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Quantifying the economic burden of road traffic injuries in South Asia: a human capital approach

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Abstract

Background: Road traffic injuries (RTIs) are a major public health issue in South Asia, with significant contributions to mortality and morbidity in the region. Despite ongoing efforts to mitigate their impact, RTIs continue to place a heavy strain on the health systems and economies of South Asian countries. In this study, we quantified the economic burden of RTIs in eight South Asian countries—Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka—by estimating the monetary value of years of life lost (MVYLL) due to premature mortality from RTIs.

Methods: We utilized the Human Capital Approach (HCA) to calculate MVYLL resulting from RTIs related deaths in 2021, using number of deaths data from the Global Burden of Disease (GBD) study 2021 and country-specific economic data (Gross Domestic Product and Government Health Expenditure) from the World Health Organization's Global Health Expenditure Database (WHO-GHED). We also performed sensitivity analyses to assess the effects of varying discount rates and life expectancy assumptions on the estimates.

Results: India bore the largest share of the economic burden, with an estimated MVYLL of 12.33 billion USD, followed by Pakistan (1.37 billion USD) and Bangladesh (701 million USD). The highest burden was observed in the 15-29 years age group, reflecting the loss of life among younger populations. Females accounted for a disproportionate share of the total MVYLL across the countries. Sensitivity analyses confirmed the robustness of our estimates, with minimal variations based on different assumptions.

Conclusion: RTIs represent a substantial economic burden on South Asia, particularly for younger, Female populations. Our findings highlight the urgent need for stronger road safety policies, targeted public health interventions, and improvements in healthcare infrastructure. Addressing the economic and public health challenges posed by RTIs is crucial for reducing premature mortality and excess morbidity in the region.

Keywords: *Road traffic injuries, economic burden, human capital approach, South Asia, years of life lost, MVYLL, gender disparities*

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Evidence in Context

- Road traffic injuries in South Asia have a substantial economic impact, with India bearing the highest burden at $12.33 billion in 2021.
- Young adults (15-29 years) are most affected, particularly males.
- Urgent road safety policies and targeted interventions are needed.
- The study used the Human Capital Approach, validated by sensitivity analyses

To view Article

Introduction

South Asia accounts for a substantial portion of global Road traffic injuries (RTIs), with a road traffic death rate of more than 5 per 100,000 population [1]. RTIs are a leading cause of death and disability, particularly among young males and children, with two-wheelers being major contributors to accidents [2]. The economic impact of RTIs is significant, costing billions of US dollars and affecting the Gross Domestic Product (GDP) by 0.3 to 7.5 percent in the region [3].

RTIs not only cause physical harm but also impose a considerable economic burden, which includes both direct and indirect costs. Direct costs encompass property damage, medical treatment, and rehabilitation, while indirect costs involve productivity losses, disability, legal expenses, and insurance claims. Globally, road injuries are projected to cost the world economy nearly $2 trillion between 2015 and 2030, equivalent to an annual tax of 0.12% on global GDP [4]. Developing countries experience higher fatality rates from RTIs compared to developed countries. These countries account for 90% of global road traffic deaths, despite having only about 50% of the world's motor vehicles[5]. In high-income nations, RTIs account for a smaller share of GDP losses [5].

Given the significant challenges posed by RTIs in South Asia, it is essential to assess and quantify their economic burden to inform policy and prioritize public interventions. This study aims to quantify the economic burden of RTIs in South Asia using the Human Capital Approach (HCA). By quantifying the burden, the study provides valuable insights into the economic burden of RTIs, which can guide policymakers in implementing targeted strategies to reduce fatalities, improve infrastructure, and strengthen healthcare systems. Additionally, it highlights the broader implications for economic growth, emphasizing the urgent need for a comprehensive road safety approach in South Asia.

Methods

Data source

Data on the estimated number of deaths from RTIs and life expectancy for both sexes in eight South Asian countries were sourced from the 2021 Global Burden of Disease (GBD) study [6]. The GBD study utilizes an ensemble method to estimate causes of death, incorporating various covariates across different geographic levels, as detailed in previous publications [6, 7]. Covariates included in the RTIs model are described elsewhere [8]. Additionally, data on Government Health Expenditure per capita and GDP per capita at current prices were obtained from the WHO-GHED [9]. All the economic data is taken at current US dollar prices.

Analytical Framework

The economic burden of RTIs was assessed using the HCA, which adopts a macroeconomic perspective to measure the total loss to a country resulting from disease burden [10]. HCA evaluates the economic productivity linked to an individual’s skills or educational training and estimates productivity losses for years of life lost due to premature mortality[10, 11]. This approach has been widely used to estimate the economic burden of various diseases, including non-communicable diseases, injuries, and neglected tropical diseases in different countries [12, 13]. Among the many applications, the HCA has been used to estimate the burden of suicide deaths in India and Africa, and in Canada, it has also been employed to assess the economic impact of implementing prevention strategies for RTIs [10,13]. There are several methods for applying HCA, each with distinct assumptions and nuances that influence the estimates of economic burden.

Economic Analysis

We employed the HCA to calculate the total monetary value of years of life lost (TMVYLL) across 8 countries in 2021. The calculations were performed in line with the methodologies outlined by Nigam et al. [10] and Kirigia and colleagues [13]. We calculated the Monetary Value of Years of Life Lost (MVYLL) for each state (m), each sex (s), and each age group (j) using the formula provided in Equation (1). MVYLL was calculated as the product of the non-health GDP per capita and the number of RTIs deaths, adjusted for discount rates.

These discount rates account for the opportunity cost of lost productivity and the potential return on investment. (TMVYLL) for each *m* and *s* was computed as the cumulative MVYLL across *j*, for 5 year age group from 10 to 95+ [Equation (2)].

$$\mathrm{MVYLL}_{j,s,m} = \sum_{i=1}^{k_{j,s,m}} \left\{ \left[1/(1 + \text{discount rate}^{k_{j,s,m}} \right] \times \text{non} - \text{health GDP per person}_{s,m} \times \mathrm{RTID}_{j,s,m} \right\}$$

…(Equation 1)

$$\mathrm{TMVYLL}_{s,m} = \sum \left(\mathrm{MVYLL}_{j,s,m} \right)$$

… (Equation 2)

$$k_{j,s,m} = \text{Life expectancy} - \text{Average age of death}_{j,s,m}$$

… (Equation 3)

In healthcare economics, discount rates are used to consider the time value of money, representing the opportunity cost of investing in healthcare rather than in other ventures that might offer economic benefits. We applied discount rates consistent with those used by Kirigia et al. and Nigam et al. [10, 14] Discounting was performed by raising the inverse of the discount rate to the power of*k*over a range from 1 to*k*, where*k*represents the final year of years of life lost, calculated as the difference between life expectancy (LE) and the average age at death [Equation (3)]. We calculated MVYLL and TMVYLL for 8 countries, covering 18 5-year age groups for both males and females. In our primary analysis, we applied a three percent discount rate along with country-specific average life expectancy values to the eighteen 5-year age groups for each sex, as well as to the ten 5-year working-age groups (ages 15-64) for males and females combined.

Results

Overall economic burden of RTIs

Our estimates reveal significant economic burdens due to premature mortality from RTIs across South Asia (Figure 1). India experiences the highest MVYLL at 12.33 billion USD. Pakistan follows with 1.37 billion USD, Bangladesh and Sri Lanka report MVYLLs of 701 million USD and 255 million USD, respectively. Nepal's MVYLL of 76.79 million USD highlights the economic loss from early mortality, while Afghanistan's 50.21 million USD. Bhutan and the Maldives have the lowest MVYLLs at 6.25 million USD and 4.33 million USD, respectively, indicating relatively lower economic losses from premature mortality due to RTIs.

Age-wise burden of RTIs in South Asia

The analysis of TMVYLL across South Asian countries reveals a consistent pattern in the burden of mortality, with younger age groups experiencing the highest levels of mortality. This trend is evident in India, where the TMVYLL is 12,327.84 million (10,848.12–13,937.58 million). The highest burden of mortality is observed in the 20-24 years age group, with 1,482.24 million (1,296.19–1,636.29 million), followed closely by the 25-29 years group at 1,489.12 million (1,336.20–1,657.94 million), and the 15-19 years group at 859.04 million (736.06–991.67 million). A similar pattern emerges in Pakistan, where the TMVYLL is 1,370.44 million (1,034.60–1,763.59 million), with the 20-24 years group experiencing the highest MVYLL at 229.48 million (174.03–290.94 million), followed by 25-29 years at 219.67 million (168.46–279.72 million) and 15-19 years at 154.05 million (116.14–198.83 million).

In Bangladesh, the TMVYLL due to RTIs stands at 701.03 million (462.92–992.52 million), with the 20-24 years group again bearing the highest burden, at 96.18 million (64.00–137.63 million), followed by the 25-29 years group at 89.87 million (58.42–124.39 million) and the 15-19 years group at 88.53 million (58.12–124.72 million). In Sri Lanka, where the TMVYLL is 255.75 million (164.87–362.18 million), the highest MVYLL is also observed in the 20-24 years group at 36.47 million (23.83–49.90 million), followed by 25-29 years at 32.79 million (21.46–44.51 million) and 15-19 years at 18.76 million (12.16–25.35 million). Similarly, Nepal had a TMVYLL of 76.79 million (50.70–112.39 million), with the highest burden in the 20-24 years group at 10.50 million (6.94–16.18 million), followed by the 25-29 years group at 9.04 million (5.89–13.75 million) and 15-19 years at 6.87 million (4.34–10.94 million).

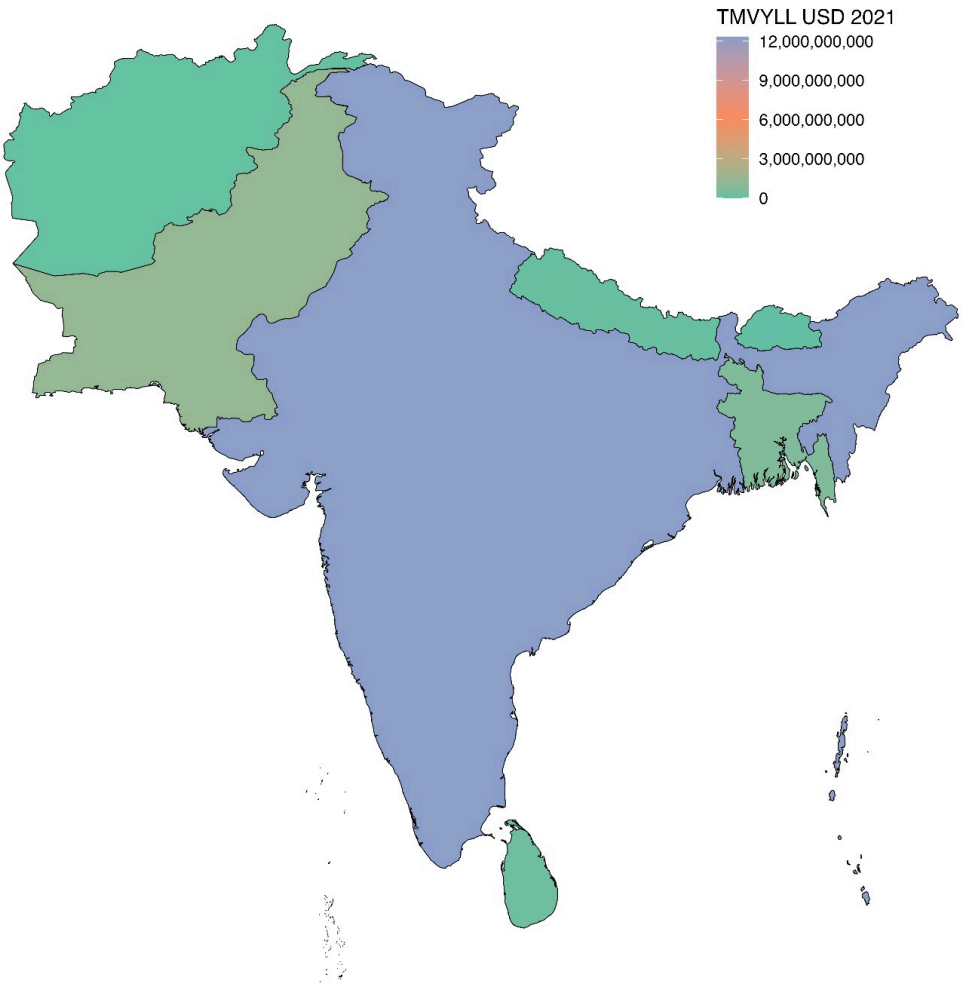

Figure 1: Total monetary value of Years of Life Lost (YLL) due to road traffic injuries in South Asia in US dollars at current prices with 3% discount rate, 2021

The same pattern of higher mortality due to RTIs in younger age groups is observable in Afghanistan, Bhutan, and the Maldives. In Afghanistan, where the TMVYLL is 50.21 million (42.46–71.14 million), the 20-24 years group has the highest MVYLL at 8.81 million (6.16–12.22 million), followed by the 15-19 years group at 7.79 million (5.28–10.88 million). Bhutan's TMVYLL of 6.25 million (3.98–9.30 million) also reveals the highest MVYLL in the 20-24 years group, at 0.86 million (0.54–1.29 million), while in the Maldives, the TMVYLL is 4.33 million (2.86–6.14 million), with the 25-29 years group exhibiting the highest MVYLL at 0.77 million (0.52–1.24 million).

The analysis of MVYLL for males across various age groups reveals a clear pattern of decreasing mortality burden with increasing age. In the 10-14 years group, the MVYLL is 207.21 million (165.98–256.30 million), indicating a relatively high level of premature mortality in this age group. The burden continues to rise in the subsequent age groups, peaking at 920.00 million (775.68–1,081.44 million) in the 20-24 years group, followed by a slight decrease to 908.49 million (785.21–1,044.10 million) in the 25-29 years group. The MVYLL remains elevated in the 30-34 years group at 857.51 million (746.96–979.59 million) and gradually decreases in older age groups.

The highest burden is consistently observed in the younger age groups, with the 15-19 years and 20-24 years groups exhibiting the greatest loss of life years. For instance, the 15-19 years group has an MVYLL of 562.18 million (461.56–676.10 million), and the 20-24 years group follows closely with 920.00 million (775.68–1,081.44 million). After these younger groups, the MVYLL progressively decreases, indicating lower levels of premature mortality with age.

In the older age groups, particularly in those aged 95 years and beyond, the MVYLL is the lowest, recorded at 27.16 million (21.61–31.79 million) in the 95+ years group.

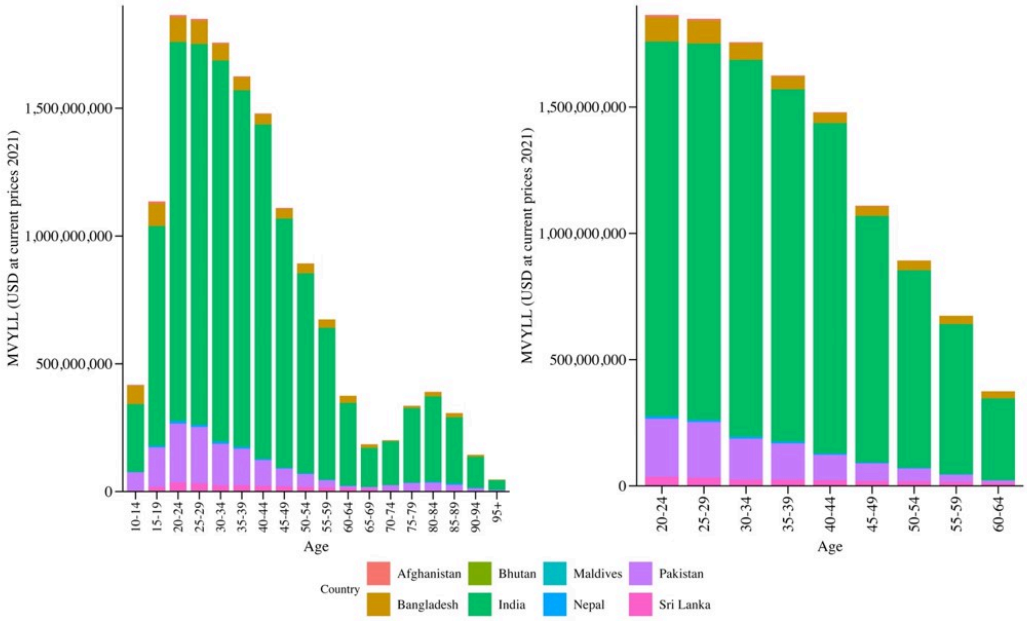

Figure 2: Monetary value of Years of Life Lost (YLL) due to road traffic injuries in South Asia by age group in US dollars at current prices with 3% discount rate, 2021

Sex-wise burden of RTIs in South Asia

The analysis of MVYLL for females across various age groups reveals a similar pattern of decreasing mortality burden with increasing age. In the 10-14 years group, the MVYLL is 210.33 million (168.50–260.12 million), reflecting a significant level of premature mortality.

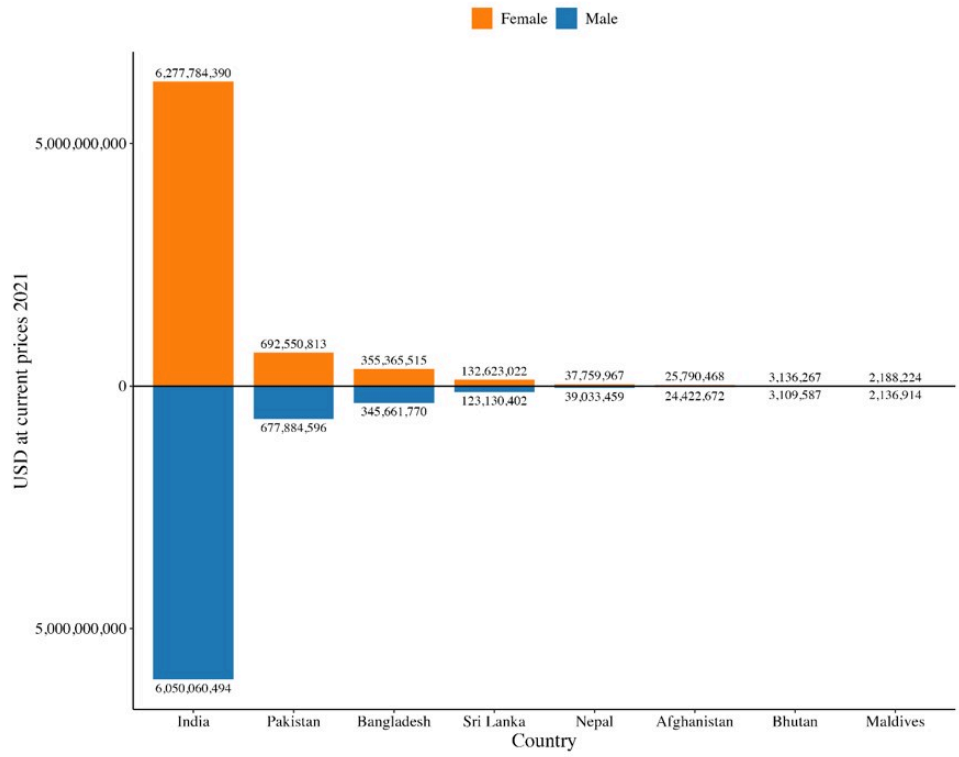

Figure 3: Monetary value of Years of Life Lost (YLL) due to road traffic injuries in South Asian countries by sex in US dollars at current prices with 3% discount rate, 2021

The burden rises in the subsequent age groups, peaking at 945.02 million (796.93–1,110.64 million) in the 20-24 years group, followed by a slight decrease to 941.31 million (813.80–1,081.54 million) in the 25-29 years group. The MVYLL remains elevated in the 30-34 years group at 899.53 million (783.82–1,027.29 million), and gradually decreases in older age groups.

Table 1: Monetary Value of Years of Life Lost due to road traffic injuries in South Asia, by age and sex in US dollars in millions at current prices with 3% discount rate, 2021

Age	Female	Male
10-14	210.33 (168.5-260.12)	207.21 (165.98-256.3)
15-19	573.7 (471.1-689.85)	562.18 (461.56-676.1)
20-24	945.02 (796.93-1110.64)	920 (775.68-1081.44)
25-29	941.31 (813.8-1081.54)	908.49 (785.21-1044.1)
30-34	899.53 (783.82-1027.29)	857.51 (746.96-979.59)
35-39	838.84 (725.54-972.46)	786.1 (679.65-911.66)
40-44	773.36 (657.49-895.26)	706.48 (600.34-818.22)
45-49	590.73 (500.63-703.24)	519.1 (439.64-618.37)
50-54	489.56 (414.04-576.67)	403.18 (340.56-475.43)
55-59	390.63 (331.71-455.97)	283.45 (240.04-331.69)
60-64	247.52 (211.51-288.87)	127.47 (107.81-149.93)
65-69	115.26 (97.88-136.27)	69.76 (58.98-82.79)
70-74	58.57 (49.76-68.24)	142.75 (125.07-161.93)
75-79	105.79 (91.94-121.1)	230.17 (201.01-261.94)
80-84	145.33 (125.43-166.52)	245.03 (211.71-280.52)
85-89	122.39 (105.18-139.17)	184.78 (158.98-209.82)
90-94	59.51 (49.69-68.92)	84.62 (70.75-97.87)
95+	19.82 (15.75-23.23)	27.16 (21.61-31.79)

The highest burden is consistently observed in the younger age groups, with the 15-19 years and 20-24 years groups exhibiting the greatest loss of life years. For instance, the 15-19 years group has an MVYLL of 573.70 million (471.10–689.85 million), and the 20-24 years group follows closely with 945.02 million (796.93–1,110.64 million). After these younger groups, the MVYLL progressively decreases, indicating lower levels of premature mortality with age. In the older age groups, particularly those aged 95 years and beyond, the MVYLL is the lowest, recorded at 19.82 million (15.75–23.23 million) in the 95+ years group.

Discussion

This study provides a comprehensive assessment of the economic burden of RTIs in South Asia, using HCA to quantify the MVYLL across eight countries. The results reveal a substantial monetary loss to countries due to premature mortality. India, the most populous country in the region, accounts for the largest share of this burden, with an estimated 12.33 billion USD in lost productivity in 2021. This is followed by Pakistan (1.37 billion USD), Bangladesh (701 million USD), and Sri Lanka (255 million USD), among others. The economic losses are predominantly associated with preventable deaths in the younger, working-age populations, emphasizing that RTIs are not just a health issue but a significant barrier to economic development in these countries. Furthermore, as many of these countries are labeled as emerging economies, the prevention of the loss of young lives should be prioritized as a part of sustainable development and to increase economic productivity.

The considerable economic burden in these countries reflects both the large populations and the multifaceted challenges faced by their healthcare systems, including insufficient road safety measures, limited access to emergency care, lower education and awareness, engagement of younger populations in risky behaviors, and high rates of preventable mortality. Additionally, the relatively lower MVYLL values in smaller nations like Bhutan and the Maldives point to the potential benefits of improved healthcare access and better road safety systems. These differences underscore the importance of tailored policies and interventions [15], as well as the need to invest in road safety infrastructure and healthcare services in high-burden countries.

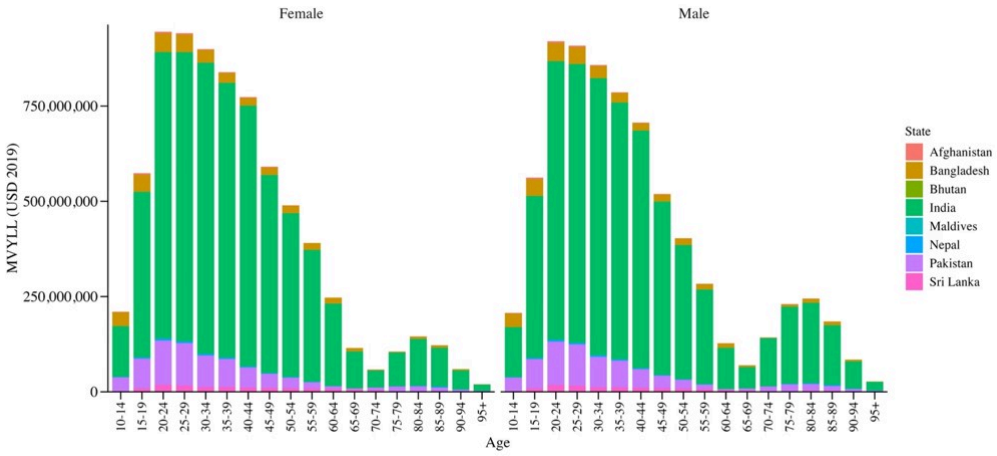

Figure 4: Monetary value of Years of Life Lost (YLL) due to road traffic injuries in South Asia by sex at in US dollars at current prices with 3% discount rate, 2021

This study's findings align with previous research on the economic costs of RTIs, which highlight that lower-income countries tend to experience higher relative economic losses compared to higher-income nations [1-3,16]. In South Asia, where the majority of the population is young and economically active, the losses from RTIs have far-reaching implications for the region's productivity and long-term development [17]. One of the most striking findings of this study is the disproportionate burden of RTIs on younger age groups, particularly those aged 15-29 years. This age group consistently experiences the highest levels of MVYLL across all countries in the study. In India, for example, the 20-24 years age group bears the highest economic loss, amounting to 1.48 billion USD, followed by the 25-29 years and 15-19 years groups. This pattern is also observed in other South Asian countries, including Pakistan, Bangladesh, and Sri Lanka, where young adults face the greatest risk of fatal injuries from road traffic accidents.

The higher burden of RTIs in younger age groups can be attributed to a combination of factors, including riskier driving behaviors such as speeding, impaired driving (due to alcohol or drugs), and a lack of awareness about road safety [17]. Young adults, particularly males, are more likely to be involved in road traffic accidents [18]. The gender disparities in RTI mortality are evident in our study, with males consistently bearing a greater share of the MVYLL in all age groups. This trend mirrors findings from other studies that men, particularly in their late teens and early twenties, are more likely to engage in behaviors that increase the risk of road traffic accidents, such as speeding, reckless driving, and driving under the influence of alcohol or drugs [18,19]. These factors contribute to the higher fatality rates observed in males compared to females. However, the burden on females should not be underestimated. The findings show that females in South Asia, while generally experiencing lower MVYLL than males, still suffer significant economic losses from premature mortality, particularly in the younger age groups. In countries such as India, Pakistan, and Bangladesh, females aged 15-24 years experience a notable level of RTI-related mortality, underscoring the need for gender-sensitive public health interventions. In particular, programs aimed at improving the safety of female passengers and reducing their exposure to risk factors such as inadequate road infrastructure and lack of access to healthcare after accidents should be prioritized [2,20]. Overall, as it relates to policy-making and designing public health interventions, such activities should be undertaken with a focus on younger populations who in general have a higher probability of engagement in risky behaviors (e.g. drinking and driving, speeding, etc). Engagement of role models and influencers, school and college-based educational campaigns, and enforcing prevailing and newer policies are some examples of activities to be combined with other interventions to address multiple risk behaviors related to RTIs (e.g. substance use and rash driving).

Given the high economic burden of RTIs in South Asia, urgent policy action is required to address the root causes of road traffic fatalities and reduce the impact on economic productivity. Strengthening road safety regulations and enforcement is paramount. Public health campaigns aimed at changing attitudes towards road safety, particularly among young adults, are essential to addressing this issue [21-23].

Moreover, the implementation of road safety measures such as improved signage, traffic lights, red light cameras, and speed limits, along with greater enforcement of laws, could be effective in reducing the rate of RTI-related fatalities [1,15,24]. Special attention should be given to the socio-cultural factors that drive risky behaviors in young men, and tailored approaches should be developed to target these groups [3,25]. Investment in healthcare systems is also crucial. Enhancing access to emergency care, improving trauma management, and providing rehabilitation services for RTI survivors can reduce the long-term economic impact of RTIs [21,26,27]. Policies aimed at strengthening pre-hospital care, improving trauma center capacity, and ensuring timely access to medical treatment are vital components of a comprehensive RTI prevention strategy [28-30].

While this study provides valuable insights into the economic burden of RTIs, it has several potential limitations. First, the human capital approach focuses solely on the loss of productivity due to premature mortality and does not capture other costs, such as healthcare expenditures, disability-related costs, and the social costs of RTIs [10,13,31]. Future studies should incorporate these additional costs to provide a comprehensiveof the economic impact of RTIs. Second, the study relies on data from the GBD study, which uses modeling techniques to estimate RTI-related deaths. While the GBD study provides a valuable source of data, the estimates may be subject to limitations related to data availability and accuracy, particularly in low-income countries [32,33]. We were also not able to ascertain the cause of RTIs in the countries under investigation due to the lack of availability of any such data that could have been crucial in a more granular and causal analysis of loss of life and related costs. Future research on the effectiveness of existing road safety interventions, as well as cost-effectiveness analyses of potential policies and programs, would be valuable in informing evidence-based policy decisions.

Conclusion

The findings of our study emphasize the need for targeted, gender-sensitive interventions and stronger road safety measures in South Asia. Addressing the root causes of RTIs, including risky driving behaviours and limited healthcare access, is essential to reducing the economic impact. While this study focuses on productivity losses, future research should incorporate additional costs, such as healthcare expenditures and disability-related costs. The findings underscore the alignment with the United Nations Sustainable Development Goals (SDGs), particularly Goal 3 (Good Health and Well-being) and Goal 8 (Decent Work and Economic Growth), by aiming to reduce preventable mortality and enhance economic development in the region.

Abbreviations

GBD: Global Burden of Disease

GDP: Gross Domestic Product

HCA: Human Capital Approach

RTIs: Road traffic injuries

MVYLL: Monetary value of years of life lost

WHO-GHED: World Health Organization’s Global Health Expenditure Database

TMVYLL: Total monetary value of years of life lost

SDGs: Sustainable Development Goals

Supporting information: None

Ethical Considerations: Not applicable

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Clinical Trial: Not applicable

Consent for publication: Note applicable

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