Integrated Databases for Enhanced QALY/DALY-Based Economic Assessments of Traffic Accidents in Algeria

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ARTICLE INFO	ABSTRACT
	Introduction: Road traffic injuries pose a significant public health and economic burden in Algeria, particularly among young, active populations. Despite the global adoption of DALY and QALY metrics for health planning, Algeria's fragmented data systems hinder accurate burden estimation. This paper proposes an integrated national database framework to enhance the reliability of BoD metrics, support evidence-based policymaking, and guide targeted interventions for improved road safety and health outcomes. **Objectives**: This paper aims to develop a policy framework for integrating health, transport, and demographic data systems in Algeria to improve the accuracy of DALY and QALY metrics and support effective road traffic injury interventions. **Methods**: This study uses a qualitative, policy-focused approach that combines comparative analysis and institutional feasibility assessment to improve DALY and QALY estimations in Algeria. Drawing on secondary sources from WHO, IHME, and national agencies in Sweden and Australia, the methodology involves four steps: benchmarking international data systems, mapping Algeria's current databases, analyzing stakeholder roles, and projecting improvements in BoD metrics from data integration. The process aligns global best practices with Algeria's institutional context to inform a practical framework for enhancing road injury data quality and supporting evidence-based public health and transport policy. **Results**: The study revealed major obstacles to generating accurate DALY and QALY estimates in Algeria due to fragmented institutions, inconsistent technical standards, legal limitations, and human resource shortages. Data on traffic injuries are dispersed across ministries with limited coordination or interoperability. A proposed National Integrated Road Injury Data System (NIRIDS) addresses these issues through a modular, interoperable architecture linking health, police, mortality, and survey data. Key stakeholders and governance structures are identified, with a phased implementation strategy beginning with urban pilots and scaling nationally. The framework emphasizes secure data sharing, digital infrastructure upgrades, and the need for strong political and institutional commitment. **Conclusions**: Algeria must modernize its approach to road traffic injury prevention through integrated, data-driven systems. Establishing NIRIDS, supported by legal reform, governance structures, digital infrastructure, and international partnerships, will enable accurate BoD metrics, guide resource allocation, and improve health policy, safety interventions, and long-term outcomes. **Keywords:** Burden of Disease, Road Traffic Injuries, Integrated Health Data Systems, DALY and QALY Estimation.

INTRODUCTION

Road traffic accidents (RTAs) represent one of the most severe public health concerns worldwide, particularly affecting low- and middle-income countries (LMICs). The World Health Organization (2023) estimates that approximately 1.19 million individuals lose their lives each year due to road crashes, while tens of millions sustain injuries, many of which result in permanent disabilities (Ahmed, et al., 2023). Although LMICs possess only 60% of the global vehicle fleet, they account for more than 90% of all road-related deaths, reflecting systemic disparities in road safety and healthcare capacity (Ameratunga, Hijar, & Norton, 2006). Algeria, as a middle-income North African country, illustrates this

global issue. The combination of rapid urbanization, increasing motorization, and limited traffic safety infrastructure has elevated RTAs as a major cause of premature death and long-term disability.

Among the most affected groups in Algeria are young adults aged 15 to 44, a demographic that forms the backbone of the country's labor force. According to national data, nearly 22,000 road crashes are recorded annually, resulting in approximately 3,300 fatalities and more than 30,000 injuries (National Delegation for Road Safety, 2023). These statistics likely underestimate the true burden, as minor injuries and long-term consequences often go unreported. The economic costs associated with RTAs, including healthcare expenditures, rehabilitation services, emergency responses, loss of productivity, and damage to infrastructure, are estimated to represent between 1.5% and 3% of Algeria's Gross Domestic Product (Belakhdar, Assessing the Burden of Years of Life Lost (YLL) Due to Traffic Fatalities in Algeria (2020-2023), 2024). This dual burden of human suffering and economic loss signals the urgent need for data-driven road safety strategies.

Over the past decade, national trends in Algeria indicate some improvement. The number of reported traffic accidents fell from 40,101 in 2014 to 22,751 in 2023 (Belakhdar, The Economic Cost of Years Lived with Disability (YLD) Due to Traffic Accident Injuries in Algeria (2020-2023), 2025). Fatalities declined from 4,812 in 2014 to approximately 3,300 in 2022, although the number rose to 3,628 in 2023, which may reflect more comprehensive reporting. Similarly, injuries decreased from over 65,000 in 2014 to around 30,000 in recent years (Laouar, Benmechiche, Benaissa, & Bennacer, 2024). Despite these declines, injury rates remain high, and the quality and consistency of the data remain questionable (Belakhdar, Estimating the Economic Burden of Quality-Adjusted Life Years (QALYs) Losses from Road Accidents in Algeria (2020–2023), 2025). Fluctuations in reporting methods and underrepresentation of non-fatal and long-term outcomes weaken the country's ability to assess the true impact of RTAs.

1. The Relevance of Burden of Disease Metrics

The Burden of Disease (BoD) framework has become a cornerstone in public health analysis and policymaking. It provides a comprehensive means of measuring population health loss, combining both mortality and morbidity into unified indicators. Two widely recognized BoD metrics are Disability-Adjusted Life Years (DALYs) and Quality-Adjusted Life Years (QALYs). DALYs aggregate two components: Years of Life Lost (YLL) due to premature mortality, and Years Lived with Disability (YLD), which accounts for non-fatal health consequences (Mauricio , 2019). In contrast, QALYs adjust years lived based on quality of life, applying utility values that range from 0 (death) to 1 (perfect health) to each year of life (Sassi, 2006).

These metrics enable health authorities and policymakers to quantify the impact of diseases and injuries in a standardized manner. In the context of RTAs, DALYs and QALYs provide a more accurate reflection of burden than mortality data alone, capturing the full range of physical, psychological, and economic consequences. They are instrumental in identifying high-risk populations, evaluating policy interventions, and conducting cost-effectiveness analysis of health programs. In countries with strong data systems, BoD metrics inform decisions about trauma care allocation, emergency service coverage, road safety investments, and injury prevention campaigns (Peden, et al., 2004). However, the usefulness of these metrics depends heavily on the availability and quality of underlying data across sectors.

2. Fragmentation of Health and Transport Data in Algeria

Despite efforts to improve road safety, Algeria continues to face substantial limitations in its capacity to produce accurate Burden of Disease (BoD) estimates due to the fragmentation of its data systems. Information related to traffic injuries is dispersed across multiple institutions, including police departments, the national gendarmerie, civil protection services, insurance companies, health services, the National Center for Road Safety and Prevention, and the National Delegation for Road Safety. These entities often operate independently, each using distinct data standards, definitions, and digital platforms.

The lack of interoperability among these databases presents major challenges. Variations in coding practices—such as inconsistent application of the International Classification of Diseases (ICD-10)—hinder efforts to harmonize and analyze data across systems (Bougueroua & Carnis, 2016). Hospital records are frequently disconnected from police and national gendarmerie crash reports and mortality registries, limiting the ability to trace injury cases from the crash site to clinical outcomes and long-term recovery. This siloed data environment contributes to the underreporting

of non-fatal injuries and rehabilitation outcomes, resulting in incomplete or inaccurate estimates of Years Lived with Disability (YLD) and overall Disability-Adjusted Life Years (DALYs).

Fig.1. Institutional Fragmentation in Traffic Injury Data Collection in Algeria
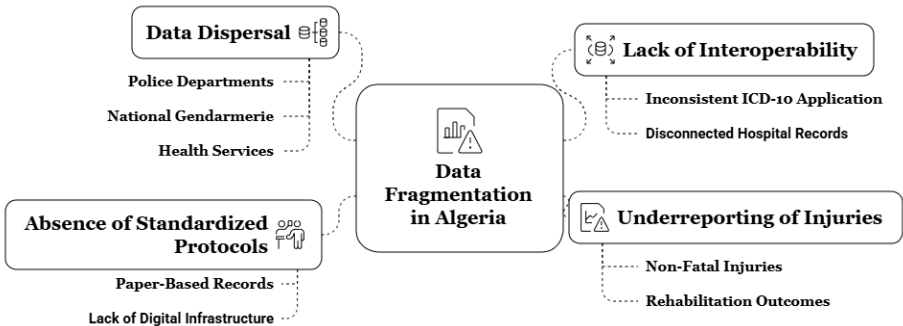
Source: Illustration by the authors

Moreover, the absence of standardized protocols for data collection and sharing exacerbates these challenges. Many health facilities and law enforcement agencies still rely on paper-based records, which not only delay reporting but also increase the risk of data loss and duplication. Without a robust digital infrastructure and coordinated governance, Algeria's current data environment falls short of supporting real-time injury surveillance or comprehensive BoD calculations.

3. The Role of Integrated Database Systems

Global experience illustrates the value of integrated database systems in strengthening the application of BoD metrics to injury prevention. In Sweden, the Swedish Traffic Accident Data Acquisition (STRADA) system links police reports and hospital records to provide a national-level platform for monitoring road traffic injuries. This integration has significantly improved the quality and timeliness of injury data, enhancing the effectiveness of road safety interventions and enabling more accurate DALY estimates (Astrid, Peter, & Per, 2019).

Australia offers another instructive example through its National Injury Surveillance Unit (NISU), which consolidates data from hospitals, transport agencies, and mortality records. This comprehensive approach allows for detailed analysis of injury trends by age, gender, location, and severity, supporting both policy evaluation and public health planning (Cameron, Williamson, O'Connor, & Richardson, 1993). These integrated systems enable health authorities to track injuries across the continuum of care—from the initial crash through hospitalization, rehabilitation, and final outcomes—providing a holistic view of population-level health loss.

Such models demonstrate that interoperable data ecosystems are not merely technical tools but strategic assets in the governance of road safety. They facilitate targeted interventions, timely evaluation of policy outcomes, and efficient allocation of public health resources. For Algeria, adopting similar systems would offer an opportunity to modernize its injury surveillance architecture, enhance data-driven policymaking, and align with international health information standards.

OBJECTIVES

This study aims to address the structural barriers that hinder Algeria's ability to use BoD metrics effectively for traffic injury prevention. It proposes a policy-oriented framework for integrating health, transport, and demographic databases into a unified national system capable of generating reliableBoD metrics such as DALY and QALY estimates. Drawing on comparative analysis of Sweden's and Australia's experiences, the study evaluates Algeria's current institutional and technical capacities and outlines a phased implementation strategy for a National Integrated Road Injury Data System (NIRIDS).

This approach responds directly to Algeria's growing commitment to modernize its public health infrastructure and reduce preventable causes of death and disability. The establishment of an integrated, interoperable data system would empower decision-makers to better understand the real burden of RTAs, allocate resources more efficiently, and improve outcomes through evidence-based interventions. The findings and recommendations outlined in this

paper are intended to support the design of future health and transport policy reforms anchored in reliable, cross-sectoral data.

LITERATURE REVIEW

The Disability-Adjusted Life Year (DALY) and the Quality-Adjusted Life Year (QALY) are cornerstone metrics in the field of health economics and burden of disease (BoD) assessment. Developed to quantify the health impact of diseases and injuries, both metrics integrate morbidity and mortality data into a single value that represents the loss or gain of healthy life years (Dimoliatis, 2004).

DALY was introduced through the Global Burden of Disease Study led by the World Bank and the World Health Organization in the early 1990s. It is calculated as the sum of Years of Life Lost (YLL) due to premature death and Years Lived with Disability (YLD), thereby capturing both fatal and non-fatal outcomes (Murray & Lopez, 1996). This measure is particularly suitable for understanding the burden of injuries such as those from road traffic accidents, which often result in significant disability even when death is avoided.

QALY, on the other hand, is widely used in cost-utility analysis to evaluate the effectiveness of health interventions. It combines life expectancy with a quality-of-life weight, typically ranging from 0 (death) to 1 (perfect health), to reflect the value of health outcomes (Weinstein & Stason, 1977). QALY allows for comparing interventions across diseases by standardizing outcomes in terms of both longevity and well-being.

These metrics have become essential tools in health decision-making, particularly in resource-limited settings where the prioritization of interventions based on economic and social returns is necessary (Russell, Gold, Siegel, Daniels, & Weinstein, 1996). Their effectiveness, however, is deeply dependent on the quality, completeness, and integration of underlying data systems.

1. Applications of DALY and QALY in Road Traffic Injury Analysis

The application of DALY and QALY metrics in road traffic injury analysis has grown substantially over the past two decades. Road traffic injuries often have complex outcomes that include both immediate fatalities and long-term disabilities, making them particularly suitable for BoD estimation. For instance, YLL captures early mortality due to crashes, while YLD reflects outcomes such as spinal cord injuries, traumatic brain injuries, and amputations, which require extended rehabilitation or result in permanent functional limitations (Tainio, Olkowicz, Teresiński, de Nazelle, & Nieuwenhuijsen, 2014).

In global estimates, road traffic injuries consistently rank among the top ten causes of DALYs lost, particularly among adolescents and young adults (GBD 2019, 2022). These findings emphasize the need for countries to invest in high-quality data collection and integration mechanisms to ensure DALY and QALY estimates reflect actual population-level trends. The presence of reliable estimates allows for evidence-based policymaking, particularly in relation to road safety planning, investment in trauma care, and rehabilitation services.

2. The Importance of Integrated Data for BoD Metrics

Accurate estimation of DALY and QALY relies on data from various sources, including hospitals, emergency services, police, vital registries, insurance providers, and population surveys. Fragmented or incomplete data can severely distort BoD estimates, leading to misinformed policies and resource misallocations. Integrated databases are essential for linking injury events across different points of the care continuum (crash occurrence, emergency response, hospitalization, recovery, or death).

Research has demonstrated that countries with centralized and interoperable databases are better equipped to assess the full impact of injuries. Integrated data systems improve the validity of epidemiological surveillance and economic evaluation and enhance the capacity to monitor interventions and respond rapidly to emerging trends (AbouZahr & Boerma, 2005).

For example, linking hospital discharge records with police reports enables the identification of non-fatal cases that would otherwise be missed if only one data source were used. Similarly, combining mortality registries with demographic data improves the accuracy of YLL estimations by ensuring that cause-of-death attributions align with standard classifications (Mahapatra, et al., 2007).

3. International Experiences with Integrated Injury Surveillance Systems

Several countries have developed and successfully implemented integrated injury surveillance systems, providing practical models for low- and middle-income countries such as Algeria. The Swedish Traffic Accident Data Acquisition System (STRADA) is a national database that integrates traffic injury data from the police and hospitals. Launched in 1996, STRADA collects standardized information on traffic incidents, including the nature of the crash, vehicle types involved, injury mechanisms, and medical outcomes. This system allows public health authorities, transportation planners, and law enforcement agencies to jointly analyze trends, assess policy interventions, and prioritize risk-reduction strategies (Skyving, 2015).

One key feature of STRADA is its real-time reporting capacity, which supports proactive safety measures and timely evaluations. The system has contributed to the development of Sweden's Vision Zero policy, a nationally coordinated initiative to eliminate road fatalities and serious injuries (Belin, Tillgren, & Vedung, 2012). STRADA's ability to deliver consistent and reliable DALY and QALY inputs has been instrumental in evaluating the long-term impact of traffic safety interventions.
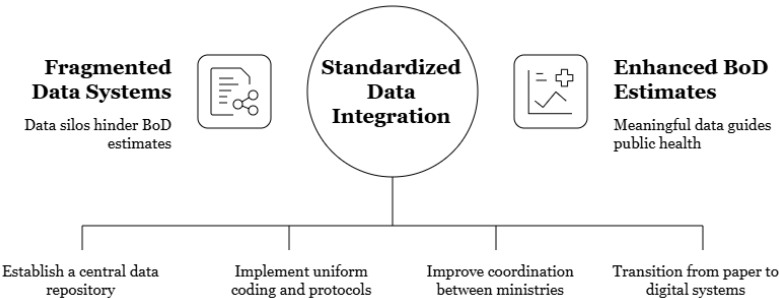
On the other hand, Australia has adopted a comprehensive approach to injury surveillance through the National Injury Surveillance Unit (NISU), managed by the Australian Institute of Health and Welfare. NISU integrates data from hospitals, coroners, emergency departments, and transport authorities. It supports nationwide research on injury trends, risk factors, and health outcomes (Australian Institute of Health and Welfare, 2005).

The integration of datasets through NISU has enabled Australia to conduct longitudinal studies that inform national road safety strategies, including legislation on seatbelt usage, helmet mandates, and drink-driving limits. These data are also used in health economic modeling to estimate QALY gains and cost-effectiveness ratios of interventions (Waters, Hyder, & Phillips,, 2005). The Australian model demonstrates the utility of harmonized coding systems (such as ICD-10) and cross-sector collaboration in producing accurate BoD assessments that can directly influence policy development.

4. Challenges in Data Integration Across LMICs

Despite the benefits observed in high-income countries, many LMICs face significant barriers to integrating data systems for BoD calculations. Challenges include institutional fragmentation, lack of standardized data formats, insufficient digital infrastructure, and limited legal frameworks for data sharing (Koumamba, Bisvigou, Ngoungou, & Diallo, 2021). In some cases, data collection processes remain paper-based, leading to delays, inconsistencies, and reduced data quality.

Fig.2. Integrating Data Systems for BoD Calculations

Fragmented Data Systems — Data silos hinder BoD estimates

Standardized Data Integration

Enhanced BoD Estimates — Meaningful data guides public health

Establish a central data repository | Implement uniform coding and protocols | Improve coordination between ministries | Transition from paper to digital systems

Source: Illustration by the authors

Additionally, there is often a lack of coordination between ministries and agencies, particularly between the health and transport sectors. This misalignment prevents the establishment of centralized data repositories and limits the country's capacity to monitor injury outcomes over time. Studies from sub-Saharan Africa and South Asia have identified these barriers as major constraints to the operationalization of DALY and QALY metrics in policy frameworks (Mbondji, et al., 2014).

These challenges mirror the current situation in Algeria, where data related to road traffic injuries are collected by disparate entities, including the police, national gendarmerie, civil protection services, insurance companies, health

services, the National Center for Road Safety and Prevention, and the National Delegation for Road Safety, without standardized coding or linkage protocols. Overcoming these structural and institutional obstacles is critical to enhancing Algeria's capacity to generate meaningful BoD estimates that can guide public health interventions.

METHODS

This study adopts a qualitative, policy-focused methodology combining comparative analysis and institutional feasibility assessment to explore how integrated data systems from other countries could enhance Burden of Disease (BoD) estimations, with a particular focus on Disability-Adjusted Life Years (DALY) and Quality-Adjusted Life Years (QALY) in Algeria. The analysis draws on secondary data from peer-reviewed literature, policy documents, and institutional reports, with key references including the World Health Organization (WHO), the Institute for Health Metrics and Evaluation (IHME), and national agencies in Sweden and Australia.

The research process comprises four interlinked steps. First, international benchmarking was conducted using Sweden's STRADA system and Australia's National Injury Surveillance Unit, both recognized for their ability to integrate hospital, police, and mortality data to generate reliable injury metrics. Second, Algeria's current data systems were mapped to identify gaps, redundancies, and barriers to interoperability across health, transport, and civil registration sectors. The third step involved analyzing stakeholder roles to assess institutional responsibilities and coordination potential between key actors such as the Ministry of Health, Ministry of Transport, National Gendarmerie, and the National Statistics Office. Lastly, a hypothetical projection was developed to estimate how integrated data systems could improve the accuracy of DALY and QALY calculations, particularly through the inclusion of unreported non-fatal injuries.

Together, these methodological steps provide a practical foundation for developing an integrated framework aligned with both global best practices and the contextual realities of Algeria's public health and transport sectors.
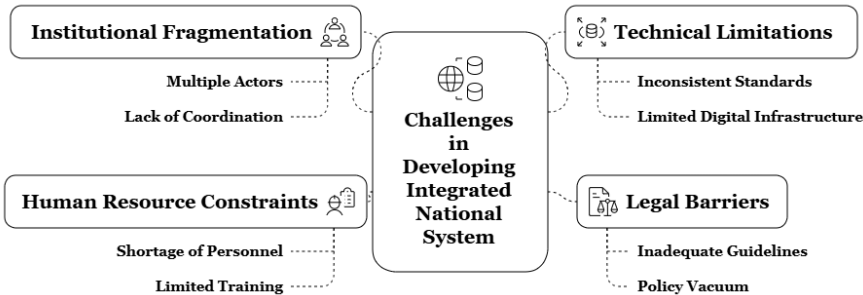
RESULTS

This section presents the results of an in-depth analysis of Algeria's current landscape for the estimation of Burden of Disease (BoD) metrics—Disability-Adjusted Life Years (DALY) and Quality-Adjusted Life Years (QALY)—in the context of road traffic injuries. It begins by identifying systemic challenges that hinder the development of an integrated and functional data ecosystem capable of supporting accurate, comprehensive, and policy-relevant BoD estimates. These challenges include institutional fragmentation, inconsistent technical standards, legal constraints, and shortages in human capital, all of which contribute to data silos and undermine intersectoral coordination. The second part of the section builds on these findings to propose a tailored framework for a National Integrated Road Injury Data System (NIRIDS). This proposed model outlines the necessary data architecture, stakeholder roles, governance mechanisms, and phased implementation strategy needed to overcome existing barriers and foster a unified, data-driven approach to road safety and public health decision-making in Algeria.

1. Challenges in the Algerian Context

Efforts to develop an integrated national system for estimating Burden of Disease (BoD) metrics such as Disability-Adjusted Life Years (DALY) and Quality-Adjusted Life Years (QALY) face numerous systemic challenges in Algeria. These challenges stem from institutional fragmentation, technical and legal constraints, human resource limitations, and geographic disparities. Collectively, they hinder the production of accurate and actionable health data necessary for evidence-based policymaking in the context of road traffic injuries.

Fig.3. Challenges in Developing an Integrated BoD System in Algeria

Institutional Fragmentation	Technical Limitations
Multiple Actors	Inconsistent Standards
Lack of Coordination	Limited Digital Infrastructure
Human Resource Constraints	Legal Barriers
Shortage of Personnel	Inadequate Guidelines
Limited Training	Policy Vacuum

Challenges in Developing Integrated National System

Source: Illustration by the authors

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1.1. Institutional Fragmentation and Lack of Coordination

A major obstacle to data integration in Algeria is the lack of institutional coordination. Multiple actors, including the Ministry of Health, the Ministry of Transport, the National Gendarmerie, emergency services, police, insurance providers and the National Statistics Office, collect and manage road traffic injury data independently. Each body operates with its own objectives, definitions, and reporting protocols. Without a central coordinating mechanism or legal mandate for data exchange, efforts to build a coherent BoD data infrastructure remain fragmented (Bhatti, Razzak, Lagarde, & Salmi, 2011). For instance, police crash reports, hospital records, and mortality registries exist in parallel systems with minimal interoperability, which impedes the ability to track cases across the continuum of care and calculate DALY or QALY accurately.

1.2. Technical Limitations and Data Standards

The problem is compounded by inconsistencies in data standards and limited use of digital infrastructure. Different agencies apply varying case definitions and classification systems. While the Ministry of Health often relies on ICD-10 for disease coding, law enforcement and transport authorities lack standardized clinical classifications, making injury data difficult to align (Bhalla, 2009). Many institutions continue to rely on paper-based systems, particularly in remote areas, resulting in delayed reporting, data loss, and reduced reliability (Nankunda & Evdorides, 2025). Even where digital systems exist, they are rarely compatible. Health facilities, police departments, and civil registries often use different software or data formats, preventing the seamless integration of injury-related information.

The lack of a national data linkage mechanism, such as unique patient identifiers, further restricts cross-sectoral tracking of health outcomes. As a result, non-fatal injuries, long-term disabilities, and rehabilitation outcomes are often underreported, contributing to a significant underestimation of the total burden of road traffic injuries.

1. 3. Legal Barriers and Governance Gaps

Inadequate legal and regulatory frameworks also limit data sharing across institutions. Without clear guidelines on consent, anonymization, and data security, institutions are hesitant to share sensitive information, even when it serves a public health interest (Williams, Axelsen, & Brea, 2024). In contrast, countries like Sweden and Australia have developed strong data governance models supported by privacy legislation, enabling them to build integrated systems that still safeguard individual rights (Australian Digital Health Agency, 2020). This legal uncertainty contributes to institutional risk aversion and slows down the modernization of Algeria's health information system.

1.4. Human Resource Constraints and Regional Disparities

Human capital represents another critical limitation. There is a shortage of trained personnel in health informatics, epidemiology, and data management within both the health and transport sectors. This shortage affects not only the quality of data collection but also the analytical capacity needed to interpret BoD metrics and integrate them into health policy decisions (AbouZahr & Boerma, 2005). Most public sector employees involved in data reporting receive limited or no training on international standards or digital systems, further weakening institutional readiness.

As a result, BoD estimates based on incomplete or uneven data may fail to reflect the true burden of injuries across Algeria's population (Jayathissa & Hewapathirana, 2023). Addressing these structural challenges requires a coordinated national strategy, investment in infrastructure and human resources, and the creation of enabling legal frameworks. Without these foundational reforms, the vision of a unified, data-driven road safety policy will remain out of reach.

2. Proposed Framework for Integrated Databases

The persistent fragmentation of health, transport, and demographic data systems in Algeria creates significant barriers to the effective application of Burden of Disease (BoD) metrics, particularly for assessing the public health impact of road traffic injuries. Inconsistent data collection methods, limited interoperability across sectors, and incomplete records characterize this fragmentation, undermining the reliability of critical metrics such as Disability-Adjusted Life Years (DALY) and Quality-Adjusted Life Years (QALY). These metrics play a vital role in quantifying the health and economic burden of road traffic injuries, a leading cause of morbidity and mortality in Algeria. The absence of a unified data infrastructure complicates efforts to identify high-risk populations, prioritize interventions, and evaluate the impact of road safety measures. As a result, policymakers and public health officials face challenges in developing

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evidence-based strategies to reduce the burden of road traffic injuries, limiting the country's ability to address this pressing public health issue effectively.

Fig.4. NIRIDS Data Integration Process
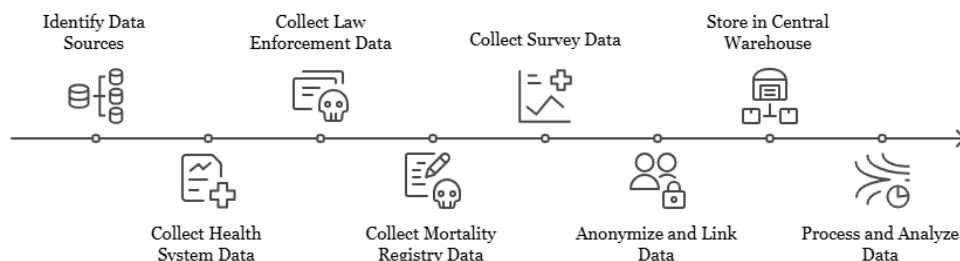
Source: Illustration by the authors

This section proposes the development of a National Integrated Road Injury Data System (NIRIDS), drawing on international best practices while tailoring solutions to Algeria's unique administrative, cultural, and infrastructural context. The NIRIDS framework aims to address institutional gaps through the establishment of a centralized, interoperable platform that integrates data from health facilities, traffic police, emergency services, and demographic registries. Standardized data collection protocols, regular audits to ensure data quality, and modern technologies such as cloud-based storage and real-time reporting would enhance accessibility and timeliness. Collaboration among government agencies, healthcare providers, and research institutions would be fostered, enabling more accurate estimations of DALYs and QALYs to support targeted interventions. The proposed system seeks to establish a robust evidence base for a coordinated, data-driven public health response, addressing the immediate challenges of road traffic injuries while strengthening Algeria's broader health information ecosystem for future public health initiatives.

2.1. Data Architecture and Functional Design

An effective NIRIDS requires a modular, interoperable data architecture capable of linking records across institutions while preserving data integrity and privacy. The core design must support real-time and retrospective data integration across four primary domains: health services, law enforcement, mortality registration, and population health surveys.

Health system data must encompass emergency room visits, intensive care unit (ICU) admissions, surgical procedures, hospital discharge summaries, and long-term rehabilitation outcomes. These data are currently scattered across public hospitals, private clinics, and insurance providers. Linking them to crash data can provide insight into injury severity, clinical pathways, and recovery durations. In countries like Sweden and Australia, health records form the backbone of road injury surveillance, allowing for accurate calculation of Years Lived with Disability (YLD) (Kesicki & Bracker, 2014).

Law enforcement records, including crash scene reports, vehicle types, road and weather conditions, time of day, driver behavior, and use of safety equipment, must be digitized and standardized. These datasets, primarily generated by the National Gendarmerie and police units, can serve as the entry point for case tracking. Their integration with clinical data allows for a full incident-to-outcome continuum necessary for DALY estimations.

Mortality registries, housed within the Ministry of Interior and civil status offices, need to capture cause-specific deaths using standardized classifications, particularly ICD-10 codes. This layer enables the estimation of Years of Life Lost (YLL) and must be consistently linked to crash and clinical data.

National health and population surveys, including quality-of-life measures and disability tracking, should complement administrative records to refine QALY estimates. These surveys can provide utility weights based on self-reported health states, particularly for post-accident recovery trajectories, which administrative data may overlook (Russell, Gold, Siegel, Daniels, & Weinstein, 1996).

All data should be anonymized and linked using unique, encrypted patient identifiers that permit longitudinal follow-up across multiple systems while maintaining strict confidentiality. A central data warehouse, equipped with automated data cleaning algorithms and quality assurance protocols, should serve as the primary repository for analytical processing.

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2.2. Key Stakeholders and Institutional Roles

A successful integrated data framework for the National Integrated Road Injury Data System (NIRIDS) hinges on robust technical design and effective stakeholder collaboration. The National Delegation for Road Safety serves as the lead data custodian, overseeing the standardization, integration, and governance of road injury data across all sectors. It ensures alignment with national and international reporting standards, such as Burden of Disease (BoD), and maintains the integrity and security of the centralized data system while coordinating data-sharing protocols among stakeholders.

The police and national gendarmerie, operating under the Ministry of Interior, are tasked with digitizing and standardizing crash reports. They ensure accurate and timely data collection at accident scenes and facilitate seamless data exchange with healthcare and civil protection services. Their role also includes supporting enforcement-related analytics to enhance road safety measures, contributing critical data to the NIRIDS framework.

Civil protection services play a vital role by providing first-response data, including incident details and initial medical interventions at crash sites. They collaborate closely with health services to ensure a smooth flow of emergency response data, contributing to real-time reporting within the NIRIDS framework. Their timely and accurate data collection is essential for capturing the immediate impact of road injuries.

Health services, managed by the Ministry of Health, focus on standardizing medical coding practices, overseeing hospital data entry, and tracking rehabilitation outcomes. Their work ensures compatibility with international health information systems and provides essential medical data for calculating Years Lived with Disability (YLD) and Disability-Adjusted Life Years (DALY), strengthening the analytical foundation of the NIRIDS system.

Insurance companies, such as CNAS and CASNOS, contribute administrative data on medical reimbursements, rehabilitation durations, and patient follow-ups. These datasets are crucial for refining YLD estimates and conducting cost-of-injury analyses, enhancing the economic accuracy of the NIRIDS framework. Meanwhile, the National Statistics Office (ONS) harmonizes classification systems across health, transport, and civil registration datasets, leveraging statistical expertise to produce BoD estimates, support Quality-Adjusted Life Years (QALY) models, and meet national and international reporting requirements.

Academic and research institutions conduct advanced epidemiological analyses, develop DALY and QALY models, and validate data outputs through peer-reviewed studies, ensuring methodological transparency and training health economists (Tan-Torres Edejer, et al., 2023). Civil society organizations, including road safety and disability advocacy groups, contribute qualitative data and support community engagement in data collection and health education, fostering inclusivity and accountability. This multi-sectoral approach, led by the National Delegation for Road Safety, ensures a robust, transparent, and inclusive road injury data framework.

2.3. Governance and Regulatory Framework

To ensure effective coordination and operation of the National Integrated Road Injury Data System (NIRIDS), the National Delegation for Road Safety, as the lead data custodian, will serve as the central governance body. Positioned to facilitate inter-sectoral collaboration, this anchoring ensures alignment with the roles of key stakeholders, including police, national gendarmerie, civil protection services, health services, insurance companies, the National Statistics Office (ONS), academic institutions, and civil society organizations, fostering unified commitment to road safety data integration.

The National Delegation for Road Safety will define data standards, validate data-sharing protocols, oversee system architecture, and ensure compliance with national and international data protection regulations. It will operate through specialized working groups addressing technical standards, ethical compliance, capacity building, and policy implementation, ensuring seamless collaboration among stakeholders like health services for medical data standardization and the ONS for harmonized classification systems.
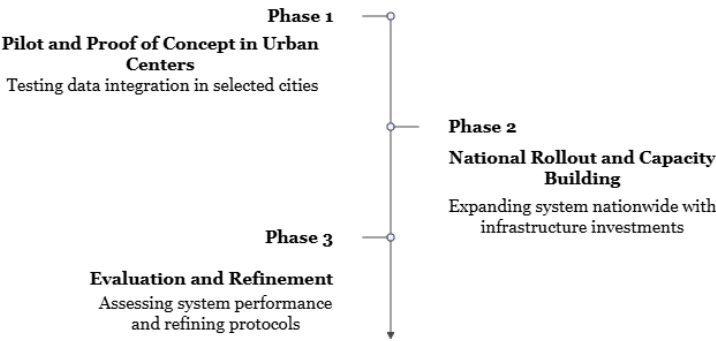
A dedicated legislative framework will enshrine the National Delegation's mandate, mandating data interoperability among institutions such as the police, national gendarmerie, and insurance companies, while guaranteeing the protection of personal information. Drawing on principles from the European Union's General Data Protection Regulation (GDPR), this framework will ensure that data shared across sectors are anonymized, used exclusively for public health and road safety purposes, and safeguarded with robust cybersecurity measures (OECD, 2022).

The National Delegation will publish annual Burden of Disease (BoD) reports and road safety performance indicators, leveraging contributions from academic institutions for analytical rigor and civil society for community insights. These reports will be disseminated to relevant stakeholders, including health services, insurance companies, parliamentarians, and advocacy groups, ensuring transparency and fostering evidence-informed public discourse.

2.4. Implementation Phases and Timeline

The operationalization of the National Integrated Road Injury Data System (NIRIDS), led by the National Delegation for Road Safety, follows a phased approach to ensure technical learning, institutional adaptation, and resource mobilization.

Fig.5. NIRIDS Implementation Strategy

Phase 1
Pilot and Proof of Concept in Urban Centers
Testing data integration in selected cities

Phase 2
National Rollout and Capacity Building
Expanding system nationwide with infrastructure investments

Phase 3
Evaluation and Refinement
Assessing system performance and refining protocols

Source: Illustration by the authors

In Phase 1 (Pilot and Proof of Concept), the urban center of Batna is selected to test data integration protocols, reflecting its unique demographic and infrastructural context. The pilot links hospital admission data from health services with crash reports from police and national gendarmerie, alongside mortality registries, using unique patient identifiers. Civil protection services contribute first-response data, while the National Statistics Office (ONS) ensures standardized classifications. Technical audits and stakeholder feedback, including from insurance companies and academic institutions, guide system adjustments, with the National Delegation overseeing coordination and compliance with data protection standards.

Phase 2 (National Rollout and Capacity Building) expands the validated system nationwide, requiring significant investment in digital infrastructure, such as cloud-based data warehouses and enhanced connectivity for remote health centers. The National Delegation for Road Safety coordinates training for staff from health services, police, national gendarmerie, and civil protection services in data entry and analysis, ensuring interoperability across sectors. Insurance companies like CNAS and CASNOS provide administrative data to refine system outputs. Partnerships with international organizations, such as the World Health Organization (WHO) and the Institute for Health Metrics and Evaluation (IHME), may offer technical and financial support to strengthen capacity, aligning with the National Delegation's governance framework and legislative mandates for data sharing.

Phase 3 (Evaluation and Refinement) focuses on assessing NIRIDS performance through key indicators like data completeness, processing speed, interoperability, and accuracy of Burden of Disease (BoD) estimates, supported by ONS and academic institutions. External audits and peer-reviewed validations, involving research institutions, ensure analytical rigor, as referenced in prior methodologies (Tan-Torres Edejer, et al., 2023). The National Delegation for Road Safety refines protocols based on findings and may integrate new modules, such as disability outcomes or mental health tracking, incorporating inputs from civil society. Annual BoD reports and road safety performance indicators, disseminated to stakeholders like parliamentarians and advocacy groups, maintain transparency and align with the governance framework's commitment to evidence-informed public discourse.

DISCUSSION

The implementation of a National Integrated Road Injury Data System (NIRIDS), led by the National Delegation for Road Safety, holds transformative potential for public policy and health economics in Algeria. Accurate and timely health information, integrated from datasets provided by health services, police, national gendarmerie, civil protection services, insurance companies, and the National Statistics Office (ONS), enables reliable estimations of the burden of

road traffic injuries. This section outlines the major policy and economic benefits of NIRIDS, focusing on five key domains: improved burden of disease estimation, targeted intervention design, enhanced cost-effectiveness evaluation, evidence-based funding allocation, and alignment with international reporting standards.

1. Enhanced Accuracy of DALY and QALY Estimates

NIRIDS, under the governance of the National Delegation for Road Safety, will significantly improve Disability-Adjusted Life Years (DALY) and Quality-Adjusted Life Years (QALY) calculations. Currently, Algeria's estimates rely on fragmented data, with health services' hospital records often lacking follow-up data, police and national gendarmerie crash reports missing long-term injury outcomes, and civil protection services' data not systematically linked to mortality registries. This limits precise calculations of Years of Life Lost (YLL) and Years Lived with Disability (YLD). Integrating data across the entire care continuum—from crash site information gathered by civil protection services and police to hospitalization and rehabilitation records maintained by health services and insurance companies—will enable comprehensive tracking of injury cases. International studies project that accounting for underreported disability and mortality data could raise DALY estimates by 20–30%, revealing a more accurate burden and helping health services and the ONS design more effective responses (Magoola, Kobusingye, Bachani, Tumwesigye, & Kimuli, 2018).

2. Evidence-Based Targeting of Interventions

Reliable Burden of Disease (BoD) metrics, harmonized by the ONS and overseen by the National Delegation for Road Safety, allow policymakers to identify demographic and geographic patterns of road traffic injuries. Disaggregated data by age, gender, location, and injury severity, drawn from police, national gendarmerie, and civil protection services, can highlight high-risk groups and accident hotspots. For example, data might reveal elevated injury rates among young male motorcyclists in urban areas, prompting targeted safety campaigns led by civil society organizations or stricter enforcement by police. In Australia, integrated data systems guided investments in pedestrian infrastructure (Henley & Harrison, 2016). Similarly, NIRIDS could enable real-time surveillance, supported by civil protection services' first-response data and health services' medical records, allowing rapid deployment of countermeasures in high-incidence zones and dynamic adjustments to trends.

3. Strengthened Cost-Effectiveness Analyses

NIRIDS, with data contributions from insurance companies (e.g., CNAS, CASNOS) and analytical support from academic institutions, enhances the capacity for cost-effectiveness evaluations of road safety and health interventions. QALY and DALY metrics, refined through integrated data from health services and the ONS, allow health economists to assess interventions like new trauma centers by estimating lives saved and disabilities averted. These analyses, validated by academic institutions, help policymakers prioritize high-impact interventions, such as seatbelt enforcement or speed reduction measures, as seen globally (Akkari, Belakhdar, & Harkati, 2025). The National Delegation for Road Safety ensures that data from police, national gendarmerie, and insurance companies are standardized, enabling accurate cost-benefit comparisons in resource-constrained settings (Ambinintsoa, Bachani, Lauer, Lai, & Chisholm, 2018).

4. Efficient and Equitable Resource Allocation

Comprehensive BoD data, integrated by the National Delegation for Road Safety and harmonized by the ONS, enable equitable and efficient resource allocation across regions and populations. Current funding for emergency care, rehabilitation, and road safety often relies on outdated data, but NIRIDS provides real-time insights from civil protection services, health services, and insurance companies. For instance, a high DALY burden in specific wilayas could justify increased allocation of ambulances or trauma specialists, while data revealing disparities for women or elderly road users could prompt targeted interventions by civil society organizations. This approach ensures technical efficiency and distributive justice, directing resources to areas with the greatest need (Murray, et al., 2012).

5. Compliance with International Health and Safety Standards

Accurate DALY and QALY estimates, supported by the National Delegation for Road Safety's governance and the ONS's statistical expertise, enable Algeria to meet international commitments, such as the World Health Organization's reporting requirements and the United Nations Sustainable Development Goals (SDGs) Targets 3.6 and 17.18. Harmonized data from health services, police, national gendarmerie, and insurance companies improve

Research Article

Algeria's standing in global comparisons, such as the Institute for Health Metrics and Evaluation's Global Burden of Disease Study. Enhanced data quality, validated by academic institutions, increases eligibility for international technical and financial support from global donors (OECD, Health Data Governance: Privacy, Monitoring and Research, 2015), with the National Delegation ensuring compliance with data protection standards.

6. Economic Impact and Potential Cost Savings

NIRIDS, driven by integrated data from all stakeholders, could yield significant economic benefits. Road traffic injuries impose direct costs (emergency services, rehabilitation, insurance payouts) and indirect costs (productivity losses), estimated at 1.5–3% of GDP annually (Elvik, 2016). Real-time data from civil protection services and police can facilitate earlier interventions, while optimized rehabilitation through coordinated health services and insurance systems can enhance recovery outcomes. Together, these improvements could yield annual savings of approximately 1.2 billion DZD through reduced healthcare expenditures and increased productivity. Cost-benefit analyses, supported by academic institutions, offer a robust basis for investing in preventive infrastructure—such as safer pedestrian crossings—under the strategic direction of the National Delegation for Road Safety and with insights from civil society, ultimately reducing both human suffering and economic losses.

CONCLUSION

Algeria faces an unprecedented opportunity to transform its approach to road traffic injury prevention through a data-driven framework led by the National Delegation for Road Safety. Road traffic accidents impose a significant burden on public health and economic development, affecting thousands annually and straining public resources. Tools like Disability-Adjusted Life Years (DALYs) and Quality-Adjusted Life Years (QALYs) offer immense potential for evidence-based decision-making, but their effectiveness is limited by data fragmentation and lack of interoperability among stakeholders such as health services, police, national gendarmerie, civil protection services, insurance companies, and the ONS. Addressing these challenges is critical for building a responsive and equitable health system.

The National Integrated Road Injury Data System (NIRIDS), governed by the National Delegation for Road Safety, bridges institutional gaps by integrating data from health services, police, national gendarmerie, civil protection services, insurance companies, and the ONS. This unified system ensures comprehensive tracking of traffic-related injuries and fatalities across the care continuum—from crash site data collected by civil protection services to hospital records and rehabilitation outcomes from health services and insurance companies. A modular, interoperable database, standardized by the ONS and validated by academic institutions, supports precise DALY and QALY metrics, enabling accurate evaluation of policy interventions and efficient resource allocation.

Implementing NIRIDS requires a coordinated national effort led by the National Delegation for Road Safety. A pilot project in urban centers like Algiers, Oran, and Constantine, where data density and stakeholder capacity are robust, should test data linkages between police crash reports, civil protection first-response data, health services' hospital records, and insurance reimbursement data. These pilots will assess technical feasibility, identify challenges, and provide a foundation for nationwide scaling, allowing the National Delegation to refine data standards and protocols with input from civil society organizations.

The National Delegation for Road Safety, as the central governance body, ensures cross-sector coordination, defines data collection protocols, standardizes classification systems with the ONS, and enforces compliance with national data protection laws. Supported by working groups on technical standards, ethical compliance, and capacity building, it fosters collaboration among stakeholders and oversees annual Burden of Disease (BoD) reporting, incorporating insights from academic institutions and civil society to ensure transparency and accountability.

Legal and regulatory reform is essential to support NIRIDS. Algeria must enact legislation facilitating data sharing among police, national gendarmerie, health services, insurance companies, and the ONS while safeguarding privacy, drawing on principles from the European Union's General Data Protection Regulation. This legal framework, enforced by the National Delegation, will define stakeholder responsibilities, permissible data uses, and penalties for non-compliance, fostering a culture of collaboration across sectors.

Investment in digital infrastructure and human capital is critical. Many health and law enforcement facilities rely on paper-based systems, delaying data transmission and increasing errors. A phased digital transformation, guided by the National Delegation, should equip hospitals, police stations, and civil protection units with electronic data systems,

expand broadband connectivity, and train staff in data management. Strategic partnerships with organizations like the World Health Organization and the Institute for Health Metrics and Evaluation, facilitated by the National Delegation, will provide technical assistance and global best practices, enhancing NIRIDS and supporting Algeria's international commitments under the Sustainable Development Goals.

The benefits of NIRIDS extend beyond statistical improvements. Accurate BoD metrics, supported by ONS harmonization and academic validation, enable targeted interventions, such as infrastructure improvements in high-risk areas identified by police and civil protection data or safety campaigns led by civil society for vulnerable groups. Precise DALY and QALY estimates, incorporating insurance data, improve cost-effectiveness evaluations, optimizing resource allocation and reducing economic losses estimated at 1.5–3% of GDP. Embedding data-driven decision-making into Algeria's health and transport policies allows NIRIDS, under the strategic leadership of the National Delegation for Road Safety, to leverage stakeholder expertise and international best practices in shaping a safer, healthier future.

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