testing to drive compliance, ensuring that steps are taken to avoid any participation or conflicts of interest with the alcohol industry.

3 Invest in interventions to promote road safety, including the interventions modelled in the investment case

Zambia can reap significant economic benefits from scaling up the interventions modelled in this investment case: speed bumps, roadside pathways, road crossings, post-crash prehospital care, alcohol breath testing. By investing in road safety, Zambia can expect a return-on-investment of 9.6:1 over 30 years. As evidenced by the economic analysis, these interventions provide not only important health and societal benefits but also provide significant returns on investment.

Even though economic returns are important, it should not be the only consideration. While the intervention on post-crash care is more costly than the other preventive interventions, it has significant potential to save lives, averting more than 10,000 deaths (at 80 percent scale up, second only to speed bumps. Extending the impact of the intervention for post-crash prehospital care towards reduction in injury severity would improve the economic returns from the intervention [26]. Moreover, providing post-crash care is the right of all victims of road traffic incidents, and this is an effective and essential way to prevent road fatalities.

Moreover, by investing in safer roads Zambia will reap a broader range of benefits which are not modelled in this investment case. Zambia can expect to gain additional benefits through averted road traffic accidents which result in 'damages only' (not involving bodily harm), which account for 65 percent of RTAs in Zambia, however are not included in this analysis. Investing in road safety measures can also bring environmental benefits through a reduction in emissions, air pollution, and noise pollution. Measures can also improve noncommunicable diseases through promoting walking, cycling and other physical activity while also reducing air pollution [22]. Implementing road safety measures can also improve inclusivity and equality, as vulnerable groups are often disproportionally affected by poor transport environments. Investing in road safety will be key to achieving the ambitious goals set out in Zambia's *Non-Motorised Transport Strategy*, as well as helping to achieve broader development goals and the SDGs.

4 Improve research and data management systems

Reliable and up-to-date data on road traffic accidents, injuries and fatalities is crucial for monitoring trends, evaluating progress and tailoring prevention measures [22]. As such, Zambia would benefit from implementing measures to ensure there is robust research and data available on road traffic safety.

A study conducted in 2019 Monze General Hospital found that data collection on road traumas was poor, lacking key variables that would facilitate analysis of road trauma cases. The study also highlighted potential underreporting of accidents, a lack of a formal system linking data collection from police and hospitals and lack of a standardised road trauma surveillance system [66].

Zambia would benefit from implementing the following measures:

- Ensuring all data sources on road traffic accidents are linked including hospital, police, insurance and ambulance data
- Implementing a standardized road trauma surveillance system
- Implementing training for police and first responders to facilitate the accurate reporting of injury severity, cause of the crash, road user and vehicle type
- Conducting monitoring and evaluation of interventions to assess effectiveness
- Continuing the dissemination of key data to relevant stakeholders
- Utilizing new technologies to support data collection and analysis (where feasible)

This may also be aided by the roll out of the Accident Information System (AIS) as recommended in the RTSA report 2019 [13].

Improved research and surveillance will aid Zambia to increase understanding and knowledge of road traffic accidents and inform decision-making, including budgetary allocation.

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