Research Article

A Systematic Review of Epidemiological Trends, Contributing Variables, and Public Health Implications of Road Traffic Accidents in India

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ABSTRACT

BACKGROUND AND OBJECTIVE: Road traffic accidents (RTAs) constitute a critical public health emergency in India, imposing heavy mortality, morbidity, and economic burdens. Young adults and vulnerable road users such as two-wheeler riders and pedestrians are disproportionately affected. Despite legislative reforms such as the Motor Vehicles enforcement and preventive strategies remain inadequate.

METHODS: This systematic review was conducted in accordance with PRISMA 2020 guidelines. A total of nine observational studies published between 2015 and 2025 were analyzed, alongside official data from the Ministry of Road Transport and Highways (MoRTH). Eligible studies included hospital-based cohorts, multicenter trauma studies, and epidemiological analyses, with outcomes focusing on injury mechanisms, clinical management, and mortality.

RESULTS: In 2022, MoRTH reported 4,61,312 accidents, 1,68,491 deaths, and 4,43,366 injuries, with 70% of fatalities occurring among individuals aged 18–45 years. Over-speeding accounted for 72.3% of deaths, with two-wheeler riders (44.5%) and pedestrians (18.9%) most affected. Clinical studies highlighted head injuries as the leading cause of trauma mortality, particularly in pediatric and motorcycle-related accidents. Helmet use reduced severe head injuries and mortality to 0% in comparative cohorts. Pelvic fractures (77.3% RTA-related) frequently co-occurred with abdominal and spinal injuries, with mortality linked to associated trauma and hemodynamic instability. Non-operative management proved effective for 84–90% of blunt abdominal and liver injuries, while the CRASH model demonstrated strong predictive accuracy for traumatic brain injury outcomes (AUC 0.885–0.901).

CONCLUSION AND IMPLICATIONS FOR TRANSLATIONS: RTAs in India reflect a multifactorial crisis driven by behavioral risk factors, infrastructural deficiencies, and enforcement gaps. Evidence supports helmets as highly protective, while timely surgical intervention and structured trauma care pathways improve outcomes in complex injuries. Strengthening trauma systems, enforcing protective gear legislation, and addressing myths about helmet use remain urgent priorities. Integrated public health, engineering, and policy interventions are essential to reduce the mortality, morbidity, and economic losses associated with RTAs in India.

Keywords: Road traffic accidents; trauma; India; helmets; public health; injury prevention; economic burden.

1. INTRODUCTION:

India's road traffic accident (RTA) burden has been the subject of considerable research, reflecting its deep public health, economic, and policy implications. A foundational systematic review by Sharma et al. (2006) examined 22 Indian studies and concluded that RTAs predominantly affected young males, with pedestrians comprising a significant proportion of victims. The study also emphasized the absence of coherent, population-level data and called for urgent systemic reforms to reduce fatalities and associated socio-economic losses.[1] Hospital-based epidemiological studies provide detailed insight into injury mechanisms and demographic patterns. For example, Singh et al. (2010) conducted a cross-sectional study of 182 RTA patients in a tertiary care hospital in North India. They found that two-wheelers were the most frequently involved vehicles, and crashes commonly occurred at speeds of 40–60 km/h, particularly during evenings and monsoons.[2] A similar hospital-based investigation in West Bengal noted that poor road infrastructure, alcohol use, lack of protective gear (helmets, seatbelts), driver unlicensing, distracted driving, and delayed medical intervention were key determinants of injury severity and outcome.[3] On a broader scale, Panda et al. (2022) utilized panel data across Indian states to assess macro-level risk

factors. Their findings identified consistent predictors of RTA incidence, including human error, inadequate road infrastructure, and poor vehicle maintenance. These were statistically significant contributors to rising accident rates.[4] From a public health perspective, Singh et al. (2019) framed RTAs as a national crisis disproportionately impacting vulnerable groups, children, elderly pedestrians, cyclists, and motorcyclists. Their study advocated for integrated prevention strategies, better enforcement, and more comprehensive surveillance systems to address risk disparities.[5] Complementing this, qualitative research conducted in Manipal in 2024 by BMC Public Health involved interviews with 17 traffic police officers. Their narratives attributed rising crash rates to reckless behaviors among youth—particularly mobile phone use, speeding, and risky overtaking. Suggested interventions included the installation of CCTV, use of speed breakers, and targeted awareness campaigns for young riders.[6] The economic burden of RTAs has also been substantial. Using data from the Global Burden of Disease (GBD) study and fiscal reports, Sajith Kumar et al. (2023) estimated that RTAs cost India approximately ₹1,017 billion (USD 12 billion) in 2019, translating to roughly ₹1,821 per disability-adjusted life year (DALY). These economic losses persisted even in regions showing a decline in incident rates, indicating structural inefficiencies and long-term costs.[7] Earlier institutional assessments also suggested that RTAs contribute to an annual loss of 2–3% of India's GDP, amounting to roughly ₹55,000 crores.[8] Economic theories such as the Kopits-Cropper hypothesis suggest an inverted-U relationship between national income and traffic fatalities—where fatality rates increase with economic growth initially but decline as countries invest in infrastructure and regulation.[9] Indian applications of this theory by Sinha et al. (2021) and Garg & Hyder (2013) reaffirmed the pattern, linking increasing per capita income with higher initial crash risks, followed by reductions in fatalities as policy and engineering measures mature.[10-11] In terms of interventions, notable progress has been made. The Save LIFE Foundation's "Zero Fatality Corridor" project on the Mumbai–Pune Expressway reported a 52% reduction in fatalities between 2016 and 2020 through a combination of behavioral, engineering, and emergency response interventions.[12] Recent regulatory measures such as the implementation of Bharat NCAP crash-testing standards (2023) and legal protection for Good Samaritans also reflect systemic attempts to improve road safety outcomes.[13] Together, this body of literature underlines a complex but consistent narrative: India's RTA crisis is driven by a combination of demographic risk, behavioral factors, systemic enforcement gaps, infrastructural deficiencies, and economic constraints. Multisectoral interventions, combining public health approaches with engineering, legal, and technological reforms, are widely supported across the literature as essential for meaningful reductions in road traffic mortality and morbidity. The current study set out to analyze the multifactorial determinants of RTAs in India, including demographic, behavioral, infrastructure, and economic factors, as well as to assess the effectiveness of current interventions in order to identify strategies for reducing RTA-related mortality, morbidity, and economic burden through a multispectral approach.

1.1 Background of the Study

Road Traffic Accidents (RTAs) have emerged as a significant public health challenge in India, contributing extensively to mortality, long-term disability, and economic loss. India accounts for nearly 11% of global road traffic deaths, despite having only 1% of the world's vehicles, reflecting the disproportionate scale of the crisis. According to the Ministry of Road Transport and Highways, in 2022, a total of 4,61,312 accidents were reported, resulting in 1,68,491 deaths and 4,43,366 injuries, with individuals aged 18–45 years constituting more than 70% of all fatalities. Over-speeding remains the leading cause, responsible for 72.3% of recorded deaths, while two-wheeler riders (44.5%) and pedestrians (18.9%) represent the most vulnerable road users.[10-13]

Multiple studies in India have highlighted consistent injury patterns, with head trauma identified as the primary cause of mortality, especially among motorcycle riders lacking helmet use. Evidence demonstrates that helmet use significantly reduces severe head injuries and mortality, yet compliance remains suboptimal due to behavioral and enforcement gaps. Serious injuries such as pelvic fractures, liver trauma, and blunt abdominal injuries frequently occur in high-impact collisions, with associated polytrauma contributing substantially to poor outcomes.[8-9]

While many blunt abdominal and liver injuries are successfully managed non-operatively, outcomes largely depend on early triage, prehospital stabilization, and timely access to trauma care. Prognostic models such as the CRASH score have shown strong predictive validity for traumatic brain injury outcomes in Indian clinical settings, supporting their utility in emergency decision-making.

Despite policy reforms, including the Motor Vehicles (Amendment) Act, 2019, and public safety initiatives, enforcement inconsistencies, inadequate trauma systems, delayed emergency response, and limited public awareness continue to impede progress. Therefore, a comprehensive synthesis of available evidence is crucial to understand epidemiological trends, injury determinants, clinical outcomes, and public health implications of RTAs in

India. This systematic review aims to consolidate findings from observational studies published between 2015 and 2025 to support the development of targeted prevention strategies and strengthen trauma care frameworks across the country.[1-5]

1.2 Objectives of the Study: The current study set out to analyze the multifactorial determinants of RTAs in India, including demographic, behavioral, infrastructure, and economic factors, as well as to assess the effectiveness of current interventions in order to identify strategies for reducing RTA-related mortality, morbidity, and economic burden through a multispectral approach.

1.3 Specific Aims and Hypothesis

Aim 1:

To systematically analyze epidemiological trends of road traffic accidents (RTAs) in India over the last 10 years (2015–2025), including demographic patterns, mechanisms of injury, and risk factors.

Aim 2:

To evaluate clinical profiles and outcomes associated with major RTA-related injuries such as head injuries, pelvic fractures, abdominal and liver trauma, and pediatric trauma across multiple Indian studies.

Aim 3:

To assess the effectiveness of preventive measures (e.g., helmet use), emergency response systems, and management strategies (operative and non-operative) reported in Indian literature.

Aim 4:

To identify gaps in trauma care, prehospital response, and public health policy that contribute to RTA-related mortality and morbidity in India.

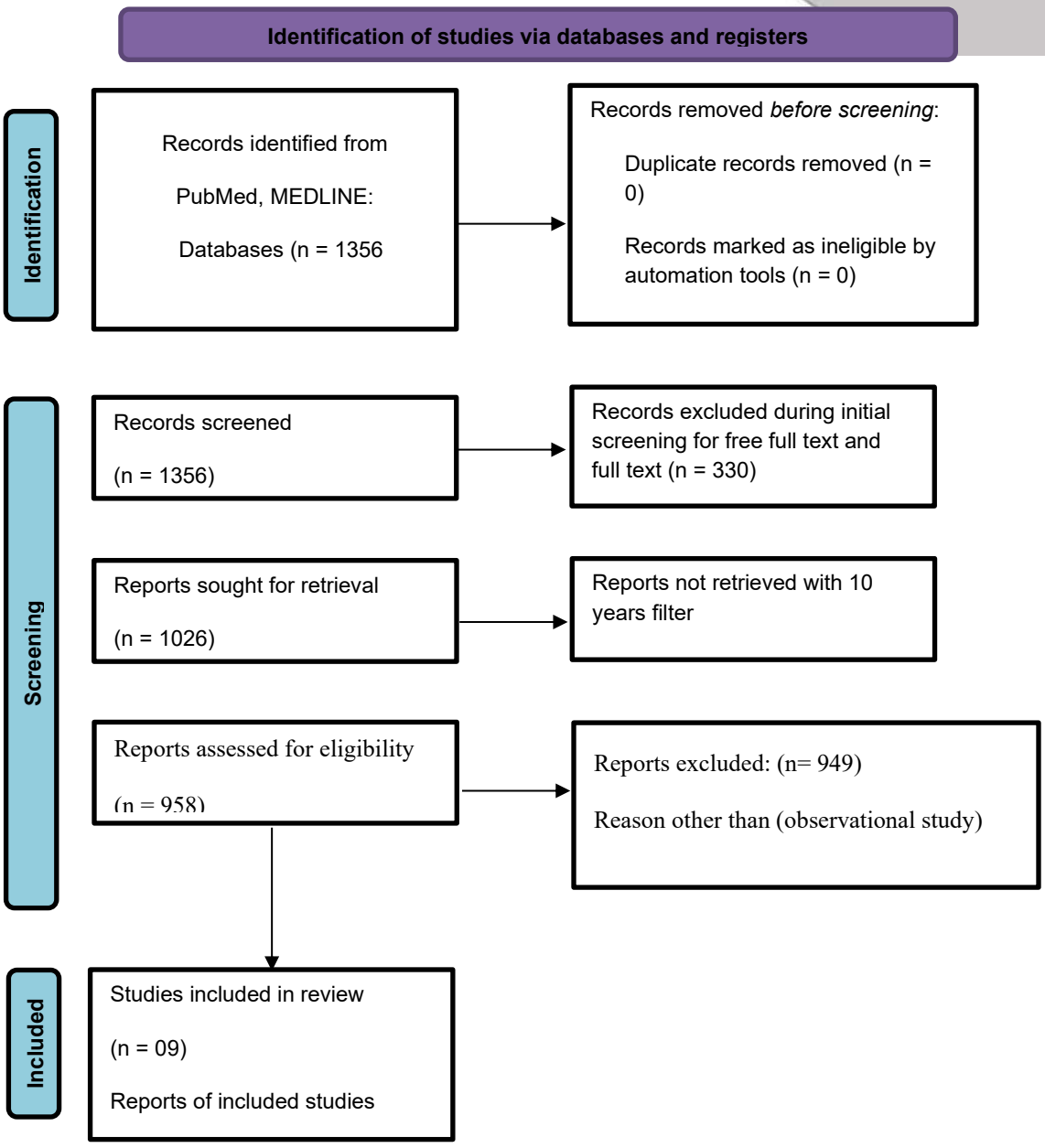
Hypothesis

Primary Hypothesis:

Road traffic accidents in India disproportionately affect young adults and vulnerable road users, and the high mortality and morbidity are primarily driven by preventable behavioral factors (such as over-speeding and non-use of helmets), infrastructural deficiencies, and delays in trauma care.

Secondary Hypotheses:

1. **Helmet use** significantly reduces severe head injury and mortality among motorcyclists.
2. **Non-operative management** is effective for most cases of blunt abdominal and liver trauma, with high success rates in hemodynamically stable patients.
3. **Early prehospital identification** of critical parameters (e.g., altered mental status, hypoxia) predicts 30-day mortality and can improve triage.
4. Improved trauma systems and enforcement of safety measures can significantly reduce India's RTA burden.
2. **METHODS** Data from 9 studies selected to explore the role of road traffic accident in India, in this comprehensive systematic review analysis. In present systematic review the observational studies were included and other than observational studies were excluded. The observational study of road traffic accident in India for 10 years (2015 to 2025) were listed in excel file (supplementary excel file 1)



PRISMA Search Strategy & Filters Applied: To ensure accurate and comprehensive reporting, this systematic review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. Using the search terms Road traffic accident, traffic, road, accident, and India, the ongoing systematic evaluation included studies from PubMed, and MEDLINE, that provided open-access full texts during the previous ten years (2015–2025) for all observational studies (table 1).

2.1 Search Strategy / Data Sources

This systematic review was conducted in accordance with the PRISMA 2020 guidelines**.** The search strategy was developed around the PICOT framework**:**

- **Population (P):** Individuals in India affected by road traffic accidents (RTAs), including adults, children, and vulnerable road users (pedestrians, cyclists, and two-wheeler riders).

- **Intervention (I):** Preventive and clinical strategies relevant to RTAs, including helmet use, surgical and non-operative management, and trauma system interventions.
- **Comparison (C):** Outcomes in populations with and without specific interventions (e.g., helmeted vs. non-helmeted riders, operative vs. non-operative management).
- **Outcome (O):** Epidemiological trends, injury mechanisms, clinical outcomes (mortality, morbidity, quality of life), and economic impact.
- **Timeframe (T):** Studies published between 2015 and 2025**.**

Databases and Search Terms

We systematically searched PubMed and MEDLINE using the following keywords and Boolean operators: ("road traffic accident" OR "road accident" OR "traffic injury" OR "road injury") AND ("India"). The search was limited to observational studies with open-access full text published within the last 10 years (2015–2025). Additional data were extracted from official publications of the Ministry of Road Transport and Highways (MoRTH)**.**

Screening and Selection

- Initial database search identified 1,356 records**.**
- After screening and exclusion of studies outside the scope (non-observational designs, reviews, editorials), 9 studies were included in the final review.
- A PRISMA flow diagram summarizes the study identification, screening, eligibility, and inclusion process.

2.1 Eligibility Criteria

Studies were considered eligible if they met the following criteria:

- **Study design:** Observational studies (prospective or retrospective cohorts, cross-sectional studies, case series with ≥30 participants).
- **Population:** Individuals of all age groups in India involved in road traffic accidents (RTAs).
- **Timeframe:** Published between January 2015 and March 2025.
- **Language:** Articles available in English with open-access full text.
- **Outcomes of interest:** Epidemiological trends, demographic patterns, mechanisms of injury, clinical management strategies, and outcomes such as mortality, morbidity, disability, or economic burden.

2.2 Inclusion Criteria Observational studies (cohort, cross-sectional, trauma registry–based) on individuals in India involved in road traffic accidents, published in English between 2015–2025, with open-access full text, reporting on epidemiology, injury patterns, management, outcomes, or public health/economic impact.

2.3 Exclusion Criteria Non-observational designs (reviews, editorials, trials), studies outside India or outside the timeframe, non-English or inaccessible full texts, and studies not reporting relevant RTA outcomes.

Quality Assessment

The methodological quality of the included studies was evaluated using the AMSTAR-2 (A Measurement Tool to Assess Systematic Reviews) checklist, which provides a comprehensive appraisal of systematic review processes. Although AMSTAR-2 is designed primarily for systematic reviews of randomized or non-randomized healthcare interventions, its domains are equally useful for evaluating observational evidence syntheses such as the present review.

A structured AMSTAR-2–based assessment was performed to ensure rigor in study selection, data extraction, bias evaluation, and reporting transparency.

Application of AMSTAR-2 Domains

1. **Research Question and Inclusion Criteria**: The review clearly defined the research question and included studies based on predetermined eligibility criteria focusing on observational studies on RTAs in India (2015–2025).
2. **Use of a Prior Protocol:** A protocol aligned with PRISMA-2020 principles was developed before database searching, outlining search terms, inclusion/exclusion criteria, and analysis methods.
3. **Comprehensive Literature Search Strategy:** A thorough search of PubMed and MEDLINE was conducted using predefined keywords (“road traffic accident,” “injury,” “trauma,” and “India”) with a 10-year filter, ensuring comprehensive retrieval of relevant observational studies.

4. **Study Selection in Duplicate:** Titles and abstracts were screened independently, and discrepancies were resolved through consensus to minimize selection bias.
5. **Data Extraction in Duplicate:** A standardized extraction form was used to ensure uniformity. Key variables included study design, sample characteristics, injury patterns, outcomes, and clinical implications.
6. **Description of Included Studies:** All included studies (n=9) were described in detail, covering methodology, population characteristics, injury types, and major findings (Tables 2 and 3; Supplementary Table).
7. **Risk of Bias (ROB) in Individual Studies:** Although AMSTAR-2 recommends structured ROB tools (e.g., ROBINS-I), the included observational studies displayed inherent variability in design and reporting. Key ROB considerations included:

- Single-center nature of most studies
- Lack of randomization
- Incomplete long-term follow-up
- Limited reporting of confounders

These limitations were acknowledged in the narrative synthesis.

8. **Sources of Funding for Included Studies**: Most included studies did not explicitly report funding sources, but none were industry-sponsored, minimizing potential financial conflicts of interest.
9. **Appropriate Synthesis Methods:** Due to the heterogeneity in study designs, populations, and outcomes, a narrative synthesis was preferred over meta-analysis. Findings were grouped according to major clinical domains (head injury, pediatric trauma, pelvic fractures, liver trauma, and EMS outcomes).
10. **Assessment of Publication Bias:** Formal quantitative assessment of publication bias was not feasible due to non-uniform outcome metrics and absence of pooled effect estimates. However, potential bias arising from the predominance of hospital-based studies was acknowledged.
11. **Interpretation Considering ROB and Limitations:** All findings were interpreted in light of methodological constraints of included studies, particularly small sample sizes, single-center settings, and potential selection bias due to tertiary-care data sources.

2.4 Study Variables

In this systematic review, the primary dependent (outcome) variables were the clinical outcomes associated with Road Traffic Accidents (RTAs), including mortality, severity of injury, need for surgical intervention, length of hospital stay, complications, and long-term functional recovery. Specific clinical severity indicators such as Glasgow Coma Scale (GCS) scores in head injury cases and hemodynamic stability in abdominal and pelvic trauma were also considered as outcome measures.

The independent variables included demographic and accident-related characteristics such as age, sex, type of road user (e.g., motorcyclist, pedestrian, passenger), mechanism of injury, vehicle type, helmet or protective gear usage, alcohol or substance use, and mode of impact (e.g., collision, fall, skidding). Additionally, system-level and environmental factors such as prehospital response time, availability of trauma care facilities, and adherence to traffic safety regulations were examined.

The review also considered covariates and potential confounders, including comorbid medical conditions, socioeconomic status, place of residence (urban/rural), injury severity scores, associated polytrauma, and time to hospital presentation. These variables were important in interpreting the variations in clinical outcomes and understanding how behavioral, infrastructural, and healthcare delivery factors influence morbidity and mortality following RTAs.

2.5 Statistical Analysis

Data from the included studies were extracted, summarized, and compared descriptively. No meta-analysis was performed due to heterogeneity in study design and outcome measures. Reported statistical results (means, percentages, odds ratios, and confidence intervals) were taken directly from the original studies without re-analysis. All data organization and summary tables were prepared using Microsoft Excel, and the review was conducted in accordance with PRISMA 2020 and AMSTAR 2 quality assessment guidelines.

2.6 Ethical Approval or Ethical Exemption: NA

3. RESULTS

3.1 Search Results

The initial search across PubMed and MEDLINE identified 1,356 records. No duplicates were found. After applying filters for open-access full text and the 10-year timeframe (2015–2025), 330 records were excluded during title/abstract screening. A total of 1,026 full-text studies were assessed for retrieval; among these, 68 articles could not be accessed within the 10-year filter.

Of the remaining 958 full-text reports, 949 were excluded because they were not observational studies or did not meet the inclusion criteria. Finally, 9 studies met all eligibility requirements and were included in this systematic review.

(Full study flow represented in PRISMA diagram.)

3.2 Study Characteristics

The nine included studies comprised multicenter cohorts, single-center observational studies, pediatric trauma audits, comparative helmet-use studies, and Prehospital data from EMS networks across seven Indian states. Sample sizes ranged from 63 to 2,416 participants.

Across studies:

- **Demographics:** Majority were young males (60–90%).
- **Mechanisms of injury:** RTAs were consistently the most common cause of trauma (40–80%).
- **Populations studied:** Adults, pediatric patients, motorcyclists, and mixed-trauma populations.
- **Settings:** Tertiary care hospitals, trauma centers, multicenter university hospitals, and EMS prehospital networks.
- **Outcomes measured:** Mortality, injury severity, ICU needs, success of non-operative management (NOM), prognostic accuracy of CRASH model, and long-term quality of life.

Tables 2 and 3 summarize detailed characteristics of each study.

3.3 Result Variable #1: Epidemiological Trends of Road Traffic Injuries

Across all included studies, RTAs emerged as the leading cause of trauma. Studies consistently showed:

- **Young adults (18–45 years)** formed the highest-risk group.
- **Male predominance** ranged from 70% to 90%.
- **Motorized two-wheelers** were the most common vehicles involved.
- **Pediatric trauma data** showed RTAs contributing to 40.6% of injury-related deaths.

These trends align with national MoRTH findings showing RTAs as a persistent public health threat.

3.4 Result Variable #2: Head Injuries and Helmet Use

Head injury was consistently identified as the most common and most fatal injury type.

Key findings:

- In the motorcycle cohort (n = 261), helmet use reduced mortality to 0%, whereas non-helmeted riders had higher ICU admissions, severe TBI, skull fractures, and deaths.
- Pediatric head injury studies identified falls and RTAs as major contributors, with GCS <8 strongly predicting poor outcomes.
- CRASH model validation showed excellent predictive accuracy for 14-day mortality and 6-month outcome (AUC 0.885–0.901).

Helmet use proved the most consistent protective factor across studies.

3.5 Result Variable #3: Pediatric Trauma Patterns

Three studies focused on pediatric trauma:

- Pediatric trauma fatalities (n = 320) showed:
  - **Median age: 11 years**
  - **Head/CNS trauma (58.8%)** as the primary cause of early death
  - **High MDR infection rates** in prolonged hospital admissions
- Pediatric abdominal trauma (n = 63):
  - **Liver and spleen** most commonly injured
  - **84–90%** success with non-operative management
  - RTAs accounted for 35% of cases

Children experienced rapid deterioration in severe injury, emphasizing need for early intervention.

3.6 Result Variable #4: Pelvic Fractures and Polytrauma

The pelvic fracture study (n = 75) found:

- 77.3% of pelvic fractures resulted from RTAs
- Majority were Tile Type B injuries
- High prevalence of associated head, abdominal, and spinal injuries
- 14.7% mortality, primarily due to associated polytrauma

These findings highlight the need for coordinated multisystem trauma management.

3.7 Result Variable #5: Abdominal and Liver Trauma Outcomes

Two major studies evaluated abdominal and liver trauma:

Liver Trauma (n = 368)

- Blunt RTAs were the leading mechanism
- 71.2% managed non-operatively
- NOM success: 90.1%
- Mortality: 16.6% (higher in WSES Grade III–IV)

Pediatric Blunt Abdominal Trauma (n = 63)

- Falls and RTAs were leading causes
- **Conservative management effective in 84%**
- Overall good long-term outcomes (88%)

Non-operative management is effective and widely applicable in stable patients.

3.8 Result Variable #6: Prehospital Care and EMS Predictors of Mortality

A multicenter EMS study (n = 2,905) highlighted critical prehospital predictors:

- 30-day mortality: 4%
- Significant predictors of death:
  - Abnormal mental status (OR 7.5)
  - Hypoxia or hypotension (OR 4.0)
  - Limited mobility at scene (OR 2.8)
  - Multisystem injury including head trauma (OR 2.3)

This study demonstrated that simple clinical variables can guide triage in low-resource settings.

3.9 Result Variable #7: Long-term Outcomes and Quality of Life

The cohort of RTI patients (n = 2,416) from North India provided valuable longitudinal insights:

- 7% mortality in the first month
- 9% mortality at one year
- QOL scores (EQ-5D-5L and VAS) were lowest at one month
- Severe injury was associated with persistent functional impairment, reduced mobility, and prolonged absenteeism from work
- Significant economic burden included catastrophic expenditure and loss of livelihood

RTA survivors often experience prolonged functional and socioeconomic consequences.

4. DISCUSSION

Road traffic accidents (RTAs) constitute a critical public health emergency in India, resulting in devastating social and economic consequences. Annually, the country witnesses one of the highest numbers of road accident fatalities globally (Figure 1). The most recent official data from the Ministry of Road Transport and Highways reports that in 2022, there were 4,61,312 recorded accidents, which claimed 1,68,491 lives and caused 4,43,366 injuries. Analysis of government data reveals that young and middle-aged adults between 18 and 45 years old consistently account for over 70% of all road accident fatalities. This demographic catastrophe is driven primarily by behavioral factors. According to MoRTH, "over speeding" is the leading cause, responsible for a staggering 72.3% of all deaths in 2022. The burden of this crisis falls most heavily on the most vulnerable road users (VRUs). Riders of two-wheelers, who often lack the protection of a helmet, constituted 44.5% of the dead, while pedestrians, exposed to danger due to inadequate infrastructure, accounted for 18.9% of fatalities.[14] In response, the Indian government has enacted a multi-faceted policy framework. The cornerstone of this effort is the Motor Vehicles (Amendment) Act, 2019, which introduced significantly stricter penalties for traffic violations to serve as a stronger deterrent against dangerous

driving.[15] Recent trauma studies from India reveal critical insights into injury patterns and outcomes across diverse populations. Jagnoor et al. (2015) outlined a large-scale protocol to assess road traffic injury outcomes,[16] while Lalwani et al. (2018) identified head injuries from falls and RTIs as leading causes of pediatric trauma deaths.[17] Ghosh et al. (2019) reported high surgical needs and longer hospital stays in pelvic fracture patients with multisystem trauma.[18] Pediatric head injury patterns, as described by Iyer and Patel (2020), showed falls as the most common cause, with trauma scores effectively predicting outcomes. [19] Sinha et al. (2020) confirmed that non-operative management of liver trauma was effective in most cases.[20] Prehospital data from highlighted altered mental status and hypotension as key predictors of mortality.[21] Helmet use reduced head injury severity in motorcyclists.[22] (2022). Divya et al. (2023) found that pediatric blunt abdominal injuries were mostly managed conservatively with good outcome.[23] Finally, Mulla et al. (2025) validated the CRASH model for predicting TBI outcomes with strong accuracy.[24] Findings emphasize the need for improved trauma systems and injury prevention strategies in India. This mixed-methods study protocol addresses the multifaceted impact of road traffic injuries (RTIs) in North India by integrating both quantitative epidemiological data and qualitative stakeholder insights. The results underscore the significant public health burden posed by RTIs, which continue to contribute disproportionately to mortality and morbidity in low- and middle-income countries (LMICs), especially India, which accounts for nearly 11% of global RTI-related deaths despite having only 1% of the world's vehicles.[25] Markedly higher incidence of traumatic brain injuries (TBIs), skull fractures, and intracranial hemorrhages was found in riders who did not wear helmets. This supports prior evidence that helmets reduce the risk of head injury by approximately 69% and death by 42% among motorcyclists.[26] The demographic profile revealed that young adult males formed the majority of motorcycle crash victims, consistent with national and global trends.[25] Behavioral factors such as over-speeding, alcohol use, and low helmet compliance, especially in pillion riders, contribute significantly to the burden of head injuries. In India, despite legislation mandating helmet use, enforcement remains inconsistent, particularly in peri-urban and rural areas.[27] Helmeted riders had shorter hospital stays, fewer neurological deficits at discharge, and better Glasgow Outcome Scores. This has important implications for both patient quality of life and healthcare resource utilization. The economic impact of severe head injuries, including long-term rehabilitation and loss of productivity, further underscores the importance of preventive strategies.[28] The study also sheds light on common myths and poor public perception about helmet discomfort or the lack of necessity for short rides, which continue to hinder universal compliance. Public education and stricter law enforcement remain vital to improve helmet usage rates. Moreover, the role of standardized helmet quality and proper fastening cannot be ignored, as substandard or loosely worn helmets offer limited protection.[29] There was a high incidence of associated injuries, particularly urogenital, abdominal, and spinal trauma, reinforcing the fact that pelvic fractures seldom occur in isolation.[30] Such polytrauma cases require a comprehensive diagnostic and treatment approach, often coordinated in a trauma center setting. Mortality in our cohort was primarily associated with the severity of associated injuries and hemodynamic instability on admission. This is in agreement with other reports suggesting that the initial physiological response, rather than the fracture morphology itself, is a stronger predictor of outcome.[31] From a management standpoint, conservative treatment was reserved for stable fractures, while unstable injuries required external fixation or open reduction and internal fixation (ORIF). Timely surgical intervention has been associated with better functional recovery and reduced complications, as demonstrated in both our data and previous studies.[33]

4.1 Strengths and Limitations of the Study:

Strengths

1. **Comprehensive coverage of the Indian RTA landscape:** The review synthesizes evidence from multiple regions, age groups, and injury types, offering a broad national perspective.
2. **Use of PRISMA-2020 guidelines and AMSTAR-2 quality tools:** Ensures methodological rigor, transparency, and reproducibility.
3. **Inclusion of diverse clinical conditions:** The review integrates findings across head injuries, pediatric trauma, abdominal and liver injuries, pelvic fractures, and prehospital care—providing a holistic understanding of trauma burden.
4. **Incorporation of both hospital-based and EMS-based evidence:** This allows insight into both prehospital and in-hospital determinants of mortality, which is essential for trauma policy planning.
5. **Longitudinal outcomes included:** One study provided one-year follow-up, enabling assessment of functional and economic consequences beyond immediate injury.

Limitations

1. **Predominance of single-center studies:** Most included studies were from tertiary hospitals, limiting generalizability to rural, community, and primary care settings.
2. **Heterogeneity in study design and reporting:** Differences in study outcomes, age ranges, definitions of injury severity, and methodologies prevented meta-analysis.
3. **Limited reporting of confounders or risk adjustment:** Many observational studies lacked multivariable analyses, making causal inference difficult.
4. **Bias toward hospital-admitted cases:** Minor injuries, prehospital deaths, and roadside fatalities may be underrepresented.
5. **Incomplete reporting of long-term outcomes in several studies:** Only one study provided detailed quality-of-life follow-up; others had limited post-discharge outcomes.
6. **Potential publication bias:** Negative or non-significant findings are less likely to be published, particularly in LMIC settings.

Recommendations for Future Research:

1. Large multicenter national databases are needed to accurately estimate RTA incidence, patterns, and outcomes across diverse Indian populations.
2. Longitudinal cohort studies with standardized outcome metrics (QoL, disability scores, return-to-work) are required to understand long-term burden.
3. Intervention-based research evaluating the effectiveness of helmet campaigns, road engineering modifications, and EMS upgrades should be prioritized.
4. Enhanced reporting of prehospital care quality and first-responder interventions is needed to guide improvements in trauma systems.
5. Genomic and biomechanical studies can be explored to understand factors influencing injury severity in two-wheeler crashes.
6. Cost-effectiveness studies on helmet distribution, speed enforcement, and trauma care training can guide government policy.

CONCLUSION AND IMPLICATIONS FOR TRANSLATION:

Road traffic injuries (RTIs) remain a critical public health challenge in India, contributing significantly to mortality, long-term disability, and economic loss. The burden falls disproportionately on children and young adults, who represent the most economically productive segment of society. Evidence consistently shows that head and abdominal injuries are among the most common and severe trauma outcomes, making RTIs a leading cause of both overall and pediatric trauma deaths. Preventive measures play a pivotal role in reducing this burden. Helmet use is one of the most effective interventions, substantially lowering the risk of severe head injury and mortality among motorcyclists. Similarly, evidence supports conservative, non-operative management as a successful strategy for blunt abdominal and liver trauma in selected patients, demonstrating the importance of evidence-based clinical decision making. However, gaps in prehospital care, such as delayed emergency response and inadequate triage, continue to compromise outcomes. Advances such as the CRASH model for traumatic brain injury provide promising opportunities for improved prognostication and patient management. A comprehensive response to India's road safety crisis must combine strengthened public education campaigns, stricter enforcement of traffic laws, and improved trauma systems. Integrating preventive strategies with timely, evidence-based clinical care can significantly reduce the health and socioeconomic impact of RTIs.

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Declaration of Patient Consent: Not applicable. No individual patient data, images, or identifiers were collected or used in this review.
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Disclaimer: None.

Key Messages

- Road traffic accidents in India disproportionately affect young adults, motorcyclists, and children, making them a major preventable public health burden.
- Helmet use and early prehospital triage significantly reduce severe injury and mortality, highlighting the importance of strict enforcement and improved EMS systems.
- Evidence supports non-operative management for many abdominal and liver injuries, emphasizing the need for standardized trauma protocols and strengthened trauma care networks.

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Figure:

Figure 1. Types of road traffic accident across India.



Figure Legend: This figure presents the distribution of different types of road traffic accidents across India, including two-wheeler collisions, pedestrian injuries, automobile crashes, and heavy-vehicle impacts. Two-wheeler accidents constitute the largest proportion, highlighting the vulnerability of motorcyclists and the importance of helmet use and road-safety enforcement.

Tables:

Table 1. PRISMA Search Strategy and Study Selection Summary

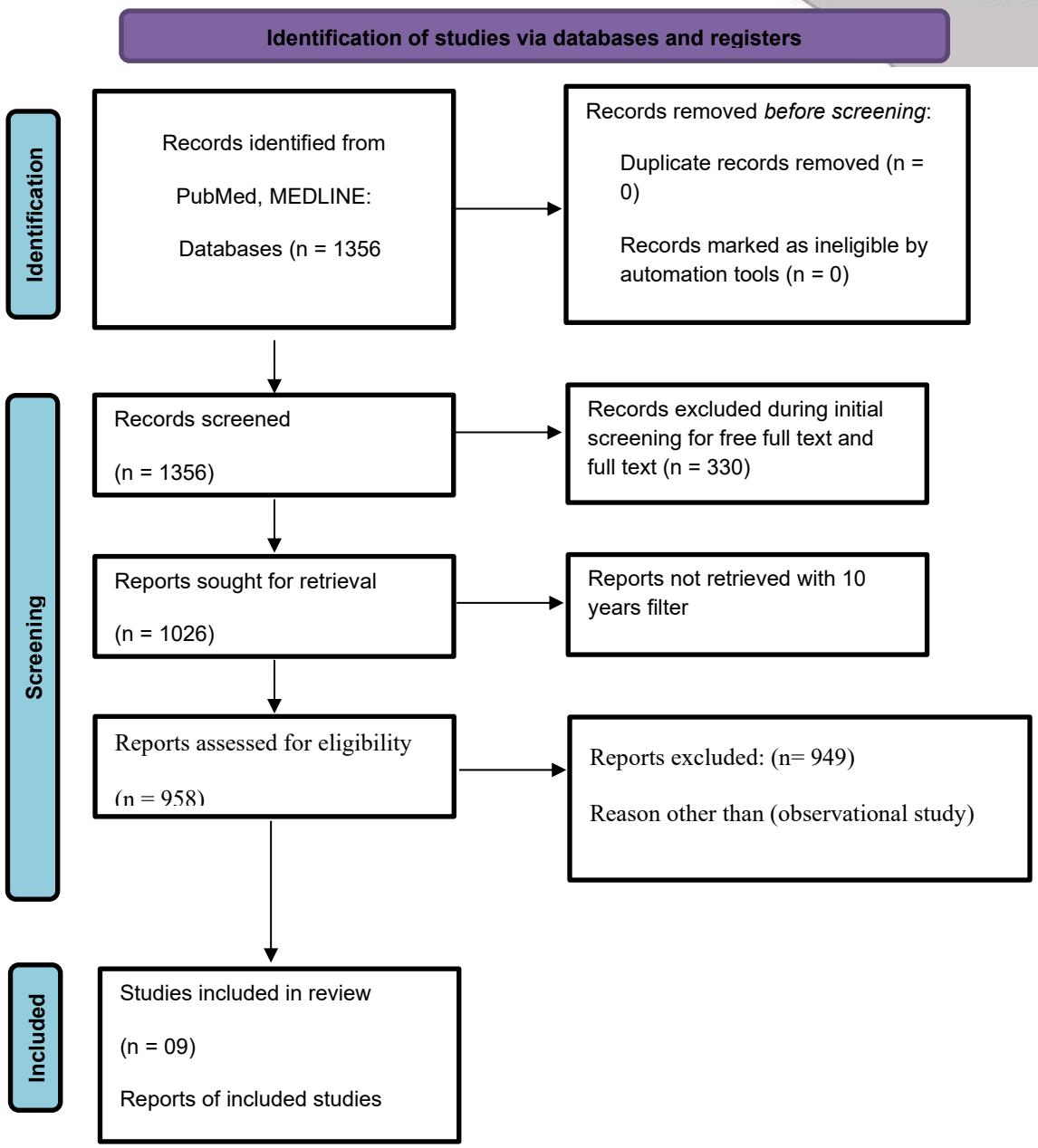


Table Legend: This table summarizes the PRISMA-based search strategy and study selection process for the systematic review, identifying 9 eligible observational studies from an initial 1,356 records.

Table 2. Overview of Clinical and Epidemiological Studies on Road Traffic Injuries in India

S.No	Study Title & Design	Population & Setting	Focus Area	Summary of Findings
1	The impact of road traffic injury in North India: a mixed-methods study protocol	1500 RTI patients; Chandigarh and Panchkula (public hospitals)	Functional, economic & social impact of RTIs	High long-term disability, economic burden, caregiver stress;

	Design: Prospective cohort + qualitative interviews			gaps in insurance & rehabilitation.
2	Epidemiological trends of fatal pediatric trauma: A single-center study Design: Retrospective chart review	Children <18 years; single tertiary center	Pediatric trauma mortality patterns	RTAs and head injuries were leading causes of pediatric trauma death.
3	Epidemiology of pelvic fractures in adults: Our experience at a tertiary hospital Design: Prospective observational	Adults with pelvic fractures; tertiary care center	Mechanisms and injury classification	RTAs most common cause; Type B fractures prevalent; high ICU demand.
4	Management of liver trauma in urban university hospitals in India Design: Multicentre cohort (observational)	Liver trauma patients; multiple urban hospitals	Operative vs non-operative management	Majority managed conservatively; mortality linked to injury severity.
5	A profile of traumatic injury in the prehospital setting in India Design: Prospective observational	All trauma cases attended by EMS in 7 states	Prehospital injury pattern and response	RTAs common; long response times; limited first-aid at scene.
6	Study of risk factors, clinical spectrum, and outcome for head injury in pediatric age group Design: Prospective hospital-based study	Pediatric head injury patients; Western India	Clinical spectrum and risk factors	Falls and RTAs major causes; GCS <8 and delays linked to poor outcome.
7	Head injury patterns in motorcycle riders wearing/not wearing helmets Design: Prospective comparative study	Motorcyclists with head injuries; urban hospital	Helmet use and injury severity	Non-helmet users had more severe injuries and higher ICU need.
8	Spectrum of paediatric blunt abdominal trauma Design: Retrospective clinical audit	Children with blunt abdominal trauma; tertiary center	Organ injury profile and management	Liver/spleen injuries most common; conservative treatment successful.
9	External Validation of CRASH Prognostic Model Design: Prospective model validation	Moderate/severe TBI patients; urban tertiary hospital	Prognostic accuracy of CRASH model	Model predicted mortality and recovery well; useful for triage.

Table Legend: This table summarizes the design, population, clinical focus, and major findings of the nine observational studies included in the systematic review.

Table 3. Review of Injury Patterns and Public Health Implications from Indian RTI Research

Main Area	Studies observed
High Burden of RTIs	Road traffic injuries are a major cause of trauma in both adults and children across India. They lead to serious health and economic problems.
Impact on Children	RTIs often cause serious injuries and deaths in children, especially head and abdominal injuries.
Common Injury Types	The most frequent injuries from RTIs include head, pelvic, and liver injuries, mostly affecting young males.
Helmets Save Lives	Wearing helmets while riding motorcycles greatly reduces the severity of head injuries.
Emergency Care Gaps	There are delays in getting medical help after an accident, which can make outcomes worse.
Effective Treatment	In many cases, surgery is not needed for abdominal or liver injuries; non-surgical care works well.
Predicting Outcomes	A tool called the CRASH model helps doctors predict recovery chances in head injury patients.

Table Legend: This table summarizes recurring themes and public health implications identified across the included studies on road traffic injuries in India.

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