

# Road Traffic Accidents: Causes, Consequences, and Preventive Strategies

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**Abstract**—Road traffic accidents constitute a major, yet largely preventable, global public health crisis, accounting for approximately 1.19 million deaths and over 65 million disability-adjusted life years annually. They represent the leading cause of mortality among children and young adults aged 5–29 years and disproportionately affect low- and middle-income countries, which bear over 90% of global road traffic fatalities despite lower vehicle ownership. Beyond mortality, road traffic accidents generate profound and enduring consequences, including permanent physical disability, psychological trauma, social disruption, and substantial economic losses amounting to 1–3% of national gross domestic product. This review synthesizes current evidence on the multifactorial causes, health and economic consequences, and evidence-based preventive strategies for road traffic accidents. Human behavioral factors such as speeding, alcohol impairment, fatigue, and non-use of protective devices emerge as the predominant contributors, interacting with vehicle defects, environmental hazards, and unsafe infrastructure to amplify crash risk and injury severity. The burden is particularly pronounced among young adults in their most economically productive years, creating cascading societal and health system impacts. Evidence consistently demonstrates that comprehensive preventive strategies—including seat belt and child restraint use, helmet enforcement, speed management, traffic calming, safe road infrastructure design, and integrated urban planning—can substantially reduce crash frequency and injury severity. Adoption of systemic, Safe System–based approaches that integrate education, enforcement, engineering, and policy coordination is essential for achieving sustained reductions in road traffic injuries. Strengthening implementation of these interventions, particularly in resource-limited settings, is critical to meeting global road safety targets and reducing preventable mortality, disability, and economic loss.

**Keywords**— Road traffic accidents; Injury prevention; Public health burden; Speed management; Road safety infrastructure; Low- and middle-income countries.

## I. INTRODUCTION

Road traffic accidents represent one of the most pressing and preventable public health crises of the modern era, claiming approximately 1.19 million lives annually and causing an estimated 65.1 million disability-adjusted life years (DALYs) globally. Road traffic injuries have emerged as the leading cause of death for children and young adults aged 5–29 years, ranking as the 15th leading cause of death for people of all ages and surpassing major infectious diseases including HIV/AIDS, tuberculosis, and malaria in many regions. Alarming, 92% of road traffic fatalities occur in low- and middle-income countries, despite these nations accounting for approximately 60% of the world's vehicles, reflecting profound disparities in road safety infrastructure and enforcement capacity. Beyond mortality, road traffic accidents impose staggering economic consequences, costing countries between 1–3% of their gross domestic product annually, with global macroeconomic losses estimated at US\$1.8 trillion dollars equivalent to 10–12% of global GDP. Understanding the multifactorial causes, comprehensive consequences, and evidence-based preventive strategies of road traffic accidents is essential for formulating effective public health interventions and reducing this substantial burden of preventable mortality and morbidity<sup>[1, 2]</sup>.

*Causes of Road Traffic Accidents*  
*Human Behavioral Factors*

Human behavioral factors represent the predominant contributors to road traffic accidents, accounting for the vast majority of crash causation. These behavioral factors operate across multiple temporal scales and can be classified into four categories based on their mechanisms and duration of impact. Long-term capability-reducing factors include inexperience (particularly among young and newly licensed drivers), aging-related declines in sensory and cognitive function, disease and disability, alcoholism, and chronic drug abuse, each of which substantially diminishes a driver's capacity to operate vehicles safely.

Short-term capability-reducing factors include drowsiness and fatigue, acute alcohol intoxication, short-term drug effects, acute psychological stress, and temporary distraction, all of which acutely impair the perceptual and cognitive capacities essential for safe driving. Fatigue and drowsiness merit particular emphasis, as sleep-deprived drivers demonstrate substantially impaired reaction time, vigilance, and decision-making comparable to alcohol intoxication.

Long-term risk-promoting behavioral factors include habitual speeding, chronic disregard of traffic regulations, non-use of seat belts and helmets, and the personality characteristic of accident proneness, each reflecting stable individual differences in risk tolerance and compliance behavior. Short-term risk-promoting factors include impulsive acts, moderate alcohol consumption, suicidal or self-harmful driving behavior, and driving while under the influence of psychotropic substances<sup>[3, 4]</sup>.

Speeding deserves particular emphasis as the most prevalent behavioral factor contributing to fatal road accidents. Increased vehicle speed multiplicatively increases both the probability of accident occurrence and the severity of resulting injuries, as the kinetic energy at collision scales with the square of velocity. Alcohol consumption substantially impairs concentration, reaction time, vision, and fear responses, thereby elevating accident probability and severity (Figure 1). Drunken driving is estimated to contribute to a substantial proportion of fatal road accidents globally, with alcohol impairing the neurobiological systems essential for safe driving performance.

### CAUSES OF ROAD TRAFFIC ACCIDENTS



Figure 1. Behavioral and Capability-Related Determinants of Road Traffic Accidents

#### Vehicle and Environmental Factors

While human factors predominate, vehicle condition and environmental factors contribute substantially to accident causation. Vehicle-related factors include inadequate maintenance, defective braking systems, tire failures, malfunctioning lighting, and structural design limitations affecting crashworthiness. Environmental factors include adverse weather conditions (rain, fog, snow), poor road visibility, inadequate road illumination, hazardous road design characteristics, and traffic congestion. The interaction between human behavioral limitations and environmental challenges creates compounded risk; for example, fatigue-impaired drivers demonstrate particularly poor performance during adverse weather or reduced visibility conditions.

Infrastructure design substantially influences accident risk through multiple pathways; poorly designed roadways with inadequate sight lines, sharp curves, hazardous intersections, and absent traffic calming measures encourage excessive speeding and unsafe driving behaviors. Conversely, well-designed road infrastructure with appropriate lane markings, traffic signals, pedestrian protections, and physical traffic calming measures substantially reduce crash frequency and injury severity<sup>[5]</sup>.

#### Consequences of Road Traffic Accidents Mortality and Disability Burden

The immediate human consequences of road traffic accidents are devastating and multifaceted. Between 20 and 50 million people suffer non-fatal injuries annually, with many experiencing permanent disability. Road traffic accidents disproportionately affect young adults aged 18–45 years, who constitute approximately 60% of road accident deaths, thereby removing individuals during their most economically productive life stages. Fatal and severe non-fatal injuries create cascading consequences for affected families and communities. Non-fatal accidents frequently result in severe injuries causing permanent disability, including spinal cord injuries causing paralysis, traumatic brain injuries causing cognitive and neurological impairment, and amputation of limbs. These permanent disabilities necessitate long-term care and rehabilitation, imposing substantial burdens on both affected individuals and their families<sup>[6, 7]</sup>.

#### Psychological and Social Consequences

Road traffic accident victims and their families commonly experience profound psychological trauma, including depression, anxiety disorders, and post-traumatic stress disorder (PTSD). The loss or permanent disability of family wage-earners creates acute psychological distress, financial hardship, and disrupted family structures. Survivors with severe injuries frequently experience social isolation, reduced community participation, and diminished quality of life, as physical limitations and disability stigma restrict vocational and recreational opportunities.

#### Economic Consequences

Road traffic accidents impose enormous direct and indirect economic costs to individuals, families, healthcare systems, and nations. Direct costs include emergency medical care, hospitalization, surgical interventions, rehabilitation services, and long-term disability management. Indirect costs encompass lost productivity from fatal and non-fatal injuries, lost educational opportunities for children of deceased parents, reduced earning capacity of disabled survivors, and property damage to vehicles and infrastructure. The global economic burden is further amplified by legal and judicial costs, insurance administration expenses, and out-of-pocket costs borne by affected families.

Road traffic accidents cost most countries 3% of their gross domestic product, with low and middle-income economies experiencing losses equivalent to 2–6% of GDP annually. These economic losses substantially exceed development assistance received by many low-income countries, thereby representing a major barrier to economic development and poverty reduction. Healthcare systems in low and middle-income countries experience particular strain, as emergency departments and trauma centers become overburdened with accident casualties requiring intensive care and prolonged hospitalization<sup>[8, 9]</sup>.

#### Health System Burden

Road traffic accidents create substantial burden on healthcare systems through multiple mechanisms. Public hospitals experience strain on financial resources, hospital bed

occupancy, and demand on health professionals, particularly in countries with limited healthcare capacity. The concentration of accident injuries among young, economically productive individuals creates opportunity costs, as healthcare resources diverted to trauma care become unavailable for preventive health services and treatment of chronic diseases. In low-income countries with severe healthcare resource limitations, this burden may substantially compromise overall healthcare system functioning and population health outcomes.

### *Evidence-Based Preventive Strategies*

#### *Seat Belt and Child Restraint Systems*

Seat belt use represents one of the most effective and cost-efficient interventions for reducing road traffic injury mortality and morbidity. High-quality evidence demonstrates that seat belt use reduces serious crash-related injuries and deaths by approximately 50%. For specific injury outcomes, proper seat belt use prevents 25–50% of fatal injuries, 25–45% of serious injuries, and 20–25% of minor injuries. Studies comparing belted and unbelted occupants reveal that unbelted vehicle occupants have approximately 10 times higher odds for case-fatality compared to belted occupants, 2.5 times higher odds for intracranial injury, and 2.2 times higher odds for hospital admission<sup>[10]</sup>.

The preventive effects of seat belts demonstrate dose-response relationships with injury severity; unbelted drivers experience crude case-fatality rates of 5.1% compared to belted drivers experiencing case-fatality rates below 0.4%. Importantly, unbelted rear-seat passengers elevate fatality risk to belted front-seat occupants through multiple mechanisms, establishing that seat belt compliance must be universal across all vehicle occupants to maximize protective effects. Child restraint systems for young children (ages 1–8 years) reduce serious injury risk by approximately 71–76% and head injury risk by comparable magnitudes<sup>[11–14]</sup>.

Primary enforcement seat belt laws mandating seat belt use without requiring additional traffic violations demonstrate substantially higher compliance rates and lower road traffic injury mortality compared to secondary enforcement laws requiring concurrent traffic violations for enforcement. Enhanced seat belt reminder systems (ESBRs) employing chime notifications substantially increase seat belt compliance; research indicates these systems increase seat belt use by 5 percentage points and reduce driver fatality rates by 6% compared to vehicles without such systems.

#### *Helmet Use for Motorcyclists and Cyclists*

Helmet use represents a critical protective intervention for vulnerable road users including motorcyclists and cyclists, yet compliance rates remain suboptimal in many regions. Helmets reduce the risk of head injury by 63–88%, brain injury by comparable magnitudes, and severe brain injury outcomes requiring hospitalization by 63–88%. Because approximately 75% of bicycle-related mortality is attributable to head injuries, 85% of which are preventable with helmet use, comprehensive helmet promotion programs represent high-impact interventions.

Mandatory helmet laws, when accompanied by consistent enforcement, substantially increase helmet use and reduce road traffic injury severity among helmeted cyclists and motorcyclists. Enforcement of mandatory helmet legislation demonstrates effectiveness in increasing road user compliance with helmet laws through multiple enforcement modalities including traditional police enforcement and automated camera enforcement systems<sup>[15, 16]</sup>.

#### *Speed Management and Enforcement*

Speed management represents a foundational element of comprehensive road safety interventions, as vehicle speed directly influences both crash probability and injury severity. When speed enforcement is doubled, a 20% reduction in injury accidents results from the combined effects of reduced crash frequency and reduced injury severity. Automated speed camera enforcement reduces injury accidents by 15–20%, while more intensive speed enforcement modalities including handheld laser enforcement achieve accident reductions exceeding these magnitudes.

Advanced speed enforcement technologies including average speed control (monitoring vehicle speed across road sections rather than at single points) demonstrate superior effectiveness, achieving injury accident reduction estimates of 33% for all accidents and 56% for killed-and-seriously-injured accidents. Fixed speed camera enforcement in school zones achieves 35% reduction in life-altering crash injuries among vulnerable road users including children<sup>[17]</sup>.

Physical traffic calming measures including vertical deflections (speed humps, traffic cushions), horizontal features (road narrowing, chicanes), and roundabout installations demonstrate substantial effectiveness in reducing crash frequency and severity; engineering schemes with vertical deflections prevent 44% of personal injury accidents, while schemes with horizontal features prevent 29% of accidents. The synergistic integration of enforcement and engineering measures creates greater accident reduction than either modality alone.

#### *Road Infrastructure Design and Engineering*

The "Safe System" approach to road safety emphasizes that road infrastructure design must anticipate human error and limit injury severity when crashes occur, recognizing that driver mistakes are inevitable. Evidence-based infrastructure interventions include installation of appropriate barrier systems protecting vehicles from roadside hazards (achieving up to 80% reduction in deaths and serious injuries), well-designed roundabouts providing equivalent protection, and appropriate road markings improving lane discipline and reducing crossing-path collisions<sup>[18, 19]</sup>.

Separation of vulnerable road users (pedestrians and cyclists) from motorized traffic through protected pathways and exclusive lanes substantially reduces collision frequency and injury severity. Pedestrian signal interventions extending crossing signal duration to accommodate slower crossing speeds of elderly and disabled pedestrians, coupled with traffic signal timing appropriate to pedestrian crossing speeds, improve pedestrian safety. Daytime running headlight (DRL) interventions reduce road accident casualty outcomes through improved vehicle visibility at all times of day.

### Urban Planning and Land-Use Integration

Integrated urban planning approaches incorporating land-use distribution and transportation network design substantially influence road safety outcomes. Compact city development promoting transit-oriented mixed-use development, public transportation, and non-motorized transport modes (walking and cycling) reduces exposure to high-speed motorized vehicles and reduces overall accident probability through reduced vehicle miles traveled. Urban planning incorporating traffic calming principles, reduced speed limits in residential areas, pedestrian priority zones, and complete streets supporting multiple modes of transportation creates safer urban environments<sup>[20]</sup>.

### Education, Enforcement, and Systemic Interventions

Comprehensive road safety interventions must integrate education, enforcement, and engineering components within systematic management frameworks to achieve sustained behavior change and injury reduction. Education programs addressing speed risks, alcohol effects, distracted driving, and vulnerable road user protection contribute to knowledge acquisition and, when combined with enforcement and engineering, contribute to sustained behavior change.

Law enforcement focused on high-risk driving behaviors (speeding, alcohol-impaired driving, non-use of protective equipment) combined with credible sanctions creates behavioral deterrence through certainty and certainty of punishment rather than severity. Systematic interventions including District Road Safety Committees integrating transportation, public health, law enforcement, and education sectors provide organizational infrastructure for coordinated implementation of multimodal prevention strategies<sup>[21, 22]</sup>.

## II. CONCLUSION

Road traffic accidents represent a complex, multifactorial public health crisis caused by the interaction of human behavioral limitations, vehicle factors, and environmental hazards, resulting in devastating mortality, disability, economic, and social consequences. The annual toll of approximately 1.19 million deaths and 65.1 million DALYs represents an unconscionable burden of preventable mortality and morbidity, particularly affecting young adults and populations in low and middle-income countries.

However, robust evidence establishes that comprehensive, multimodal preventive strategies incorporating protective equipment (seat belts, helmets), speed management through integrated enforcement and engineering, safe road infrastructure design, and integrated urban planning can substantially reduce crash frequency and injury severity. The evidence-based interventions reviewed including seat belt promotion, helmet legislation, speed enforcement, traffic calming engineering, protected vulnerable road user infrastructure, and systemic coordination each demonstrate efficacy in reducing road traffic injury burden when properly implemented and enforced<sup>[23]</sup>. Achieving the United Nations Sustainable Development Goal target of halving road traffic deaths and injuries by 2030 requires urgent scaling of evidence-based interventions, particularly in low and middle-income countries bearing 92% of the global road safety

burden. Success demands sustained political commitment, adequate resource allocation, inter-sectoral coordination, and recognition that road safety constitutes an essential public health and development priority. Without urgent action employing comprehensive "Safe System" approaches integrating human, vehicle, and environmental factors, road traffic injuries will continue their projected increase as motorization expands in low and middle-income countries, necessitating immediate and sustained preventive intervention.

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