Global, regional, and national burden of road injuries 1990–2023: a systematic analysis for the Global Burden of Disease Study 2023

*GBD 2023 Road Injuries Collaborators**

Lancet Public Health 2026; 11: e589–603

Published Online July 20, 2026 https://doi.org/10.1016/S2468-2667(26)00141-6

*Collaborators listed at the end of the Article

Correspondence to: Dr Marie Ng, NUS-IHME Global Burden of Disease Research Centre, National University of Singapore, Singapore **marieng@nus.edu.sg**

Summary

Background Road injuries are a leading cause of mortality and morbidity worldwide. Years of international efforts have aimed to strengthen policy engagement, including the 2020 UN General Assembly's proclamation of the Second Decade of Action for Road Safety (2021–30), targeting a 50% reduction in road traffic deaths and serious injuries by 2030. The aim of this study is to provide estimates to monitor progress and identify intervention gaps.

Methods As part of the Global Burden of Diseases, Injuries, and Risk Factors Study 2023, we estimated incidence, mortality, and morbidity of road injuries for 204 countries and territories from 1990 to 2023. Four road injury types and 47 nature-of-injury categories were examined. Morbidity and mortality data from clinical records, vital registration, and police reports were harmonised using meta-analytic techniques to ensure consistency and correct for systematic bias. Incidence was modelled with the meta-regression tool Disease Modelling-Meta-Regression version 2.1 and cause-specific mortality with the Cause of Death Ensemble model, both incorporating location-specific covariates to support interpolation. Years of life lived with disability (YLDs) were estimated from the prevalence and severity of the nature of road injury, and years of life lost (YLLs) from the number of cause-specific deaths multiplied by the standard life expectancy at the age of death. Disability-adjusted life-years (DALYs) were the sum of YLLs and YLDs. All metrics were calculated with 95% uncertainty intervals (UIs).

Findings In 2023, there were 50·9 million (95% UI 46·1–56·1) road injury incident cases, 1·34 million (1·04–1·58) deaths, and 75·3 million (59·8–89·2) DALYs globally. Road injuries were the leading global cause of death among males aged 10–39 years. Between 1990 and 2023, age-standardised incidence decreased by 38·3% (95% UI 36·9–39·7) and mortality decreased by 32·3% (6·1–49·0), but progress varied widely by World Bank income group. Mortality in low-income countries (43·8 [95% UI 31·7–56·0] deaths per 100 000 population) was approximately six times higher than in high-income countries (7·5 [7·1–7·9] deaths per 100 000), despite the high-income countries showing the highest age-standardised incidence rates (858·1 [95% UI 781·9–947·1] cases per 100 000). In the past decade, many countries achieved notable reductions in road injuries, but others, including Ghana and the USA, saw increases. More severe injuries tended to occur in low-income and middle-income countries.

Interpretation Although global incidence, mortality, and DALY rates from road injuries have declined, progress remains uneven, with pronounced disparities across income groups reflecting systemic inadequacies in infrastructure, vehicle standards, enforcement, and post-crash care. Strengthening emergency response, improving road design, enforcing safety measures, and adapting policies to the evolving demographics remain essential.

Funding Gates Foundation.

Copyright © 2026 The Author(s). Published by Elsevier Ltd. This is an Open Access article under the CC BY 4.0 license.

Introduction

Road injuries are a long-standing public health issue.[1,2] In the past two decades, numerous global initiatives have sought to bring road injuries into public health focus.[3] WHO released its first global strategy for road injury prevention in 2001,[4] followed by the UN General Assembly's inaugural road safety resolution in 2003[5] and the creation of the UN Road Safety Collaboration in 2004. Dedicated sources of financing were established, including the Global Road Safety Facility fund in 2006[6] and the UN Road Safety Fund in 2018. Private philanthropy has complemented these multilateral efforts, such as Bloomberg Philanthropies, who have invested more than US$865 million in road safety since 2007.[7] Following the UN's Decade of Action for Road Safety (2011–20)[8] and guided by the Stockholm Declaration,[9] the Second Decade of Action commenced in 2021 with an ambitious target of halving road traffic deaths and injuries by 2030.[10] Despite these global initiatives, investment and policy implementation lag behind what the target requires.[2,11]

A key barrier to progress is the persistent paucity of reliable data.[12] To raise awareness, monitor progress, and inform policy development, this study presents the most

Research in context

Evidence before this study

The Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2017 was the last comprehensive and globally comparable assessment of global morbidity and mortality from road injuries. To identify subsequent evidence, we restricted our search to studies published after 2017. We conducted a review of English-language articles in PubMed from Jan 1, 2017, to Dec 1, 2025, using search terms on road injuries and burden estimates (appendix 1 p 3). We included studies reporting road injury incidence, mortality, morbidity, or disability-adjusted life-years (DALYs), and excluded articles focused solely on clinical management, rehabilitation, or non-road-related injuries. We also reviewed key global sources, including WHO road safety reports and World Bank reports. The WHO Global Status Report on Road Safety (GSRRS), tracking road safety progress across more than 190 countries, estimated 1·19 million road injury deaths in 2021 in its most recent 2023 edition. The report also highlighted that road injury deaths remain the leading cause of mortality in children and young people aged 5–29 years, with 90% of all traffic deaths occurring in low-income and middle-income countries. However, the GSRRS provides only mortality estimates, without quantifying non-fatal outcomes such as years lived with disability (YLDs) or DALYs, and its most recent data extend only to 2021. Other published literature was limited to specific countries or regions, focused on particular age groups or road users, or offered only cross-sectional snapshots rather than long-term, standardised trend estimates.

See Online for appendix 1

Added value of this study

This study addresses key gaps in the existing evidence by providing the most up-to-date and comparable estimates of road injury incidence, mortality, and disability using data up to 2023 on the global, regional, and national levels. Using data from a broad range of sources, including hospital and emergency department records, vital registration and verbal autopsy data, censuses, surveys, and police records, we generated internally consistent estimates of road injury mortality, incidence, and disability by age, sex, location, and calendar year. The estimation framework accounts for under-reporting and misclassification and propagates uncertainty across all inputs. Unlike previous global assessments, this study systematically disaggregates road injuries by detailed road user categories resulting from nature-of-injury profiles, enabling comprehensive quantification of both fatal and non-fatal health loss. By generating burden estimates (years of life lost, YLDs, and DALYs) within a unified framework, this work enables direct comparison of road injury burden across populations, over time, and relative to other causes of health loss.

Implications of all the available evidence

Road injuries remain a major, preventable cause of premature death and disability. While international commitments, including the UN's Sustainable Development Goals and Second Decade of Action for Road Safety, signal ambition and seek to reinvigorate political will, meaningful progress demands concrete steps that galvanise cross-sector cooperation and secure sustained investment to support continuous, operational efforts.

recent findings on road injuries from the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) 2023, a comprehensive epidemiological study that produces internally consistent and comparable estimates for 375 diseases and injuries and 88 modifiable risk factors for 204 countries and territories.[13,14] We examine estimates of incidence, mortality, years of life lost (YLLs), years of life lived with disability (YLDs), and disability-adjusted life-years (DALYs) from 1990 to 2023 by country, by 21 GBD regions, and by four World Bank income groups.[13,14] Estimates are disaggregated by sex, age, nature of injury, and five specific road user types: motor vehicle occupants, motorcyclists, cyclists, pedestrians, and other road users. This report was produced as part of the GBD Collaborator Network and in accordance with the GBD Protocol.

Methods

Case definitions

Road injuries in GBD are defined as death or disability due to an unintentional interaction with an automobile, motorcycle, pedal cycle, or other vehicle. In the GBD four-level cause hierarchy, which orders causes from broad groupings to increasingly specific ones, road injuries are one of 176 Level 3 causes (other examples include falls and interpersonal violence) and are further disaggregated into five mutually exclusive Level 4 causes by road user types: motor vehicle road injuries, motorcyclist road injuries, bicycle road injuries, pedestrian road injuries, and other road injuries (eg, animal riders, occupants of animal-drawn vehicles, and tram occupants).[13,14] Intentional road injuries (eg, self-harm or assault) or other transport injuries (eg, aeroplane, train, and boat injuries) are excluded.

The nature of injury, referring to the specific bodily harm sustained, was also examined. GBD includes 47 nature-of-injury categories, grouped into seven broader classes: amputations, burns, fractures, head injuries, spinal injuries, minor injuries, and other injuries. Each cause of injury is mapped to a single nature-of-injury category; when multiple injuries are recorded for the same case, the category associated with the highest burden is selected.[13]

Data sources

Road injury morbidity was estimated using data from hospital inpatient records, emergency departments, outpatient encounters, and population-representative surveys.[13] To exclude clinically insignificant injuries (eg, scrapes), cases were restricted to injuries that

required some form of health care in a system with full health-care access.[13] Clinical data sources were mapped to road injury causes using ICD-9 and ICD-10 codes (appendix 1 p 4). Injuries that would have required care but were not treated due to financial or geographical barriers were accounted for by survey data.[13] Road injury mortality was estimated using data from vital registrations, verbal autopsies, mortality surveillance, censuses, surveys, and police records.[14]

Road injury incidence

Road injury incidence was estimated using Disease Modelling-Meta-Regression version 2.1 (DisMod-MR 2.1),[15] a Bayesian meta-regression tool to synthesise epidemiological data within a compartmental disease model while ensuring internal consistency across incidence, prevalence, remission, and mortality.[13] Input data were adjusted using standard GBD methods, to account for underascertainment, variation in care-seeking, and systematic differences in case definitions across data sources.[13,16] Country-level covariates included in the DisMod-MR 2.1 models were the age-standardised summary exposure value and vehicles per capita. Incidence estimated with DisMod-MR 2.1 corresponded to road injuries requiring inpatient care. The number of outpatient cases was derived by estimating the ratio of inpatient to outpatient cases using meta-regression—Bayesian, regularised, trimmed. Further methodological details are given in the GBD 2023 capstone appendices.[13]

Road injury mortality

Cause-specific mortality from road injuries was estimated using the Cause of Death Ensemble model (CODEm), an ensemble framework that evaluates multiple model classes and covariate sets and combines the best-performing models into a weighted ensemble.[14,17] All cause-of-death input data underwent standard GBD processing, including the redistribution of ill-defined causes of death. In settings with sparse or no direct mortality data, CODEm generates estimates by drawing on covariates and the hierarchical mixed-effects structure of its component models, allowing information to be borrowed across countries and regions.[17] Location-level covariates varied by road injury type and included, among others, the Socio-demographic Index,[18] the Healthcare Access and Quality Index,[19] and the proportion of two-wheeled vehicles. Further details are available in the GBD capstone appendices.[14,20]

Calculation of YLDs, YLLs, and DALYs

YLDs were estimated by multiplying the prevalence of each nature-of-injury sequela by its corresponding disability weight.[13] Because injury-related disability is determined by the nature of bodily harm rather than the external cause alone, incidence estimates were first mapped to nature-of-injury categories, informed by cause–nature distributions derived from clinical data sources that report both the cause and nature of injury.[13] Prevalence by nature of injury was then derived by multiplying these incidence estimates by nature-specific and severity-specific duration estimates for short-term sequelae, with an estimated proportion of cases progressing to long-term (permanent) health loss. Disability weights, ranging from 0 (full health) to 1 (equivalent to death), were assigned according to the injury nature and severity, with separate weights for short-term and long-term sequelae, and, where relevant, for treated and untreated cases.[13]

YLLs were calculated by multiplying the number of cause-specific deaths in each age-sex-location-year stratum by the standard life expectancy at the age of death.[14,18] DALYs were calculated as the sum of YLDs and YLLs. Further details are available in previous publications.[13,14,20]

For all estimates, the mean was calculated across 250 draws from the posterior distribution, and 95% uncertainty intervals (UIs) were derived from the 0·025 and 0·975 percentile values across these draws.[13,14] Age-standardised rates were computed using the GBD standard population to enable comparisons across settings with different demographic structures.[18] Data visualisations were done with Python (version 3.11.9). This study adheres to GATHER (appendix 1 p 5).

Role of the funding source

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or the writing of the report.

Results

In 2023, there were an estimated 50·9 million (95% UI 46·1–56·1) road injury incident cases globally, corresponding to an age-standardised incidence rate of 623·0 (95% UI 566·9–686·8) cases per 100 000 population (table 1; appendix 1 pp 7–9). In the World Bank income groups, the lowest incidence rate was observed in the lower-middle-income group (446·4 [405·3–491·1] cases per 100 000), while the highest age-standardised incidence rate was seen in the high-income group (858·1 [781·9–947·1] cases per 100 000; table 1; appendix 1 pp 7–9). Between 1990 and 2023, the global age-standardised road injury incidence declined by 38·3% (95% UI 36·9–39·7), with reductions observed across all income groups, ranging from decreases of 14·7% (12·8–16·6) in the lower-middle-income group to 49·0% (47·8–50·1) in the high-income group (appendix 1 pp 7–9, 34). Decreases in incidence were estimated in 179 of 204 countries and territories, while ten had increases in incidence (appendix 1 pp 10–12, 35).

Of Level 4 causes of road injuries, motor vehicle injuries accounted for the largest share of road injury cases globally (19·8 million [95% UI 17·5–22·6] cases, 38·8% of the global total) in 2023, followed by pedestrian (11·6 million [10·0–13·4] cases, 22·7%), cyclist (10·1 million [8·40–12·1]

	Incidence		Mortality	
	Age-standardised incidence rate (per 100 000), 2023	Percentage change in age-standardised incidence rate, 1990–2023	Age-standardised mortality rate (per 100 000), 2023	Percentage change in age-standardised mortality rate, 1990–2023
Road injuries				
Global	623·0 (566·9–686·8)	−38·3% (−39·7 to −36·9)	16·1 (12·5–19·0)	−32·3% (−49·0 to −6·1)
Low income	558·7 (525·8–595·3)	−25·6% (−27·4 to −23·9)	43·8 (31·7–56·0)	16·2% (−21·9 to 85·7)
Lower-middle income	446·4 (405·3–491·1)	−14·7% (−16·6 to −12·8)	19·1 (13·2–24·3)	−0·7% (−29·2 to 44·1)
Upper-middle income	751·3 (672·6–836·0)	−29·1% (−31·7 to −26·8)	13·2 (10·9–15·3)	−54·5% (−66·6 to −26·0)
High income	858·1 (781·9–947·1)	−49·0% (−50·1 to −47·8)	7·5 (7·1–7·9)	−61·1% (−62·7 to −58·5)
Motor vehicles				
Global	244·1 (216·1–279·0)	−42·3% (−44·0 to −41·0)	6·3 (5·0–7·9)	−26·4% (−48·9 to 7·2)
Low income	271·5 (252·0–294·8)	−30·2% (−32·5 to −28·1)	19·6 (13·3–27·3)	7·6% (−30·5 to 72·5)
Lower-middle income	171·9 (153·3–194·6)	−22·5% (−24·6 to −20·2)	6·2 (4·5–8·5)	−15·9% (−43·4 to 33·6)
Upper-middle income	234·4 (202·7–272·9)	−31·5% (−34·9 to −28·5)	4·8 (3·8–5·8)	−37·0% (−66·1 to 3·0)
High income	453·8 (400·0–521·7)	−48·3% (−49·6 to −46·9)	4·5 (4·2–4·7)	−54·9% (−58·1 to −51·5)
Motorcyclists				
Global	81·6 (69·3–96·2)	−16·0% (−18·6 to −12·5)	3·8 (2·6–5·0)	38·2% (−27·4 to 146·6)
Low income	39·0 (33·5–44·7)	−4·6% (−7·4 to −1·5)	4·5 (2·7–6·8)	106·5% (−10·0 to 381·5)
Lower-middle income	71·1 (60·8–83·7)	13·3% (10·4 to 17·4)	5·4 (3·0–7·5)	81·7% (−8·1 to 242·4)
Upper-middle income	107·0 (90·5–126·1)	−6·0% (−10·4 to −1·1)	3·6 (2·8–4·4)	9·6% (−46·8 to 107·6)
High income	80·7 (67·3–97·2)	−38·5% (−41·0 to −35·9)	1·1 (1·0–1·2)	−44·1% (−52·4 to −36·4)
Cyclists				
Global	122·8 (103·0–149·3)	−30·9% (−33·3 to −28·6)	1·0 (0·7–1·5)	8·4% (−50·1 to 98·3)
Low income	64·0 (54·3–77·1)	−17·9% (−20·7 to −15·1)	1·9 (1·0–3·6)	64·5% (−36·5 to 331·5)
Lower-middle income	78·9 (65·4–96·1)	−3·6% (−7·3 to 0·4)	1·2 (0·6–2·0)	54·1% (−36·1 to 233·0)
Upper-middle income	161·0 (134·6–195·1)	−15·7% (−19·9 to −11·5)	1·1 (0·7–1·5)	−6·2% (−68·5 to 105·8)
High income	183·8 (149·9–225·4)	−43·0% (−45·0 to −40·8)	0·3 (0·3–0·3)	−56·0% (−61·1 to −50·4)
Pedestrians				
Global	137·3 (119·1–159·1)	−45·0% (−46·9 to −43·0)	4·8 (3·5–6·4)	−57·7% (−71·9 to −35·0)
Low income	148·1 (133·5–162·1)	−23·8% (−26·0 to −21·7)	17·2 (11·1–24·8)	9·1% (−35·8 to 104·9)
Lower-middle income	96·0 (84·0–110·0)	−19·2% (−22·0 to −16·6)	6·1 (3·9–8·7)	−23·3% (−55·2 to 33·7)
Upper-middle income	198·2 (168·6–232·0)	−39·5% (−42·4 to −36·9)	3·5 (2·8–4·5)	−78·8% (−85·6 to −61·0)
High income	107·8 (91·1–125·0)	−63·5% (−65·1 to −62·0)	1·6 (1·4–1·7)	−76·0% (−78·6 to −72·7)
Others				
Global	37·1 (28·2–46·1)	−39·1% (−42·4 to −35·4)	0·2 (0·1–0·3)	−17·7% (−65·1 to 69·8)
Low income	36·1 (27·1–44·3)	−25·7% (−29·3 to −21·7)	0·5 (0·2–0·7)	73·2% (−37·3 to 432·0)
Lower-middle income	28·5 (21·6–35·7)	−24·9% (−28·7 to −21·5)	0·2 (0·1–0·4)	18·5% (−58·7 to 239·5)
Upper-middle income	50·8 (38·9–62·8)	−40·6% (−44·5 to −35·6)	0·2 (0·1–0·2)	−45·4% (−76·5 to 8·7)
High income	32·1 (23·2–41·6)	−42·1% (−45·2 to −38·8)	0·0 (0·0–0·1)	−63·8% (−70·8 to −56·5)

Data in parentheses are 95% uncertainty intervals. Negative percentage values indicate declines in age-standardised rates. Uncertainty intervals crossing zero indicate statistical uncertainty about the direction of change.

Table 1: **Age-standardised road injury incidence and mortality rates in 2023, and their percentage change from 1990 to 2023 globally, by World Bank income groups, and by road user type**

cases, 19·8%), and motorcyclist (6·70 million [5·71–7·91] cases, 13·2%) injuries (appendix 1 pp 13, 36). In the high-income group, cyclist injuries accounted for 20·9% (2·38 million [1·99–2·80] cases) of all road injuries, making them the second-largest Level 4 cause. At the regional level, cyclist road injuries surpassed motor vehicle injuries to constitute the largest contributor to road injuries in high-income Asia Pacific, while in tropical Latin America, motorcyclist injuries exceeded those from motor vehicles (appendix 1 p 36). Further regional and income-group patterns are in appendix 1 (p 36). From 1990 to 2023, age-standardised incidence rates decreased for all Level 4 road injury types globally (table 1; appendix 1 p 37). Consistent decreases were observed across income groups, except for motorcyclist road injuries in the lower-middle-income group (table 1; appendix 1 p 37). At the regional level, motorcyclist injuries showed marked heterogeneity, with decreases over this period in 11 regions

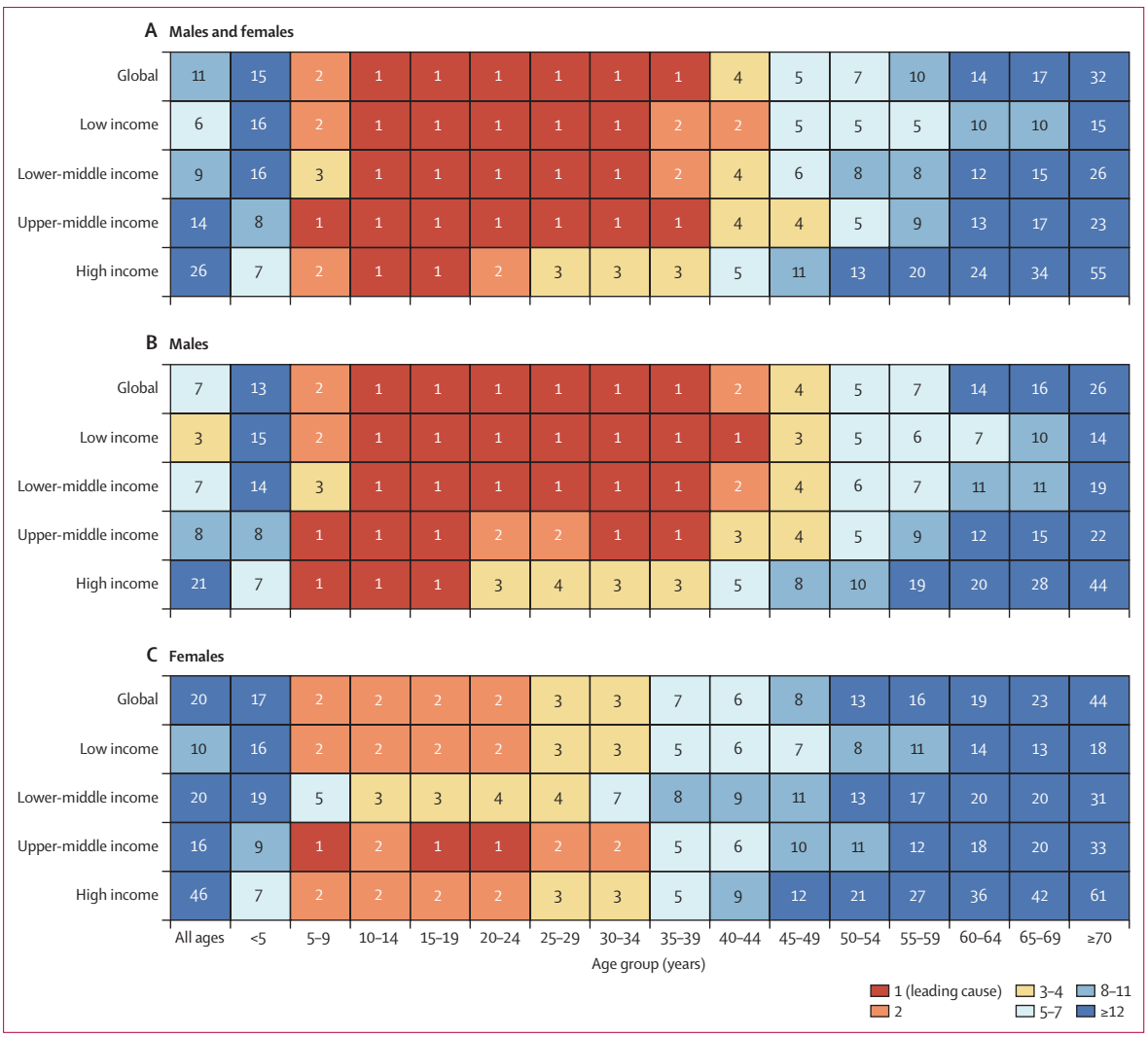


Figure 1: **Ranking of road injury deaths relative to all Level 3 causes of death, 2023**
(A) Data for males and females combined. (B) Ranking among males. (C) Ranking among females. The ranking is based on counts and is shown across age groups.

but increases in eight regions, particularly across Latin American regions (appendix 1 p 37).

There were an estimated 1·34 million (95% UI 1·04–1·58) deaths due to road injuries in 2023, corresponding to an age-standardised mortality rate of 16·1 (95% UI 12·5–19·0) deaths per 100 000 population (table 1; appendix 1 pp 14–16). Road injuries ranked 11th of all Level 3 causes of mortality globally (figure 1). More than 90% of global road injury deaths occurred in the low-income and middle-income groups (appendix 1 p 38). The high-income group had the lowest age-standardised mortality rate, estimated at 7·5 (7·1–7·9) deaths per 100 000, followed by the upper-middle-income (13·2 [10·9–15·3] deaths per 100 000) and lower-middle-income (19·1 [13·2–24·3] deaths per 100 000) groups (table 1; appendix 1 p 39). This pattern contrasted with age-standardised incidence rates, which were highest in the high-income group. The highest mortality rate was in the low-income group, at 43·8 (31·7–56·0) deaths per 100 000—almost six times higher than in the high-income group (table 1; appendix 1 p 39).

Between 1990 and 2023, the global age-standardised mortality from road injuries decreased by 32·3% (95% UI 6·1 to 49·0; table 1; appendix 1 p 39). Considerable reductions occurred in the high-income group (61·1% [58·5 to 62·7]) and the upper-middle-income group (54·5% [26·0 to 66·6]). The lower-middle-income and low-income groups had no detectable changes in age-standard mortality rates from 1990 to 2023 (table 1; appendix 1 pp 14–16, 39). Focusing on the period from 2010 to 2023, which coincides with the years of the UN Decades of Action for Road Safety, the change in global age-standardised mortality rates was –13·3% (–25·8 to 3·8). Significant reductions were observed in 80 countries and territories, 12 of which had decreases exceeding 50% (figure 2; appendix 1 pp 17–19). However,

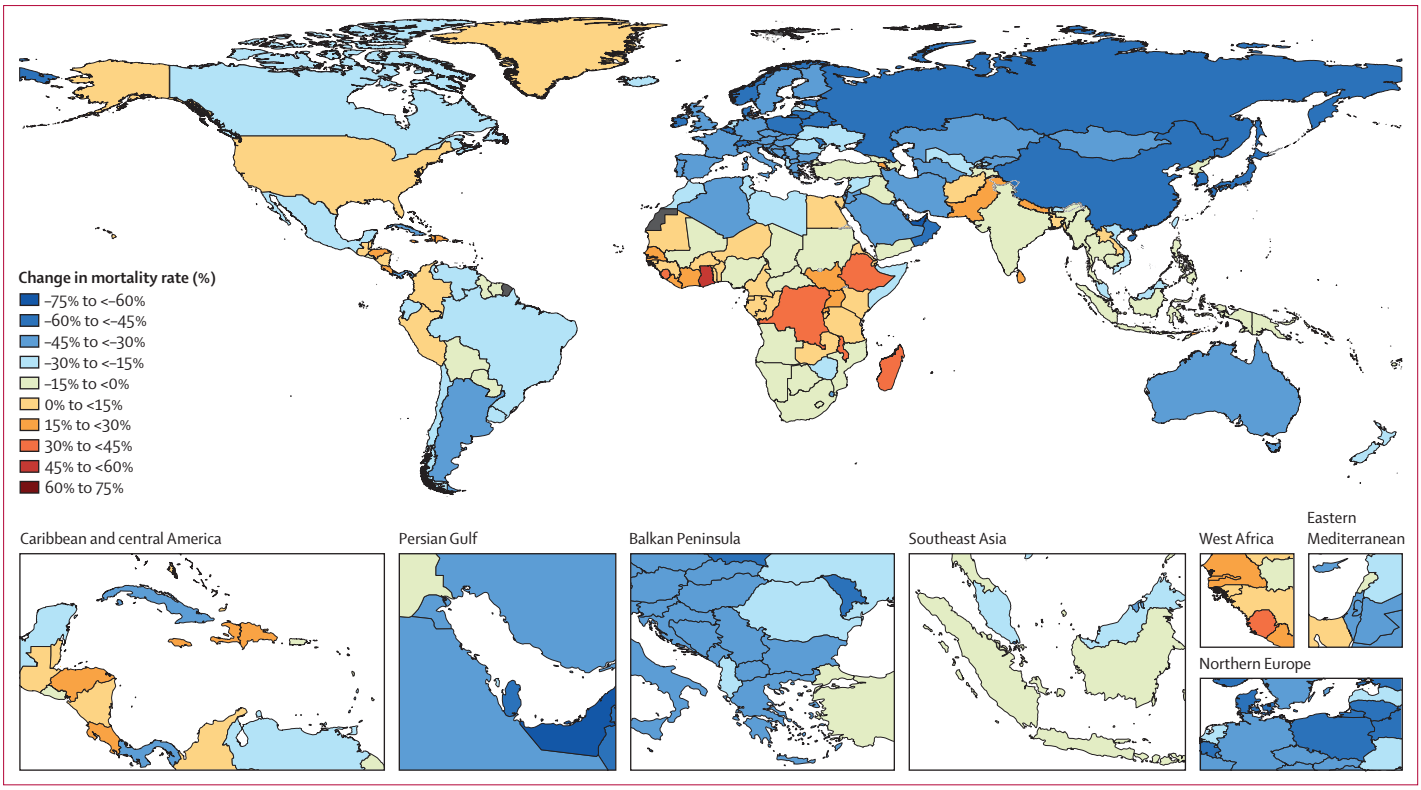


Figure 2: **Change in age-standardised mortality rates attributable to road injuries, 2010–23**

six countries had significant increases during this period, ranging from 13·2% (6·3 to 20·3) in the USA to 48·5% (8·3 to 107·5) in Ghana.

Motor vehicle road injuries accounted for the largest share of road injury deaths worldwide in 2023 (518 000 deaths [95% UI 417 000–648 000], 38·6% of the total), followed by pedestrian injuries (401 000 deaths [295 000–532 000], 29·9%; appendix 1 pp 13, 40). Although motorcyclists represented only 13·2% (6·70 million [5·71–7·91] cases) of road injury incidence, they accounted for 23·8% (319 000 deaths [217 000–416 000]) of road injury deaths. Although motor vehicle and cyclist road injury incidence rates were highest in high-income countries, the corresponding mortality rates were lowest (table 1).

Progress on addressing road injury mortality since 1990 has been uneven, with motorcyclist road injuries showing the most heterogeneous patterns, ranging from a decrease of 44·1% (95% UI 36·4 to 52·4) in the high-income group to a change of 106·5% (–10·0 to 381·5) in the low-income group (table 1; appendix 1 p 41). Despite decreases in age-standardised incidence rates, the trajectories of age-standardised mortality rates diverged between income groups for all road injury types, with the greatest reductions in the high-income group and no significant change in the low-income group (table 1).

Globally, road injuries resulted in 66·7 million (95% UI 51·5–79·4) YLLs and 8·56 million (6·25–11·2) YLDs, together accounting for 75·3 million (59·8–89·2) DALYs in 2023 (appendix 1 pp 20–28). Age-standardised YLL rates were nearly six times higher in the low-income group (2134·9 [95% UI 1546·6–2734·4] per 100 000) than in the high-income group (381·5 [362·7–401·3]) (appendix 1 pp 20–22, 42), whereas YLD rates showed a contrasting pattern, being highest in the high-income group (113·7 [82·9–152·5] per 100 000; appendix 1 pp 23–25, 43). The age-standardised DALY rate was 2229·4 (1637·2–2840·5) per 100 000 in the low-income group compared with 495·3 (457·4–541·8) per 100 000 in the high-income group (appendix 1 pp 26–28, 44). Large disparities in DALY rates were also seen at the country level (appendix 1 pp 29–31, 45). Between 1990 and 2023, global age-standardised YLL, YLD, and DALY rates all decreased significantly (appendix 1 pp 20–28), although reductions in YLL and DALY rates were confined to the high-income and upper-middle-income groups (appendix 1 p 46).

Road injury incidence rates were consistently higher in males than in females across all age groups in 2023, except among children younger than 5 years (figure 3). In males, incidence peaked in young adults aged 20–29 years, whereas in females, the highest rates were observed in young children (younger than 5 years). Age and sex patterns by road user type are shown in appendix 1 (p 47).

The greatest mortality burden was concentrated in people younger than 39 years (appendix 1 pp 48–49).

Road injuries were the leading Level 3 cause of death for individuals aged 10–39 years globally and the second leading cause of death in children aged 5–9 years (figure 1). In males aged 20–24 years, road injuries accounted for 20·7% (95% UI 15·6–24·9) of all deaths globally, corresponding to 98 000 (95% UI 71 600–121 000) deaths (appendix 1 pp 32, 48).

The most common nature of injury from road injuries was fractures, constituting 38·1% (95% UI 34·6–41·9) of all non-fatal road injury cases, corresponding to 19·4 million (95% UI 16·7–22·1) cases (table 2). Minor injuries ranked second, accounting for 35·3% (95% UI 31·2–39·1) of all non-fatal road injury cases, corresponding to 18·0 million (95% UI 15·5–20·7) cases. Head injuries occurred in 10·4% (95% UI 9·0–11·8) of road injury cases, corresponding to 5·27 million (95% UI 4·43–6·30) cases. Most head injuries were classified as moderate or severe traumatic brain injuries (appendix 1 p 50), representing 7·1% (95% UI 5·9–8·3) of all non-fatal road injury cases, corresponding to 3·62 million (95% UI 2·92–4·35) cases (table 2). Low-income, lower-middle-income, and upper-middle-income groups had a disproportionately high proportion of moderate or severe traumatic brain injuries, constituting more than 70% of head injuries (appendix 1 p 50). Motorcyclist road injuries had the highest proportion of head injuries of all road user types (13·9% [95% UI 11·3–16·6]), corresponding to 930 000 cases (95% UI 730 000–1 140 000), of which 78·9% (734 000 cases [95% UI 549 000–914 000]) were moderate or severe traumatic brain injuries (appendix 1 pp 33, 51). Of the total YLDs attributable to road injuries, fractures accounted for 47·2% (95% UI 42·8–51·1), corresponding to 4·05 million (95% UI 2·80–5·60) YLDs. Head injuries accounted for 21·3% (95% UI 17·8–24·8) of road injury YLDs, corresponding to 1·82 million (95% UI 1·27–2·46) YLDs, with moderate or severe traumatic brain injuries alone resulting in 1·58 million (1·10–2·12) YLDs (table 2).

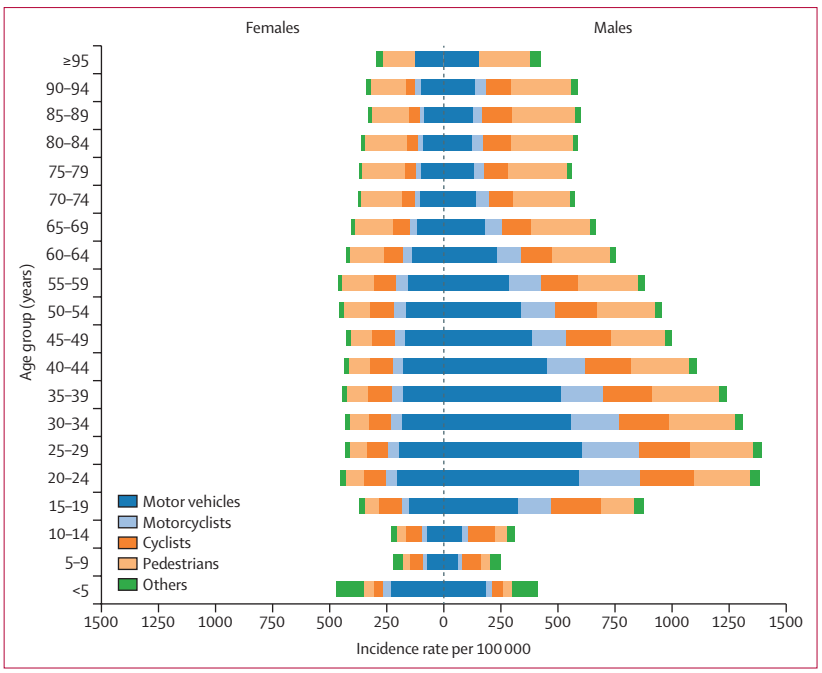


Figure 3: **Global road injury incidence rate stratified by sex, age group, and Level 4 road injury causes, 2023**

Discussion

This study provides a comprehensive global assessment of road injury burden from 1990 to 2023. With nearly 51 million incident cases, 1·34 million deaths, and over 75 million DALYs estimated in 2023, road injuries remain one of the leading causes of disease burden worldwide. Although global age-standardised incidence, mortality, and DALY rates have declined, progress varied by geography. Our findings align with the WHO Global Status Report on Road Safety 2023,[2] which estimated 1·19 million deaths globally in 2021. Although exact point estimates differ due to methodological divergence, both studies found a disproportionate mortality burden in low-income and middle-income countries (LMICs).[2] Overall, road injuries present a heterogeneous epidemiological landscape, where progress and stagnation stand in juxtaposition.

Global reductions in road injury incidence and mortality, driven largely by trends in the high-income group, reflect the importance of strengthened regulation, improved policy, heightened awareness, and post-crash and trauma care.[2] In high-income countries, the age-standardised incidence rate decreased by 49·0% and the mortality rate decreased by 61·1% from 1990 to 2023. These improvements have occurred alongside a shift in safety philosophy that reframes road safety as a public health issue rooted in preventable system failures rather than individual driver error.[21] The Vision Zero principle, which holds that no road death is acceptable or inevitable, exemplifies this shift and, since its introduction in Sweden in 1997,[22] has been adopted by many countries.[23] Closely related is the Safe System approach, premised on designing transport systems that accommodate human vulnerability and error, and endorsed by WHO and the UN for the Second Decade of Action for Road Safety 2021–30.[10] However, implementing these frameworks requires sustained political commitment, cross-sectoral coordination, and technical and infrastructural capacity;[23,24] prerequisites that can be difficult to realise in low-resource settings.

Profound inequity defines road injury burden, with 90% of deaths occurring in LMICs. The mortality rate in the low-income group was nearly six times higher than in the high-income group, more than three times higher than in the upper-middle-income group, and more than two times higher than in the lower-middle-income group. Despite the existence of international guidelines, progress in LMICs has been constrained by limited national capacity to operationalise them.[25] In many LMICs, rapid motorisation and urbanisation have outpaced the development of road safety measures,

leaving large proportions of road users exposed to high-risk environments.[26] Variations in regulatory standards illustrate these gaps: in 2022, 86% of high-income countries mandated seatbelts and seatbelt anchorages, compared with 26% of low-income countries.[2] This disparity is even more pronounced for advanced safety features such as front-impact and side-impact protection, which are mandated in less than 10% of LMICs compared with 76% of high-income countries.[2] Road infrastructure quality similarly lags, with most road length in low-income countries rated as unsafe.[27] These deficiencies are further compounded by underdeveloped post-crash response and data systems, hindering timely care and the ability to identify intervention priorities.[26,28,29]

The disparities in road safety standards across income groups coincide with an asymmetry in mortality–morbidity burden and differences in the nature of injuries. Road injuries resulted in high levels of premature mortality in LMICs, with age-standardised YLL rates three to six times higher in the low-income group than in the high-income group. By contrast, road injury burden in the high-income group manifested primarily in disability, reflected in higher YLD rates. Road injuries in low-income, lower-middle-income, and upper-middle-income groups were also more severe in nature; more than 70% of head injuries resulting from road injuries in these groups were moderate to severe traumatic brain injuries. These patterns are consistent with lower rates of helmet and seatbelt use, suboptimal speed regulation, delayed access to post-crash care, and the lack of essential trauma and surgical resources in LMICs.[2,26,30–32] However, it is important to acknowledge that some of the discrepancies in mortality and morbidity patterns observed across the income groups might also reflect how road injuries are ascertained in different contexts, particularly in LMICs, where under-reporting is pervasive.[12]

Addressing these challenges demands prioritising solutions that deliver the largest reductions in road injury mortality per unit of investment.[33] WHO-led

	Incidence		YLDs	
	Incident cases (thousands), 2023	Percentage of all road injury cases, 2023	YLDs (thousands), 2023	Percentage of all road injury YLDs, 2023
Fractures				
Global	19 400 (16 700–22 100)	38·1% (34·6–41·9)	4050 (2800–5600)	47·2% (42·8–51·1)
Low income	1370 (1210–1540)	38·0% (34·2–42·3)	187 (131–260)	42·1% (37·3–46·3)
Lower-middle income	5290 (4550–6040)	38·3% (34·7–42·6)	878 (608–1210)	43·7% (39·0–48·1)
Upper-middle income	8510 (7280–9830)	38·6% (35·0–42·9)	1840 (1260–2560)	46·7% (42·2–50·9)
High income	4200 (3630–4750)	36·9% (33·5–40·9)	1140 (789–1590)	52·4% (48·4–55·7)
Head injuries				
Global	5270 (4430–6300)	10·4% (9·0–11·8)	1820 (1270–2460)	21·3% (17·8–24·8)
Low income	354 (302–409)	9·8% (8·5–11·3)	85·6 (60·0–116)	19·3% (16·6–21·9)
Lower-middle income	1480 (1250–1760)	10·7% (9·2–12·2)	426 (297–578)	21·3% (18·2–24·6)
Upper-middle income	2500 (2080–3010)	11·3% (9·8–12·9)	981 (685–1320)	24·9% (20·7–29·2)
High income	940 (758–1150)	8·3% (6·9–9·9)	328 (225–441)	15·2% (12·6–17·7)
Moderate or severe traumatic brain injury				
Global	3620 (2920–4350)	7·1% (5·9–8·3)	1580 (1100–2120)	18·5% (15·3–21·8)
Low income	248 (206–290)	6·9% (5·7–8·1)	77·6 (54·5–105)	17·5% (14·9–20·1)
Lower-middle income	1070 (875–1280)	7·8% (6·5–9·1)	388 (271–526)	19·4% (16·5–22·5)
Upper-middle income	1860 (1500–2270)	8·4% (7·0–9·9)	892 (626–1200)	22·7% (18·7–26·8)
High income	427 (337–520)	3·8% (3·0–4·6)	218 (154–289)	10·1% (8·1–12·2)
Minor traumatic brain injury				
Global	1660 (1200–2270)	3·3% (2·4–4·4)	244 (168–334)	2·9% (2·5–3·3)
Low income	106 (74·4–147)	2·9% (2·1–4·1)	8·00 (5·46–11·1)	1·8% (1·6–2·1)
Lower-middle income	400 (286–549)	2·9% (2·1–4·0)	38·4 (26·1–52·9)	1·9% (1·7–2·2)
Upper-middle income	637 (453–878)	2·9% (2·1–3·9)	88·5 (59·7–121)	2·2% (1·9–2·6)
High income	513 (358–693)	4·5% (3·3–6·0)	109 (73·6–150)	5·0% (4·3–5·9)
Spinal injury				
Global	98·0 (68·1–137)	0·2% (0·1–0·3)	805 (576–1020)	9·5% (7·2–11·9)
Low income	5·03 (3·47–7·04)	0·1% (0·1–0·2)	32·9 (24·5–41·2)	7·5% (5·8–9·3)
Lower-middle income	21·7 (15·1–30·4)	0·2% (0·1–0·2)	154 (112–193)	7·8% (5·9–9·6)
Upper-middle income	38·5 (27·0–54·7)	0·2% (0·1–0·2)	318 (228–402)	8·2% (6·1–10·2)
High income	32·7 (22·7–45·3)	0·3% (0·2–0·4)	299 (213–386)	13·9% (10·3–17·8)

(Table 2 continues on next page)

	Incidence		YLDs	
	Incident cases (thousands), 2023	Percentage of all road injury cases, 2023	YLDs (thousands), 2023	Percentage of all road injury YLDs, 2023
(Continued from previous page)				
Other injuries				
Global	6970 (5840–8360)	13·7% (12·0–15·9)	762 (549–1020)	8·9% (7·9–10·1)
Low income	503 (434–588)	14·0% (12·1–16·3)	48·1 (33·7–65·3)	10·9% (9·3–12·7)
Lower-middle income	1930 (1600–2300)	14·0% (12·1–16·3)	197 (143–263)	9·8% (8·5–11·5)
Upper-middle income	3070 (2520–3760)	13·9% (12·1–16·3)	308 (222–417)	7·8% (6·9–9·0)
High income	1470 (1250–1750)	12·9% (11·3–15·0)	208 (148–279)	9·6% (8·7–10·6)
Amputations				
Global	675 (491–929)	1·3% (1·0–1·8)	572 (408–793)	6·7% (5·8–7·8)
Low income	52·2 (37·2–73·9)	1·5% (1·1–2·1)	40·5 (29·5–54·5)	9·1% (8·2–10·2)
Lower-middle income	200 (145–279)	1·4% (1·1–2·0)	174 (126–234)	8·7% (7·8–9·6)
Upper-middle income	321 (234–444)	1·5% (1·1–2·0)	275 (191–385)	7·0% (6·0–8·4)
High income	101 (69·1–145)	0·9% (0·6–1·3)	81·8 (52·8–124)	3·8% (3·0–4·8)
Burns				
Global	501 (302–751)	1·0% (0·6–1·5)	361 (268–466)	4·2% (3·9–4·6)
Low income	44·0 (25·6–66·5)	1·2% (0·7–1·9)	42·4 (31·1–54·0)	9·6% (8·5–10·9)
Lower-middle income	156 (93·0–231)	1·1% (0·7–1·7)	144 (105–182)	7·2% (6·5–8·0)
Upper-middle income	229 (141–336)	1·0% (0·6–1·5)	143 (106–193)	3·6% (3·3–4·1)
High income	71·2 (42·5–110)	0·6% (0·4–1·0)	31·8 (20·8–48·9)	1·5% (1·2–1·8)
Minor injuries				
Global	18 000 (15 500–20 700)	35·3% (31·2–39·1)	191 (91·0–366)	2·2% (1·2–3·8)
Low income	1280 (1100–1440)	35·4% (31·1–39·2)	6·63 (3·17–12·7)	1·5% (0·8–2·6)
Lower-middle income	4740 (4090–5470)	34·3% (30·1–38·1)	31·9 (15·0–60·7)	1·6% (0·8–2·7)
Upper-middle income	7380 (6280–8610)	33·5% (29·2–37·3)	71·9 (34·3–137)	1·8% (1·0–3·1)
High income	4560 (3970–5200)	40·1% (35·7–44·0)	80·1 (37·8–155)	3·7% (2·0–6·3)

Data in parentheses are 95% uncertainty intervals. Count data are presented to three significant figures. In the Global Burden of Diseases, Injuries, and Risk Factors Study framework, head injury corresponds to the traumatic brain injury category, which is disaggregated only into minor traumatic brain injury and moderate or severe traumatic brain injury. Non-traumatic brain injury head trauma is captured elsewhere: skull and facial fractures under the fractures categories, and superficial head lesions under open wounds and other injuries. YLDs=years of life lived with disability.

Table 2: **Nature-of-injury incident cases and YLDs attributable to road injuries, and the share of each nature-of-injury category in total road injury incidence and YLDs, globally and across World Bank income groups, 2023**

cost-effectiveness analyses have identified scalable, context-specific intervention packages for LMICs, ranging from speed management, random breath testing, and helmet enforcement in southeast Asia to a broader package including seatbelt enforcement in eastern sub-Saharan Africa.[34,35] Strengthening health-system capacity is equally crucial. Evidence suggests that more than 200 000 lives could be saved each year through enhanced trauma care coverage in LMICs.[30] Although policy priorities might differ by country, cross-setting analysis confirms that comprehensive strategies yield the greatest gains.[33] India's Zero Fatality Corridor initiative exemplifies the potential of multisectoral action; combining engineering, enforcement, and emergency response, it achieved a 43% reduction in mortality within 4 years and has since expanded to more than 100 national highways across India,[36] illustrating that meaningful progress is possible with targeted investment and multisectoral coordination.

For high-income countries, decreases in road injury burden are not assured; the USA had some of the largest increases in road injury mortality rates between 2010 and 2023. The increase, driven predominantly by pedestrian road injuries, has been associated with the uptake of larger vehicles and changes in road design.[37] In other high-income countries, changing transport patterns are redefining the distribution of road injury burden. Cyclist injuries have surpassed pedestrian injuries to become the second leading cause of road injury DALYs in several Nordic countries, whereas in high-income Asia Pacific countries such as Japan and Singapore, they now constitute the primary cause of road injury cases. A growing ageing population also necessitates an essential reassessment of infrastructure and technology, demanding inclusive and adaptable engineering that accommodates age-related needs.[38,39] Road safety strategies must evolve alongside shifting road user profiles and transport behaviour to sustain these hard-earned gains and further advance road injury reduction.

Beyond the human toll, the economic cost of road injuries is enormous, projected at $1·8 trillion between

2015 and 2030.[40] Yet, road safety remains underfunded. Within health-related official development assistance, less than 1% was directed to trauma care.[41] This chronic underfunding is further compounded by a broader contraction in official development assistance in recent years.[42] The World Bank estimated that a minimum of $200 billion of additional investment is required to meet the global road safety target of halving the number of global road injury deaths and injuries by 2030.[11] Recasting road safety as a core sustainability concern and positioning it squarely within the environmental, social, and governance agenda is essential for mobilising the scale of resources needed to achieve these goals.[43]

This study has several limitations. First, road injury data are not routinely captured across all countries or disaggregated by age-sex groups, and empirical data on non-fatal injuries and long-term disability are often sparse. In such cases, we relied on covariates and spatiotemporal models to interpolate missing information; uncertainty intervals are consequently wide for some locations and road user types and should be interpreted with caution, and some residual uncertainty remains, particularly in data-sparse settings. These data gaps highlight the importance of strengthening road injury surveillance systems. Second, GBD disability weights capture only the direct health consequences of injury and do not capture broader social, economic, and psychological effects, which remain important for policy considerations and rehabilitation planning. Third, GBD assigns a single nature-of-injury category per case, selecting the category associated with the greatest health loss; when multiple concurrent injuries occur, total morbidity burden might be underestimated, although this applies mainly to cases with substantial multimorbidity profiles. Fourth, subnational variations are not captured in this analysis; future work could explore subnational GBD estimates. Fifth, our analysis is descriptive and does not evaluate the causal effects of specific policies or interventions. Additionally, the impact of the COVID-19 pandemic must be considered when interpreting findings, as disrupted mobility patterns and constrained access to emergency care between 2020 and 2022 might have influenced observed trends independently of road safety policy.

As we approach the midpoint of the Second Decade of Action for Road Safety, global progress in reducing road injury burden has been marked by heterogeneity. Disparities in road injury outcomes expose deep inequities in political governance, technological capacity, and access to health care. Existing investments fall short of what is needed for meaningful progress. While cost-effective measures exist, realising them demands structural reform and long-term commitment.

GBD 2023 Road Injuries Collaborators

Stephanie C C van der Lubbe (co-first author), Madeline E Moberg (co-first author), Dominique Aluquin, Yawen Zhou, Hailey Lenox, Abdullah, Bhoomadevi A, Hasan Aalruz, Ukachukwu O Abaraogu, Zahra Abbasi Dolatabadi, Hedayat Abbastabar, Siddig Ibrahim Abdelwahab, Meriem Abdoun, Zinat Abdrakhmanova, Deldar Morad Abdulah, Auwal Abdullahi, Toufik Abdul-Rahman, Tesfaye Birhanu Abebe, Armita Abedi, Hansani Madushika Abeywickrama, Olumide Abiodun, Richard Gyan Aboagye, Abdullahi Tunde Aborode, Nagah M Abourashed, Mohamed Abouzid, Teklebirhan Abrha Abrha, Dariush Abtahi, Fuad Hamdi A Abuadas, Aminu Kende Abubakar, Rana Kamal Abu-Farha, Ahmad Y Abuhelwa, Hana J Abukhadijah, Niveen ME Abu-Rmeileh, Dina Abushanab, Apurba Acharya, Kiran Acharya, Aishah Fadila Adamu, Isaac Yeboah Addo, Tajudeen Adesanmi Adebisi, Babatope Oluwadamilare Adebiyi, Kamoru Ademola Adedokun, Victor Adekanmbi, Olumide Thomas Adeleke, Adekola George Adepoju, Miracle Ayomikun Adesina, Prince Owusu Adoma, Obed Adonteng-Kissi, Clifford Afoakwah, Aanuoluwapo Adeyimika Afolabi, Ebenezer Afrifa-Yamoah, Aiman P Afsar, Mahnaz Afshari, Saira Afzal, Vijay K Aggarwal, Mahdi Aghaalikhani, Salome Wumpini Agordoh, Shreyash Agrawal, Williams Agyemang-Duah, Abdul Momin Rizwan Ahmad, Aqeel Ahmad, Danish Ahmad, Khabir Ahmad, Muayyad M Ahmad, Sajjad Ahmad, Tauseef Ahmad, Ali Ahmadi, Ali Ahmed, Ayman Ahmed, Haroon Ahmed, Mehrunnisha Sharif Ahmed, Mohamed Sherif Ali Ahmed, Muktar Beshir Ahmed, Shabbir Ahmed, Dolapo Emmanuel Ajala, Marjan Ajami, Neda Akhoundi, Salah Al Awaidy, Syed Mahfuz Al Hasan, Mohammad Ahmmad Mahmoud Al Zoubi, Sami Saleh Alabdulwahab, Khurshid Alam, Mohammad Khursheed Alam, Mohammed Fasihul Alam, Mostafa Alam, Muath A Alammar, Fahad Mashhour Alanezi, Amani N. Alansari, Fahmi Y Al-Ashwal, Hussin Albargi, Mohammed Albashtawy, Shereen M Aleidi, Fadwa Naji Alhalaiqa, Amidu Alhassan, Ashraf Alhumaidi, Dari Alhuwail, Irfan Ali, Kamran Ali, Mohammad Shahid Ali, Mohammed Usman Ali, Sheikh Mohammad Alif, Samah W Al-Jabi, Moath Saleh Aljohani, Syed Mohamed Aljunid, Zaid I Alkhatib, Hazim Alkousheh, Sameer Abdulmalik Alkubati, Khaled S. Allemailem, Mohammed Z Allouh, Wesam Taher Almagharbeh, Sabah Al-Marwani, Ahmad Almatroudi, Joseph Uy Almazan, Khalid Almugheed, Mohmmad Minwer Alnaeem, Fahad Salman Alotibi, Mushtak Talib Salih Al-Ouqaili, Jaber S Alqahtani, Saeed Ali S Alqahtani, Ahmad Alrawashdeh, Intima Alrimawi, Sahel Majed Alrousan, Mohammed A Alsabri, Mohammed Amjed Alsaegh, Bandar Alsaif, Abdullah Alshami, Ali Salman Al-Shami, Abdalkarem Fedgash Alsharari, Zaid Altaany, Malik A Althobiani, Nelson Alvis-Guzman, Nelson J Alvis-Zakzuk, Yaser Mohammed Al-Worafi, Abdulmohsen Hamdan Al-Zalabani, Junaid Amin, Tarek Tawfik Amin, Saeed Amini, Kafayat Aminu, Anandhi Deva Amirtharaj, Ganiyu Adeniyi Amusa, David B Anderson, Abhishek Anil, A.H. Sruthi Anil Kumar, Aisha Ansari, Abebe Alemu Anshebo, Boluwatife Stephen Anuoluwa, Saeid Anvari, Jalal Arabloo, Jesil Mathew Aranjani, Aleksandr Y Aravkin, Demelash Areda, Benedetta Armocida, Anton A Artamonov, Francis Arthur-Holmes, Ashokan Arumugam, Mohammad Asghari-Jafarabadi, Mohammad Ashfaque, Tahira Ashraf, Muhammad Shahzad Aslam, Imad Asmar, Ömer Ataç, Mirbahador Athari, Seyyed Shamsadin Athari, Alok Atreya, Abadi Hailay Atsbaha, Julie Alaere Atta, Avinash Aujayeb, Leticia Avila-Burgos, Faseeh Bin Awais, Sana Javaid Awan, Seyyed HamidReza Ayatizadeh, Haleh Ayatollahi, Ahmad Ayed, Damilola Jeremiah Ayowole, AKM Azad, Arian Azadnia, Abrham W Azale, Alireza Azarboo, Tomasz Bączek, Andreea Corina Badache, Ashish D Badiye, Adewale Ismahil` Badru, Youngoh Bae, Nayereh Baghcheghi, Nasser Bagheri, Khlood K Baghlaf, Ruhai Bai, Atif Amin Baig, Lovenish Bains, Shankar M Bakkannavar, Yatan Pal Singh Balhara, Jose Balmori-de-la-Miyar, Khushbu Balsara, Ovidiu Constantin Baltatu, Samuel Alemu Bamboro, Juan S Barajas-Gamboa, Suzanne Lyn Barker-Collo, Amadou Barrow, Cornelia Anne Barth, Azadeh Bashiri, Rehana Basri, Mohammad-Mahdi Bastan, Abdul-Monim Batiha, Shazia Batool, Kavita Batra, Ravi Batra, Shahrzad Bazargan-Hejazi, PhD, Neeraj Bedi, Narasimha M Beeraka, Desalegn Weldebrhan Bekru, Suleiman Ayalew Belay, Asnake Gashaw Belayneh, Enku Shiferaw Belayneh, Bashir Bello, Salaheddine Bendak,

Samiun Nazrin Bente Kamal Tune, Aliyi Daba Benti, Alemshet Yirga Berhie, Mansi Sanjaykumar Bhadiyadra, Sonu Bhaskar, Arushee Bhatnagar, Sudip Bhattacharya, Jasvinder Singh Bhatti, Manpreet Singh Bhatti, Zulfiqar A Bhutta, Fengsai Bie, Corey B Bills, Abdulhakeem Binhambali, Paria Bolourinejad, Guilherme Borges, Dipan Bose, Samuel Adolf Bosoka, Alejandro Botero Carvajal, Souad Bouaoud, Soufiane Boufous, Dejana Braithwaite, Nicholas Allan Buckley, Tsion Samuel Bunare, Felix Busch, Yasser Bustanji, Senthilkumar C, Luis Alberto Cámera, Julio Cesar Campuzano Rincon, Zhong Cao, Angelo Capodici, Felix Carvalho, Ana Paula Carvalho-e-Silva, Joao Mauricio Castaldelli-Maia, Luca Cegolon, Ester Cerin, Sonia Cerrai, Sandip Chakraborty, Rama Mohan Chandika, Vijay Kumar Chattu, Anis Ahmad Chaudhary, Sirshendu Chaudhuri, Akashdeep Singh Chauhan, Akhilanand Chaurasia, Hana Chen, Patrick R Ching, Bryan Chong, Hitesh Chopra, Dinesh Kumar Choudhury, Jakir Ahmed Chowdhury, Mirza Farhana Iqbal Chowdhury, Steffan Wittrup McPhee Christensen, Isaac Sunday Chukwu, Eric Chung, Sunghyun Chung, Claudia Cosma, Stefania Curti, Omid Dadras, Hana Mahdi Dahir, Xiaochen Dai, Emanuele D'Amico, Lenards Obeng Damoah, Anh Kim Dang, Reza Darvishi Cheshmeh Soltani, Elham Davtalab Esmaeili, Bryan Gervais de Liyis, Ivan Delgado-Enciso, Andreas K Demetriades, Emina Dervišević, Aragaw Tesfaw Desale, Mitiku Desalegn, Vinoth Gnana Chellaiyan Devanbu, Devananda Devegowda, Arkadeep Dhali, Sreedhar Dharmagadda, Samath Dhamminda Dharmaratne, Bibha Dhungel, Adriana Dima, Mbekuveh Dinga-Nyoh, Vishal Diwan, Sushil Dohare, Jasmin Dönicke, Mario D'Oria, Fariba Dorostkar, Ojas Prakashbhai Doshi, Robert Kokou Dowou, Menayit Tamrat Dresse, Senbagam Duraisamy, Venkata Ravikanth Eddula, Yohannes Tekalegn Efa, Moaheda E H Eissa, Michael Ekholuenetale, Ibrahim Farahat El Bayoumy, Iman El Sayed, Mohamed Ahmed Eladl, Said El-Ashker, Iffat Elbarazi, Marwan El-Deyarbi, Hala Rashad Elhabashy, Muhammed Elhadi, Omar Abdelsadek Abdou Elmeligy, Ashraf A El-Metwally, Randa Elsheikh, Sharareh Eskandarieh, Adeniyi Francis Fagbamigbe, Ayesha Fahim, Ebenezer Gezahegn Fanta, Emerito Jose Aquino Faraon, Abdullah Farasani, Mohammad Fareed, Carla Sofia e Sá Farinha, Andre Faro, Syed Muhammad Yousaf Farooq, Nelsensius Klau Fauk, Mohammad Fayaz, Alireza Feizkhah, Ginenus Fekadu, Abdullah H Feroze, Nuno Ferreira, Aemon Berhane Fissha, Luisa S Flor, Behzad Foroutan, Matteo Foschi, Kayode Raphael Fowobaje, Richard Charles Franklin, Abdelrahman Gamil Gad, Muktar A Gadanya, Márió Gajdács, Balasubramanian Ganesh, Ezhilkugan Ganessane, Fernando Jr Barroga Garcia, Jacopo Garlasco, Zisis Gatzioufas, Ali Gerami Matin, Kalab Yigermal Gete, Mustafa Ghaderzadeh, Roya Ghafoury, Leila Ghalichi, Arin Ghamkhar, Ali Ghandili, Moein Ghasemi, Ahmad Ghashghaee, Sama Ghoba, Ali Gholamrezanezhad, Thinh Gia Gia Nguyen, Alem Abera Girmay, Alessandro Girombelli, Massimiliano Gobbo, Kimiya Gohari, Mahaveer Golechha, Pouya Goleij, Mohsen Golkar, Wei-Jie Gong, Shirisha Gooty, Shashikumar Channmgere Govindappa, Michal Grivna, Shi-Yang Guan, Giovanni Guarducci, Mohammed Ibrahim Mohialdeen Gubari, Damitha Asanga Gunawardane, Sapna Gupta, Pooja Gurnal, Reyna Alma Gutiérrez, Roberth Steven Gutiérrez-Murillo, Adrina Habibzadeh, Aryamawit Habteyesus, Shaymaa Hafedh Alkubaisy, Nguyen Hai Nam, Alazar Menbere Haile, Pritam Halder, Randah R Hamadeh, Fatimah Othman Hamarasool, Erin B Hamilton, Abdelrahman M Hamouda, Asif Hanif, Nasrin Hanifi, Mohd Anul Haq, Arief Hargono, Sara Harsini, Hamidreza Hasani, Reza Hashempour, Mohammad Hashem Hashempur, Nada Tawfig Hashim, Ibrahim Nagmeldin Hassan, Ikrama Hassan, Jeffrey J Hebert, Mohammad Heidari, Mojtaba Heydari, Matthew Hobbs, Ramesh Holla, Md Sabbir Hossain, Syed Billal Hossain, Mehdi Hosseinzadeh, Sorin Hostiuc, Junjie Huang, Ayesha Humayun, Waqar Husain, Salman Hussain, Segun Emmanuel Ibitoye, Aminu Alhassan Ibrahim, Fatma Magdi Ibrahim, Anel Ibrayeva, Olayinka Stephen Ilesanmi, Irena M Ilic, Milena D Ilic, Mustapha Immurana, Endang Indriasih, Danish Iqbal, Bilal Irfan, Lalu Muhammad Irham, Md Rabiul Islam, Md Mojahedul Islam, Md Shahinul Islam, Chidozie Declan Iwu, Oluyinka Ajibola Iyiola, Juan S Izquierdo-Condoy, Jaison Jacob, Louis Jacob, Kathryn H Jacobsen, Ali Jadidi, Mihajlo Jakovljevic, Reza Jalilzadeh Yengejeh, Jerin James, Roland Dominic G Jamora, Balamurugan Janakiraman, Rajiv Janardhanan, Saad Javed, Talha Jawaid, Sathish Kumar Jayapal, Ruwan Duminda Jayasinghe, Achala Upendra Jayatilleke, Seogsong Jeong, Bijay Mukesh Jeswani, Ravi Prakash Jha, Joseph Johnson, Jost B Jonas, Tamas Joo, Akaninyene Paul Joseph, Nitin Joseph, Bhawana Joshi, Krupal Joshi, Charity Ehimwenma Joshua, Thenmozhi K, Zubair Kabir, Dler Hussein Kadir, Bashir Kaka, Ashish Kumar Kakkar, Leila R Kalankesh, Khalil Kalavani, Rajesh Kamath, Ramat T Kamorudeen, Jiseung Kang, Kehinde Kazeem Kanmodi, Rami S Kantar, Neeti Kapoor, Sunil Kumar Kar, Mehrdad Karajizadeh, Ibraheem M Karaye, Arman Karimi Behnagh, Samad Karkhah, Mohmed Isaqali Karobari, Faizan Zaffar Kashoo, Nehemia I Kassa, Joonas H Kauppila, Neda Kaydi, Peter Njenga Keiyoro, Yousef Saleh Khader, Morteza Abdullatif Khafaie, Ajmal Khan, Hayat Ahmad Khan, Iqra Hamid Khan, Maseer Khan, Md Abdullah Saeed Khan, Muhammad Arslan Khan, Serab Khan, Sumaiya Khan, Uzma Rahim Khan, Yusuf Saleem Khan, Zahid Khan, Srijana Khanal, Sameer Uttamaro Khasbage, Haitham Khatatbeh, Moawiah Mohammad Khatatbeh, Kavin Khatri, Hamid Reza Khayat Kashani, Afshin Khazaei, Khalid A Kheirallah, Daniel Kheradmand, Mehdi Khezeli, Milad Khorasani, Samira Khoshvaght, Jagdish Khubchandani, P Ratan Khuman, Yun Jin Kim, Adnan Kisa, Marta A Kisiel, Abdul Basith KM, Shivakumar KM, Prakash Babu Kodali, Ali-Asghar Kolahi, Farzad Kompani, Hamid Reza Koohestani, Wolyu Erkano Korma, Tapos Kormoker, Ayan Hussien Korse, Arthi S Kozhumam, Kewal Krishan, Varun Krishna, Burcu Kucuk Bicer, Mohammed Kuddus, Mukhtar Kulimbet, Emmanuel Kumah, Chandan Kumar, Dewesh Kumar, Kamal Kumar, Nithin Kumar, Pawan Kumar, Pradeep Kumar, Prakash Kumar, Radha Kumar, Rakesh Kumar, Sandeep Kumar, Sumit Kumar, Tushar Kumar, Om P Kurmi, Asep Kusnali, Dian Kusuma, John Paul Kuwornu, Ville Kytö, Pallavi L C, Carlo La Vecchia, Muhammad Awwal Ladan, Lucie Laflamme, Chandrakant Lahariya, Timo Lajunen, Balzhan Lakanova, Tri Laksono, Tamás Lantos, Savita Lasrado, Mahrukh Latif, Paolo Lauriola, Caterina Ledda, Ka Yiu Lee, Munjae Lee, Seung Won Lee, Wei-Chen Lee, Yo Han Lee, Ja-Ho Leigh, Vasileios Leivaditis, Dawit Alemu Lemma, Ming-Chieh Li, Xiaopan Li, Yan Li, Zhengrui Li, Ambreen Liaqat, Xuefeng Liu, José Francisco López-Gil, Platon D Lopukhov, Surbala Devi Lourembam, Abhilash Ludhiadch, Angelina M Lutambi, Miltiadis D Lytras, Ellina Lytvyak, Zheng Feei Ma, Monika Machoy-Rakoczy, Firoozeh Madadi, Ahmed A Madfa, Hassan Magdy Abd El Razek, Mohammed Magdy Abd El Razek, Sasikumar Mahalingam, Samatar Abshir Mahamed, Preeti Maharjan, Nozad Hussein Mahmood, Azeem Majeed, Mostafa Majidnia, Igor Lima Maldonado, Deborah Carvalho Malta, Lokesh Manjani, Ramon Martinez-Piedra, J Jenifer Florence Mary, Roy Rillera Marzo, Sammer Marzouk, Sharareh Massahi, Yasith Mathangasinghe, Neeta Mathur, Khurshid A Mattoo, Steven M McPhail, Tesfahun Mekene Meto, Agezegn Asegid Mekonnen, Tesfaye Hambisa Mekonnen, Tadesse Belayneh Melkie, Osires de Medeiros Melo Neto, Walter Mendoza, Godfred Antony Menezes, Ritesh G Menezes, Emiru Ayalew Mengistie, Anusha Sultan Meo, Tuomo J Meretoja, Tomislav Mestrovic, Chamila Dinushi Kukulege Mettananda, Sachith Mettananda, Mohamed M M Metwally, Bartosz Miazgowski, Ted R Miller, Giuseppe Minervini, Long Chiau Ming, Prasanna Mithra, Chaitanya Mittal, Dhruti Modi, Lia Solomon Mogus, Mona Gamal Mohamed, Nouh Saad Mohamed, Khabab Abbasher Hussien Mohamed Ahmed, Taj Mohammad, Mokhtar Mohammadi, Abdollah Mohammadian-Hafshejani, Shafiu Mohammed, Mohammad Mohseni, Ali H Mokdad, Mohammad Ali Moni, Julio Cesar Montañez, Marie Chantel Montás, Rafael Silveira Moreira, Dimitrios Moris, Mahdis Morovvati, Shane Douglas Morrison, Mahmoud M Morsy, Md Shihab Mostafa, Rohith Motappa, Kimia Mozahheb Yousefi, Sumaira Mubarik, Shiv Kumar Mudgal, Jibran Sualeh Muhammad, Mubarak Muhammad, Sumoni Mukherjee, Francesk Mulita, Malaisamy Muniyandi,

Efren Murillo-Zamora, Satta Muthu Murugan, Balaganapathy Muruganantham, Abdisalam Hassan Muse, David Musoke, Sathish Muthu, Ayoub Nafei, Ganesh R Naik, Gopal Nambi, Vinay Nangia, Shumaila Nargus, Abdulqadir J Nashwan, Mahmoud Nassar, Zuhair S Natto, Javaid Nauman, Zakira Naureen, Samidi Nirasha Kumari Navaratna, Biswa Prakash Nayak, Kinjal Nayak, Iffat Nayila, Javad Nazari, G Takop Nchanji, Nini Asfaw Negash, Ionut Negoi, Samata Nepal, Cuong Tat Nguyen, Hien Thu Nguyen, Trang Nguyen, Taxiarchis Konstantinos Nikolouzakis, Ali Nikoobar, Peishan Ning, Dina Nur Anggraini Ningrum, Vikram Niranjan, Richmond Nketia, Shuhei Nomura, Chisom Adaobi Nri-Ezedi, Jean Claude Nshimiyimana, Chimezie Igwegbe Nzoputam, Ogochukwu Janet Nzoputam, Bogdan Oancea, Kwabena Obiri-Yeboah, Fabio Massimo Oddi, Ismail A Odetokun, Felix Akpojene Ogbo, Abiola Ogunkoya, Olusegun Olatunji Ojedoyin, Hassan Okati-Aliabad, Osaretin Christabel Okonji, Oluwaseyi Isaiah Olabisi, Andrew T Olagunju, Abdulhakeem Abayomi Olorukooba, Oluseye Olalekan Oludoye, Ahmed Omar Bali, Goran Latif Omer, Michal Ordak, Hans Orru, Esteban Ortiz-Prado, Augustus Osborne, Alaa Oteir, Adrian Otoiu, Amel Ouyahia, Mayowa O Owolabi, Tope Oyelade, Mahesh P A, Kevin Pacheco-Barrios, Jagadish Rao Padubidri, Ashok Pandey, Sanjib Raj Pandey, Seithikurippu R Pandi-Perumal, Georgios D Panos, Ilias Papadimopoulos, Evangelos Pappas, Shahina Pardhan, Chulwoo Park, Eun-Cheol Park, Pragnesh Parmar, Ava Pashaei, Maja Pasovic, Roberto Passera, Bhargav Umeshchandra Patel, Hemal M Patel, Kunal Nitinkumar Patel, Niki Rut Patel, Sangram Kishor Patel, Vipin Patidar, Shankargouda Patil, Mohamed Anas Patni, Dimitrios Patoulias, Uttam Paudel, Shrikant Pawar, Hamidreza Pazoki Toroudi, Arun Mitra Peddireddy, Amy E Peden, Jarmila Pekarcikova, Veincent Christian Filipino Pepito, Prince Peprah, Daniela A Perez-Chadid, Simone Perna, Anil K Philip, Julian David Pillay, Mapa M Prabhath N Piyasena, Shiny PJ, Evgenii Plotnikov, Roman V Polibin, Reza Pourbabaki, Farzad Pourghazi, Mohsen Poursadeqiyan, Naeimeh Pourtaheri, Sergio I Prada, Harsh Priya, Muhammad Usman Qamar, Xiang Qi, Mohammad Qodrati, Nuzul Qur'aniati, Basuki Rachmat, Venkatraman Radhakrishnan, Amir Rafe, Ibrar Rafique, Yashpal Singh Raghav, Pracheth Raghuveer, Sajjad Rahimi, Vafa Rahimi-Movaghar, Firman Suryadi Rahman, Fryad Majeed Rahman, Mohammad Hifz Ur Rahman, Mosiur Rahman, Muhammad Aziz Rahman, Amir Masoud Rahmani, Amita Rai, Pramila Rai, Sunil Kumar Raina, Judah Rajendran, Shaman Rajindrajith, Pushp Lata Rajpoot, Mahmoud Mohammed Ramadan, Majed Ramadan, Kadar Ramadhan, Shakthi Kumaran Ramasamy, Balaji Ramraj, Lokesh Rana, Nemanja Rancic, Asad Gul Rao, Kumuda Rao, Mithun Rao, Sowmya J Rao, Prateek Rastogi, Devarajan Rathish, Rashita Ravi, Salman Rawaf, Karthik Rayapureddi, Ateeq Rehman, Rainer Reile, Mina Rezaei, Nazila Rezaei, Mohsen Rezaeian, Moattar Raza Rizvi, Jefferson Antonio Buendia Rodriguez, Leonardo Roever, Ravi Rohilla, Chanapong Rojanaworarit, Moustaq Karim Khan Rony, Himanshu Sekhar Rout, Bedanta Roy, Polani Rubeshkumar, Devarajulu Reddy S, Manjula S, Aly M A Saad, Siamak Sabour, Fatemeh Sadeghi-Ghyassi, Mohammad Reza Saeb, Mohd Saeed, Umar Saeed, Mehdi Safari, Sher Zaman Safi, Amene Saghazadeh, Fatemeh Saheb Sharif-Askari, Narjes Saheb Sharif-Askari, Amirhossein Sahebkar, Vaibhav Sahni, Durgesh Prasad Sahoo, Zahra Saif, Morteza Saki, Joseph W Sakshaug, Payman Salamati, Afeez Abolarinwa Salami, Samreen Saleem, Sohrab Salimi, Jayami Eshana Samaranayake, Yoseph Leonardo Samodra, Vijaya Paul Samuel, Fasineh Shekuba Samura, Abdallah M Samy, Rama Krishna Sanjeev, Milena M Santric-Milicevic, Aswini Saravanan, Yaser Sarikhani, Mohammad Sarmadi, Sachin C Sarode, Michele Sassano, Mukesh Kumar Sathya Narayanan, Maheswar Satpathy, Jennifer Saulam, Ganesh Kumar Saya, Christophe Schinckus, David C Schwebel, John W Scott, Hamidreza Seifmanesh, Siddharthan Selvaraj, Mohammad H Semreen, Subramanian Senthilkumaran, Francesco Sessa, Yashendra Sethi, Ahmed Nabil Shaaban, Shipraa Arpan Shah, Sweni Shah, Shazlin Shaharudin, Amira A Shaheen, Samiah Shahid, Moyad Jamal Shahwan, Masood Ali Shaikh, Muhammad Aaqib Shamim, Amir Hossein Shams, Mehran Shams-Beyranvand, Alfiya Shamsutdinova, Dan Shan, Mohd Shanawaz, Amin Sharifan, Javad Sharifi Rad, Prof. Fariborz Sharifian Jazi, Bhoopesh Kumar Sharma, Bunty Sharma, Jyoti Sharma, Manoj Sharma, Ravi Kumar Sharma, Saurab Sharma, Vishal Sharma, Bereket Beyene Shashamo, Shamee Shastry, Ramzi Shawahna, Samrawit Shawel, Maryam Shayan, Ali Sheidaei, Nishat Ahmed Sheikh, Rahim Ali Sheikhi, Jiabin Shen, Samendra P Sherchan, Mahabalesh Shetty, Pavanchand Shetty, Premalatha K Shetty, Suraj S Shetty, Aminu Shittu, Nathan A Shlobin, Sina Shool, Seyed Afshin Shorofi, Kerem Shuval, Md. Kaoser Bin Siddique, Gustavo Correia Basto da Silva, Padam Prasad Simkhada, Akanksha Singh, Harmanjit Singh, Paramdeep Singh, Poornima Suryanath Singh, Surendra Singh, Surjit Singh, Natia Skhvitaridze, Valentin Yurievich Skryabin, Bogdan Socea, Md Salman Sohel, Solikhah Solikhah, Yizhe Song, Lokasani Vijaya Sree, Vignes Anand Srinivasalu, Muhammad Haroon Stanikzai, Paschalis Steiropoulos, Sebastian Straube, Chen-Yang Su, Omer Subasi, Vetriselvan Subramaniyan, Agus Sudaryanto, Nathan Suga, Thitiporn Sukaew, Surajo Kamilu Sulaiman, Mark J M Sullman, Jing Sun, Suraj Sundaragiri, Katharina S Sunnerhagen, Chandan Kumar Swain, Lukasz Szarpak, Sree Sudha T Y, Rafael Tabarés-Seisdedos, Seyyed Mohammad Tabatabaei, Celine Tabche, Ramin Tabibi, Moslem Taheri Soodejani, Iman M Talaat, Mircea Tampa, Ingan Ukur Tarigan, Mengistie Kassahun Tariku, Anika Tasnim, Aigul Yelgondiyevna Tazhiyeva, Nebyu Lakew Tefera, Emre Tel, Gebremaryam Temesgen, Mohamad-Hani Temsah, Reem Temsah, Azimeraw Arega Tesfu, Enoch Teye-Kwadjo, Dejina Thapa, Rekha Thapar, Ismaeel Tharwat, Jeevarathinam Thirumalai, Benson Thomas M, Harshal R Thube, Jansje Henny Vera Ticoalu, Madi Tleshev, Santo Imanuel Tonapa, Arole Darwin Touko, Marcos Roberto Tovani-Palone, Thang Huu Tran, Nguyen Tran Minh Duc, Domenico Trico, Mike Tuffour Amirikah, Lawrence Sena Tuglo, Munkhtuya Tumurkhuu, Ermias A Turuse, Biruk Shalmeno Tusa, Irfan Ullah, Saeed Ullah, Srikanth Umakanthan, Lawan Umar, Bhaskaran Unnikrishnan, Carolyn Anne Unsworth, Selamu Amanuel Untiso, Era Upadhyay, Sheela Upendra, Jibrin Sammani Usman, Rakesh V R, Asokan Govindaraj Vaithinathan, Pascual R Valdez, Tommi Juhani Vasankari, Narayanaswamy Venketasubramanian, Akshaya Kumar Verma, Massimiliano Veroux, Georgios-Ioannis Verras, Victor E Villalobos-Daniel, Tuan Vinh, Francesco S Violante, Vasily Vlassov, Yasir Waheed, Arvinder Wander, Wanzhou Wang, Wei Wang, Yanzhong Wang, Apichai Wattanapisit, Anthony Ike Wegbom, Fei-Long Wei, Andrea Werdecker, Taweewat Wiangkham, Dakshitha Praneeth Wickramasinghe, Faustine Williams, Andrew Awuah Wireko, Wanqing Xie, Patlolla Sriram Yadav, Vikas Yadav, Musa Yahaya, Saba Yahoo, Eesha Yaqoob, Sanni Yaya, Pengpeng Ye, Ali Cem Yekdeş, Siyan Yi, Arzu Yiğit, Vahit Yiğit, S Yogeshkumar, Dong Keon Yon, Naohiro Yonemoto, Mustafa Younis, Yong Yu, Siddhesh Zadey, Mubashir Zafar, Emilia Zainal Abidin, Dilmurat Zairov, Aurora Zanghì, Iman Zare, Michael Zastrozhin, Saad Zbiri, Mohammed G M Zeariya, Haijun Zhang, Yunquan Zhang, Zhi-Jiang Zhang, Claire Chenwen Zhong, Hao Zhou, Abzal Zhumagaliuly, Yossef Teshome Zikarg, Sa'ed H Zyoud, Shaher H Zyoud, Christopher J L Murray, Simon I Hay (co-senior author), Marie Ng (co-senior author), and Kanyin Liane Ong (co-senior author).

Affiliations
Please see appendix 2 (pp 7–32) for the affiliations for individual authors.

See Online for appendix 2

Contributors
Please see appendix 2 (pp 33–43) for more detailed information about individual author contributions to the research, divided into the following categories: providing data or critical feedback on data sources; developing methods or computational machinery; providing critical feedback on methods or results; drafting the manuscript or revising it critically for important intellectual content; and managing the estimation or publications process.

Declaration of interests

Saira Afzal reports support for the present manuscript from the Institute of Public Health Lahore (study material, manuscripts, medical writings, and library resources); grants or contracts from the Dean office, Institute of Public Health Lahore (intellectual contributions and time protection); honoraria for experts, lectures, visiting speakers, and educational seminars were provided by the Dean Institute of Public Health Lahore; support for attending meetings or travel was provided by the Dean Institute of Public Health, Lahore Pakistan; participation on a data safety monitoring board or advisory board as member of the Pakistan National Bioethics Committee, member of the Institutional Review Board of Fatima Jinnah Medical University, member of the Ethical Review Board and Data Monitoring Board of Institute of Public Health Lahore Pakistan, in charge of the Clinical Research Organization of King Edward Medical University, member of the Annals of King Edward Medical University Advisory Board; leadership or fiduciary role in other board, society, committee, or advocacy group, paid or unpaid, as a member of Pakistan Higher Education Commission Research Committee, member of Pakistan Medical and Dental Commission Research and Journals Committee, member of Pakistan National Bioethics Committee, member of Pakistan Society of Internal Medicine, member of Pakistan Association of Medical Editors, member of Medical Microbiology and Infectious Diseases Society, Fellow of Leads International, Fellow of Faculty of Public Health UK, Fellow of College of Physicians and Surgeons Pakistan; received computer software and equipment from Bergen University Norway for research writing; and other financial or non-financial interests as Dean of Public Health Institute of Public Health Birdwood Lahore, member of National Bioethics Committee Pakistan, and member of Prime Minister Taskforce on HCV, HIV, and Infectious Diseases, outside the submitted work. Muhammad Shahzad Aslam reports grants or contracts from the Xiamen University Malaysia Research Fund (XMUMRF) for grant number XMUMRF/2025-C15/ITCM/0006 ("Therapeutic and toxicity evaluation of selected medicinal herbs for NAFLD: exploring the inter-organelle contact sites modulation theory," co-investigator, January, 2025–December, 2027, ongoing), grant number XMUMRF/2023-C11/ISEM/0041 ("Children's rights education in the early years of divorce: an exploration of adolescents' perspectives," co-investigator, January, 2023–December, 2025, ongoing), and grant number XMUMRF/2026-C17/ITCM/0007 ("Olfactory stimulation and autonomic regulation in menstrual disorders," co-investigator, January, 2026–December, 2028, ongoing; all internal XMUMRF research grants administered by Xiamen University Malaysia; funds disbursed to institutional research account only; no salary, honoraria, or personal payments to author), outside the submitted work. Ruhai Bai reports support for the present manuscript from the Open Research Fund of Key Laboratory of Endocrine Glucose & Lipids Metabolism and Brain Aging, Ministry of Education (number 2023JYBZDSYS012). Ovidiu Constanin Baltatu reports support for the present manuscript from the National Council for Scientific and Technological Development Fellowship (CNPq, 304224/2022-7) and from Anima Institute; leadership or fiduciary role in other board, society, committee, or advocacy group, paid or unpaid, at VividiWise Analytics as managing partner and São José dos Campos Tech Park – CITE as biotech advisory board member, outside the submitted work. Sonu Bhaskar reports grants or contracts from the Japan Society for the Promotion of Science (JSPS), Japanese Ministry of Education, Culture, Sports, Science, and Technology (MEXT), Grant-in-Aid for Scientific Research (KAKENHI; grant ID: 23KF0126), and from JSPS and the Australian Academy of Science (JSPS International Fellowship, grant ID: P23712); payment or honoraria for lectures, presentations, speakers bureaus, manuscript writing, or educational events from the Japan Stroke Society, Japan (honoraria for invited keynote presentation at the 50th Annual Meeting of the Japan Stroke Society, Osaka) and from Semey Medical University, Kazakhstan (honorarium for invited professorship and teaching course in neurocardiovascular therapy, Semey Medical University, Kazakhstan); support for attending meetings or travel from the Japan Stroke Society, Japan (travel award for invited keynote presentation at the 50th Annual Meeting of the Japan Stroke Society, Osaka) and from Asialink, The University of Melbourne (travel support for opening invited keynote at 31st Asialink Leaders Foundation Week Program 2026, Melbourne); and leadership or fiduciary role in other board, society, committee, or advocacy group, paid or unpaid, as district chair, Diversity, Equity, Inclusion, and Belonging, Rotary District 9675, Sydney, Australia; chair, founding member, and manager, Global Health and Migration Hub Community, Global Health Hub Germany, Berlin, Germany; editorial board member, PLOS One, BMC Neurology, Frontiers in Neurology, Frontiers in Stroke, Frontiers in Public Health, Journal of Aging Research, Diagnostics, and BMC Medical Research Methodology; member, College of Reviewers, Canadian Institutes of Health Research, Government of Canada; Director of Research, World Headache Society, Bengaluru, India; expert adviser or reviewer, Cariplo Foundation, Milan, Italy; visiting director, National Cerebral and Cardiovascular Center, Department of Neurology, Division of Cerebrovascular Medicine and Neurology, Suita, Osaka, Japan; member, Scientific Review Committee, Cardiff University Biobank, Cardiff, UK; chair, Rotary Reconciliation Action Plan; and health care and medical adviser, Japan Connect, Osaka, Japan, outside the submitted work. Andreas K Demetriades reports leadership or fiduciary role in other board, society, committee, or advocacy group, paid or unpaid, as a non-stipendiary role as past President, EANS (European Association of Neurosurgical Societies), non-stipendiary role as steering committee member, AO Spine Knowledge Forum, non-stipendiary role as board member, EANS Foundation, and non-stipendiary role as board member, Global Neuro Foundation, outside the submitted work. Ibrahim Farahat El Bayoumy reports leadership or fiduciary role in other board, society, committee, or advocacy group, paid or unpaid, as Editor in Chief for Recent Trends in Infectious Diseases STM Journals and editorial member in Texila American University Journals, outside the submitted work. Andre Faro reports support for the present manuscript from the National Council for Scientific and Technological Development (CNPq, Brazil; CNPq Research Fellow, Brazil) and CNPq Researcher Fellow. Richard Charles Franklin reports support for attending meetings or travel from ACTM—annual Conference 2024–25; and leadership or fiduciary role in other board, society, committee, or advocacy group, paid or unpaid, as President—Australasian College of Tropical Medicine, President—Kidsafe Australia, board member Royal Life Saving Society Australia, and board member Auschem Training, outside the submitted work. Irena M Ilic reports support for the present manuscript from the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia (number 451-03-137/2025-03/200110). Joseph Johnson reports consulting fees from Stryker Inc (medical education consultant); and other financial or non-financial interests from research support provided by Ortho Xcel, outside the submitted work. Jagdish Khubchandani reports grants or contracts from Merck Sharpe Dohme, Inc (research unrelated to this study but concerning vaccine hesitancy), National Science Foundation, USA (research unrelated to this study but concerning public health message inconsistency), and NM-INBRE (NIH P20GM103451 subgrant; research unrelated to this study but concerning pain disorders in American adults); support for attending meetings or travel from NATCO: The Organization for Donation and Transplant Professionals (invited plenary speaker at annual event; paid for travel and accommodation); and leadership or fiduciary role in other board, society, committee, or advocacy group, paid or unpaid, as secretary, World Association of Medical Editors (not paid), member, Evidentiary Committee, American Public Health Association (not paid), member, US EPA Good Neighbor Environmental Board (not paid; assignment until 2025), and member, US FDA Digital Health Advisory Committee (not paid; assignment until 2025), outside the submitted work. Kewal Krishan reports other financial or non-financial interests from non-financial support from the UGC Centre of Advanced Study, CAS II, awarded to the Department of Anthropology, and the RUSA 2.0 grant awarded by the Ministry of Education to Panjab University, Chandigarh, India. Ja-Ho Leigh reports support for the present manuscript from the Ministry of Land, Infrastructure, and Transport of South Korea (NTRH RF-2026002); and grants or contracts from the Korean National Police Agency Grant for "Development of intelligent (AI) judgment algorithm for verification of high-risk drivers' driving fitness and commercialization of VR driving simulator" (2022–24) and the Korean National Police Agency Grant for "Development of driving ability assessment system for improvement of conditional driver's license system" (2026–27; payment made to institution for both), outside the submitted work. Ming-Chieh Li reports support for the present manuscript from the National Science and Technology Council, Taiwan (NSTC 115-2410-H-003-022; 115-2621-M-003-002); and leadership or fiduciary role in other board, society,

committee, or advocacy group, paid or unpaid, as technical editor, Journal of the American Heart Association, outside the submitted work. Ted R Miller reports grants or contracts from the Network of Employers for Traffic Safety and the AB InBev Foundation (payments to Ted R Miller's institution), outside the submitted work. Rafael Silveira Moreira reports grants or contracts from the CNPq Research Productivity Scholarship (Rafael Silveira Moreira is a research productivity fellow by CNPq [National Council for Scientific and Technological Development]; the scholarship registration number is 308986/2025-3), outside the submitted work. Shuhei Nomura reports support for the present manuscript from the Ministry of Education, Culture, Sports, Science, and Technology of Japan (grant 24H00663). Bogdan Oancea reports support for the present manuscript from UEFISCDI (project PN-IV-P6-6.1-CoEx-2024-0196, contract number 17/2.03.2026). Georgios D Panos reports payment or honoraria for lectures, presentations, speakers bureaus, manuscript writing, or educational events from Thea (payment to Georgios D Panos) and from Bayer and Roche (payment to Georgios D Panos through their institution); and support for attending meetings or travel from Thea, Bayer, and Roche (payment made to the agency of the meeting or congress), outside the submitted work. Roberto Passera reports being member of the data safety monitoring board for the clinical trial "Consolidation with ADCT-402 (loncastuximab tesirine) after immunochemotherapy: a phase II study in BTKi-treated/ineligible relapse/refractory mantle cell lymphoma (MCL) patients"—FIL, Fondazione Italiana Linfomi, Alessandria (Italy; no payment received); and leadership or fiduciary role in other board, society, committee, or advocacy group, paid or unpaid, as member of the EBMT Statistical Committee, European Society for Blood and Marrow Transplantation, Paris (France), member of the FIL Statistical Committee, Fondazione Italiana Linfomi, Alessandria (Italy), and past member 2020–23 (biostatistician) of the IRB/IEC Comitato Etico AO SS Antonio e Biagio Alessandria-ASL AL-VC (Italy; all no payment received), outside the submitted work. Amy E Peden reports support for the present manuscript from the Australian National Health and Medical Research Council (grant number: APP2009306). Samreen Saleem reports grants or contracts from Health Services Academy, Islamabad, Pakistan; and payment or honoraria for lectures, presentations, speakers bureaus, manuscript writing, or educational events from Health Services Academy, Islamabad, Pakistan, outside the submitted work. Yoseph Leonardo Samodra reports grants or contracts from NTU EPM & NSTC Taiwan (post-doctoral fellow contract); leadership or fiduciary role in other board, society, committee, or advocacy group, paid or unpaid, as a co-founder of Benang Merah Research Center (benangmerah.net); and other financial or non-financial interests from Jago Beasiswa (idebeasiswa.net; postgraduate scholarship mentor), outside the submitted work. Saurab Sharma reports grants or contracts from the Medical Research Future Funds (MRFF) Early/Mid-Career Research grant (as CI; paid to Neuroscience Research Australia, Sydney), a seed funding grant from the ANZ Back Pain Clinical Trials Networks, supported by the National Health and Medical Research Council (NHMRC; paid to Neuroscience Research Australia, Sydney), and an NHMRC Investigator Grant (Emerging Leadership 1/EL1) from the National Health and Medical Research Council (received 2025, commenced 2026; paid to the University of Sydney, Sydney; the funding bodies had no influence on Saurab Sharma's research or its reporting); support for attending meetings or travel from the Australian Pain Conference (2025 plenary lecture, unrelated to this paper; registration, travel, and accommodation costs reimbursed to Saurab Sharma); and leadership or fiduciary role in other board, society, committee, or advocacy group, paid or unpaid, as co-chair, IASP Global Year 2025 ("Pain management, research, and education in low/middle-income settings"); board member, IASP Global Alliance for Partners in Pain Advocacy (GAPPA); editorial board member, Pain Research Forum of the IASP; and associate editor, Journal of Orthopedic & Sports Physical Therapy and Physiotherapy (all unpaid), outside the submitted work. Vishal Sharma reports other financial or non-financial interests from DFSS (MHA)'s research project (DFSS28(1)2019/EMR/6) at the Department of Forensic Science (formerly Institute of Forensic Science & Criminology), Panjab University, Chandigarh, India; the RUSA 2.0 grant from MOE to Panjab University; and the PAIR grant (ANRF/PAIR/2025/000006/PAIR) to Panjab University from ANRF. Sebastian Straube reports leadership or fiduciary role in other board, society, committee, or advocacy group, paid or unpaid, as editorial board member, SN Comprehensive Clinical Medicine; board member, MSI Foundation (payments to Sebastian Straube); and member of the Scientific Advisory Committee—New Alberta Care First Automobile Insurance System, Ontario Tech University (payments to Sebastian Straube), outside the submitted work. Rafael Tabarés-Seisdedos reports grants or contracts from the Valencian Regional Government's Ministry of Education (PROMETEO/CIPROM/2022/58) and the Spanish Ministry of Science, Innovation and Universities (PID2021-129099OB-I00; the funders were not involved in the design of the manuscript or the decision to submit it for publication, nor will they be involved in any aspect of the study's conduct), outside the submitted work. Jansje Henny Vera Ticoalu reports leadership or fiduciary role in other board, society, committee, or advocacy group, paid or unpaid, as a co-founder of Benang Merah Research Center (benangmerah.net), outside the submitted work. Era Upadhyay reports patents planned, issued or pending for "A system and method of reusable filters for anti-pollution mask" (published), "A system and method for electricity generation through crop stubble by using microbial fuel cells" (published), "A system for disposed personal protection equipment (PPE) into biofuel through pyrolysis and method" (published), "A novel herbal pharmaceutical aid for formulation of gel and method thereof" (published), "Herbal drug formulation for treating lung tissue degenerated by particulate matter exposure" (published), "A method to transform cow dung into the wall paint by using natural materials and composition thereof" (published), "Biodegradable packaging composition and method of preparation thereof" (filed), "Eco-friendly bio-shoe polish from banana and turmeric" (filed), "Honey-based polyherbal syrup composition to treat air pollution-induced inflammation and preparation method thereof" (filed), "Process for preparing a caffeine free, antioxidant and nutrient rich beverage" (filed), "Polyherbal oral mist composition for dual relief and method for preparation thereof" (filed), and "Method for fabricating sustainable waterproof material sheets from LDPE plastic wastes" (filed); and leadership or fiduciary role in other board, society, committee, or advocacy group, paid or unpaid, as former joint secretary, executive council member, Indian Meteorological Society, Jaipur Chapter (India), and member secretary-DSTPURSE Program, outside the submitted work. Siddhesh Zadey reports leadership or fiduciary role in other board, society, committee, or advocacy group, paid or unpaid as ASAR co-founder and board member, Nivarana Board, G4 Alliance PRC and Asia WG Chair, Lancet Standing Commission, Citizen-Centred Health System for India, and State Mental Health Drafting Committee, Maharashtra, India, outside the submitted work. All other authors declare no competing interests.

Data sharing

Input data used in these analyses are available on the Global Health Data Exchange GBD 2023 website at https://ghdx.healthdata.org/gbd-2023. All results from this study are publicly accessible. To download estimates produced in these analyses, please visit the GBD Results tool.[44] All GBD estimates, including the different measures, metrics, causes, locations, age groups, sex, and years, are publicly available via the GBD Results tool for registered users.[44]

Acknowledgments

This paper was developed as part of the GBD Collaborator Network and GBD Protocol with support from the GBD Secretariat, Institute for Health Metrics and Evaluation (IHME), and the GBD Collaborator Network under IHME ID: 6109.[45] GBD was partially funded by the Gates Foundation. During the preparation of this work Claude Opus 4.8, a large language model developed by Anthropic, was used to assist with grammatical correction and linguistic clarity. No original research, data analysis, or interpretation were generated by AI. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Editorial note: The Lancet Group takes a neutral position with respect to territorial claims in published maps and institutional affiliations.

References

1 The Lancet. Road safety: more than reducing injuries. *Lancet* 2022; **400:** 73.
2 WHO. Global Status Report on Road Safety 2023, 1st edn. World Health Organization, 2023.

3 Hyder AA, Hoe C, Hijar M, Peden M. The political and social contexts of global road safety: challenges for the next decade. *Lancet* 2022; **400:** 127–36.

4 Peden MM, Mohan D, Hyder A, Norton R, MacKay M, Dora C. A 5-year WHO strategy on road traffic injury prevention. World Health Organization, 2001.

5 UN General Assembly. Global road safety crisis (resolution A/RES/57/309). May 29, 2003. https://docs.un.org/en/A/RES/57/309 (accessed Nov 10, 2025).

6 World Bank Global Road Safety Facility. World Bank Global Road Safety Facility activities report 2006–2008. 2009. https://documents1.worldbank.org/curated/en/110211468180904101/pdf/511130WP0GRSF010Box342018B01PUBLIC1.pdf (accessed Nov 12, 2025).

7 Bloomberg Philanthropies. Improving road safety. https://www.bloomberg.org/public-health/improving-road-safety/ (accessed June 5, 2026).

8 WHO. Global plan for the Decade of Action for Road Safety 2011–2020. World Health Organization, 2011.

9 Regeringen och Regeringskansliet. Stockholm Declaration. Feb 19, 2020. https://www.government.se/information-material/2020/02/stockholm-declaration/ (accessed Nov 25, 2025).

10 WHO. Global Plan for the Decade of Action for Road Safety 2021–2030. World Health Organization, 2021.

11 World Bank Group. A decade of saving lives through road safety investments. 2024. https://projects.worldbank.org/en/results/2024/03/25/a-decade-of-saving-lives-through-road-safety-investments (accessed Nov 27, 2025).

12 Mitra S, Neki K, Mbugua LW, et al. Availability of population-level data sources for tracking the incidence of deaths and injuries from road traffic crashes in low-income and middle-income countries. *BMJ Glob Health* 2021; **6:** e007296.

13 GBD 2023 Disease and Injury and Risk Factor Collaborators. Burden of 375 diseases and injuries, risk-attributable burden of 88 risk factors, and healthy life expectancy in 204 countries and territories, including 660 subnational locations, 1990–2023: a systematic analysis for the Global Burden of Disease Study 2023. *Lancet* 2025; **406:** 1873–922.

14 GBD 2023 Causes of Death Collaborators. Global burden of 292 causes of death in 204 countries and territories and 660 subnational locations, 1990–2023: a systematic analysis for the Global Burden of Disease Study 2023. *Lancet* 2025; **406:** 1811–72.

15 Flaxman AD, Vos T, Murray CJL, eds. An integrative metaregression framework for descriptive epidemiology. University of Washington Press, 2015.

16 Zheng P, Barber R, Sorensen RJD, Murray CJL, Aravkin AY. Trimmed constrained mixed effects models: formulations and algorithms. *J Comput Graph Stat* 2021; **30:** 544–56.

17 Foreman KJ, Lozano R, Lopez AD, Murray CJ. Modeling causes of death: an integrated approach using CODEm. *Popul Health Metr* 2012; **10:** 1.

18 GBD 2023 Demographics Collaborators. Global age-sex-specific all-cause mortality and life expectancy estimates for 204 countries and territories and 660 subnational locations, 1950–2023: a demographic analysis for the Global Burden of Disease Study 2023. *Lancet* 2025; **406:** 1731–810.

19 Haakenstad A, Yearwood JA, Fullman N, et al. Assessing performance of the Healthcare Access and Quality Index, overall and by select age groups, for 204 countries and territories, 1990–2019: a systematic analysis from the Global Burden of Disease Study 2019. *Lancet Glob Health* 2022; **10:** e1715–43.

20 James SL, Castle CD, Dingels ZV, et al. Estimating global injuries morbidity and mortality: methods and data used in the Global Burden of Disease 2017 study. *Inj Prev* 2020; **26** (suppl 1)**:** i125–53.

21 Belin M-Å, Tillgren P, Vedung E. Vision Zero—a road safety policy innovation. *Int J Inj Contr Saf Promot* 2012; **19:** 171–79.

22 Johansson R. Vision Zero—implementing a policy for traffic safety. *Saf Sci* 2009; **47:** 826–31.

23 Khan MN, Das S. Advancing traffic safety through the safe system approach: a systematic review. *Accid Anal Prev* 2024; **199:** 107518.

24 Mendoza AE, Wybourn CA, Mendoza MA, Cruz MJ, Juillard CJ, Dicker RA. The worldwide approach to Vision Zero: implementing road safety strategies to eliminate traffic-related fatalities. *Curr Trauma Rep* 2017; **3:** 104–10.

25 Job S, Wambulwa WM. Features of low-income and middle-income countries making road safety more challenging. *J Road Saf* 2020; **31:** 79–84.

26 World Bank. Guide for road safety opportunities and challenges: low and middle income country profiles. World Bank Group, 2019.

27 International Road Assessment Programme. Safety insights explorer. https://irap.org/safety-insights-explorer/ (accessed Sept 24, 2025).

28 WHO. Post-crash response: supporting those affected by road traffic crashes. World Health Organization, 2016.

29 WHO, FIA Foundation for the Automobile and Society, Global Road Safety Partnership, World Bank. Data systems: a road safety manual for decision-makers and practitioners. 2010. https://iris.who.int/handle/10665/44256 (accessed Sept 22, 2025).

30 Razzak JA, Bhatti J, Wright K, Nyirenda M, Tahir MR, Hyder AA. Improvement in trauma care for road traffic injuries: an assessment of the effect on mortality in low-income and middle-income countries. *Lancet* 2022; **400:** 329–36.

31 Wong EG, Gupta S, Deckelbaum DL, Razek T, Kushner AL. Prioritizing injury care: a review of trauma capacity in low and middle-income countries. *J Surg Res* 2015; **193:** 217–22.

32 Bhattarai HK, Bhusal S, Barone-Adesi F, Hubloue I. Prehospital emergency care in low- and middle-income countries: a systematic review. *Prehosp Disaster Med* 2023; **38:** 495–512.

33 Turner B, Job S, Mitra S. Guide for road safety interventions: evidence of what works and what does not work. World Bank, 2021.

34 Chisholm D, Naci H, Hyder AA, Tran NT, Peden M. Cost effectiveness of strategies to combat road traffic injuries in sub-Saharan Africa and south east Asia: mathematical modelling study. *BMJ* 2012; **344:** e612–612.

35 Ralaidovy AH, Bachani AM, Lauer JA, Lai T, Chisholm D. Cost-effectiveness of strategies to prevent road traffic injuries in eastern sub-Saharan Africa and southeast Asia: new results from WHO-CHOICE. *Cost Eff Resour Alloc* 2018; **16:** 59.

36 Zero Fatality Corridor. Zero Fatality Corridor: transforming the Mumbai–Pune Expressway into a fatality-free corridor. https://www.zerofatalitycorridor.in/about-zfc/ (accessed Dec 18, 2025).

37 Naumann RB, West BA, Barry V, Matthews S, Lee R. Pedestrian and overall road traffic crash deaths—United States and 27 other high-income countries, 2013–2022. *MMWR Morb Mortal Wkly Rep* 2025; **74:** 134–39.

38 Hakamies-Blomqvist L. Ageing Europe: the challenges and opportunities for transport safety. European Transport Safety Council, 2003.

39 Wilmut K, Purcell C. Why are older adults more at risk as pedestrians? A systematic review. *Hum Factors* 2022; **64:** 1269–91.

40 Chen S, Kuhn M, Prettner K, Bloom DE. The global macroeconomic burden of road injuries: estimates and projections for 166 countries. *Lancet Planet Health* 2019; **3:** e390–98.

41 Pulido D, Veronica IR. Saving lives through private investment in road safety. https://documents1.worldbank.org/curated/en/099525002222214332/pdf/P1750030e6c58506b08d5b05ccba3311628.pdf (accessed Nov 27, 2025).

42 The Organisation for Economic Co-operation and Development. Cuts in official development assistance: OECD projections for 2025 and the near term. https://www.oecd.org/en/publications/2025/06/cuts-in-official-development-assistance_e161f0c5/full-report.html (accessed Feb 12, 2026).

43 World Bank. Financing road safety: catalyzing the sustainable finance market to bridge the gap. https://documents.worldbank.org/pt/publication/documents-reports/documentdetail/099742011042514284 (accessed Nov 27, 2025).

44 Institute for Health Metrics and Evaluation. GBD Results. 2025. https://vizhub.healthdata.org/gbd-results/ (accessed Nov 13, 2025).

45 Institute for Health Metrics and Evaluation. Global Burden of Diseases, Injuries, and Risk Factors Study (GBD) Protocol. June 4, 2024. https://www.healthdata.org/sites/default/files/2024-06/GBD%20Protocol%20060424.pdf (accessed Nov 12, 2025).