

## Article

# Global incidence and mortality patterns and forecast of Pedestrian Road Traffic Injuries by Socio-demographic Index Findings from the Global Burden of Diseases, Injuries, and Risk Factors 2017 Study

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**Abstract:** (1) Background: Pedestrian injuries (PIs) represent a significant proportion of road traffic injuries. We aimed at investigating the incidence and mortality of PIs in different age groups and Socio-demographic Index (SDI) categories between 1990 and 2017. (2) Method: Estimates of age-standardized incidence and mortality along with trends of PIs by SDI levels were obtained from the Global Burden of Disease from 1990 to 2017. We also calculated forecasts until 2040. (3) Results: Globally, PIs incidence increased by 3.31% (−9.94 to 16.56) in 2017 compared to 1990. Men have higher incidence of PIs than women. Forecasted incidence was 132.02 (127.37 to 136.66) per 100,000 population in 2020, 101.52 (65.99 to 137.05) in 2030 and reduced further to 71.02 (10.62 to 152.65) by 2040. Globally across all SDI categories, there was a decreasing trend in mortality due to PIs with the global estimated percentage reduction of 37.12% (−45.19 to −29.04). (4) Conclusions: The results show that PIs are still a burden for all SDI categories despite some variation. Although incidence and mortality are expected to decrease globally, some SDI categories may require particular attention in addition to specific vulnerable age groups. Further studies addressing incidence and mortality patterns in vulnerable SDI categories are needed.

**Keywords:** road traffic injuries; pedestrians; public safety; global burden; economic loss; health policy; health care system; health indicators

## 1. Introduction

Every day, about 1,800 pedestrians never return home due to road traffic injuries and fatalities [1]. An estimated 12 million pedestrian road traffic injuries (PIs) occur on an annual basis [1]. This surge has been due to rapid urbanization leading to an increased amount of motor vehicles as well as changes in the environment and lifestyle due to global economic development [2]. Also, longevity and ageing has caused increased dependency on personal automobiles for work and non-work-related activities leading to increased risks [3].

PIs are a major public health problem across all ages and sex, accounting for nearly one quarter of all road traffic related injuries [4]. Among all road injuries, PIs carry the highest risk of a person

being severely injured, leading to significant morbidity, disability and death [5, 6]. Such a burden inflicts pain and suffering on injured pedestrians and their families and has an economic impact costing approximately 0.5% of the total world Gross National Product and 130 billion US dollars globally [7].

Critical reasons for the increase in PIs and a slower progress to reduce such occurrences could be due to the variation of socio-economic factors and disparities between different age groups and regions globally. The United Nations has a sustainable development vision to reduce injuries and deaths due to road traffic collisions by 50% in five years from 2015 to 2020 [8]. Studying global and social variation trends of PIs is essential to mitigate key risk factors. Also, such a detailed review will aid the adoption of evidence-based practices and solutions to reduce PIs and related deaths. Furthermore, quantifying a socio-economic relationship with PIs would help to identify age groups, gender, countries and regions where increased risk is documented, thereby allowing systematic planning to implement appropriate measures to reduce such risks.

Although there has been a detailed report on road traffic injuries, very few studies have quantified PIs by SDI globally [9]. This study aims to investigate the incidence and mortality patterns of PIs in different SDI categories between 1990 and 2017. It also provides a forecast for 2040.

## 2. Methods

### 2.1. Data Source and Data Extraction

The latest Global Burden of Disease, Injuries and Risk factors study 2017 (GBD 2017) is a detailed, multinational, epidemiological study with enhanced methodology providing regional and global estimates. We extracted the data on PIs from the latest GBD 2017 dataset. Age-standardized rates were used to allow comparisons of populations amongst different age groups across underlying populations. International Classification of Diseases (ICD) codes ICD-9 and ICD-10 were used by the GBD 2017 study to extract data for PIs [10, 11]. In GBD 2017, the data were obtained from several sources, including public health research studies, vital registrations, verbal autopsies, police records, trauma registries, country-based surveys, health insurance records, emergency departments, hospital out-patient records, and hospital claim records. The PIs estimation process in the GBD 2017 study used epidemiological meta-regression tools to produce incidence and mortality by age, gender, year and location. The detailed methodology was explained in methods description for the GBD 2017 [12].

The data sources were later systematically quantified using various injury modelling strategies and statistical methods by age, gender, year, country, and cause. A detailed outline concerning the methods of collecting and calculating data for the GBD 2017 study is provided elsewhere [13,14].

#### *Socio-demographic Index*

Socio-demographic Index (SDI) is a composite metric of overall development, which shows a strong positive relationship with health outcomes [15]. The measure quantifies and differentiates the countries and regions based on the spectrum of development. It encompasses three different aspects of development and is a geometric mean of income per capita, educational achievement of the population, and the fertility rate [16]. SDI is interpreted on a scale of 0 to 1, with a value of 1 indicating the highest development and value 0 the lowest development. The SDI divides the world regions into five quintiles based on their SDI values from 0 to 1, i.e., Low SDI (LSDI), Low-middle SDI (LMSDI), Middle SDI (MSDI), High-middle SDI (HMSDI) and High SDI (HSDI). A detailed methodology with regard to the calculation of SDI cut off points is reported elsewhere [14].

### 2.2. Outcome Metrics

The worldwide burden due to PIs was estimated by analyzing several outcomes, including age-standardized incidence and mortality with 95% uncertainty intervals (UI). These measures were also analyzed by age groups and segregated according to the world SDI set by the GBD 2017 study. A complete set of PIs incidence and mortality, with trends and forecasting, was computed for the years 1990, 2000, 2010, and 2017. The percentage change (degrees of change) were analyzed at different points at various times between the years 1990 and 2017. Also, the percentage difference between the

two values was calculated to show changes in age and SDI specific incidence and mortality between the years 1990 and 2017.

### 2.3. Uncertainty Intervals

Uncertainty estimations could be due to incomplete information, potential biases in information or heterogeneity among information sources, data generation process, and model uncertainty [17]. Such measurement errors affecting the data input are expressed as Uncertainty Interval (UI). UI represents a range of values that reflects the certainty of an estimate. Entire measures have been reported with a 95% UI.

### 2.4. Statistical Analysis

The Statistical Package for the Social Sciences (SPSS Statistics for Windows, version 23.0, Chicago, IL, USA) was used for statistical analysis. We estimated the percentage difference of incidence and mortality due to PIs for every SDI category with the available GBD 2017 estimates between two time points. We calculated the 95% UIs with the 2.5<sup>th</sup> and 97.5<sup>th</sup> percentiles range for the change based on the cause-specific model estimation for each GBD 2017 SDI, age group, gender, and time points between 1990 and 2017 [18]. SPSS time series modeler with the expert modeler option without events was used to predict the future trends of PIs incidence and mortality. None of the observed values during forecasting were marked as outliers.

## 3. Results

### 3.1. Incidence and Trends

In 2017, the global estimated incidence of PIs per 100,000 population was 140.92 (115.81 to 168.53) (Table 1A). This translates into 11.5 million pedestrians injuries occurring worldwide. The highest incidence was seen among the HMSDI category 195.52 (160.55 to 234.45), while the lowest PIs occurred in the HSDI category 110.05 (88.33 to 135.33). The estimates of incidence rates and trends for PIs by SDI in 1990, 2000, 2010, and 2017 are shown in Table 1A.

Globally, PIs incidence increased by 3.31% (−9.94 to 16.56) in 2017 compared to 1990. HSDI countries showed the most considerable decrease in incidence, 21.39% (−35.03 to −7.74), between 1990 and 2017, while MSDI countries showed a significant increase, 26.62% (8.87 to 44.36), in the same period (Table 2A). Within the last seven years (2010–2017), the HMSDI showed the greatest reduction of PIs 12.38% (−20.64 to −4.11). In the same period, the global reduction was 6.58% (−14.25 to 1.09). In contrast, the HSDI category showed the lowest percentage decrease of 1.79% (−9.75 to 6.17) between 2010 and 2017 (Table 2A).

**Table 1.** Incidence (A) and mortality rate (B) for pedestrian road traffic injuries (PIs) 1990-2017.

Category	A. PIs Incidence (95% UI)			
	1990	2000	2010	2017
Global	136.4 (116.91 - 157.46)	137.49 (116.86 - 159.26)	150.85 (127.55 - 175.26)	140.92 (115.81 - 168.53)
High SDI	140 (118.69 - 163.47)	118.63 (100.3 - 138.74)	112.06 (93.04 - 133.03)	110.05 (88.33 - 135.33)
High-middle SDI	187.46 (159.72 - 216.89)	184.39 (156.05 - 213.86)	223.15 (188.96 - 259.89)	195.52 (160.55 - 234.45)
Middle SDI	113.08 (96.17 - 131.72)	127.27 (108.04 - 147.98)	140.04 (118.79 - 162.58)	143.19 (118 - 171.35)
Low-middle SDI	112.34 (95.31 - 131.22)	121.58 (103.23 - 142.46)	132.21 (110.98 - 155.84)	122.9 (100.75 - 147.7)
Low SDI	136.25 (116.2 - 158.91)	132.01 (112.5 - 153.71)	135.76 (114.39 - 160.5)	122.81 (101.48 - 147.67)
Category	B. PIs Mortality (95% UI)			
	1990	2000	2010	2017
Global	9.94 (8.75 - 11.14)	9.23 (8.59 - 10.16)	7.68 (7.21 - 8.5)	6.25 (5.77 - 6.94)
High SDI	4.47 (4.37 - 4.61)	3.16 (3.11 - 3.22)	1.99 (1.95 - 2.03)	1.69 (1.64 - 1.76)
High-middle SDI	11.1 (9.56 - 12.64)	10.54 (10 - 11.25)	8.2 (7.89 - 8.97)	6.14 (5.72 - 6.67)
Middle SDI	11.8 (10.35 - 13.23)	11.17 (10.47 - 12.22)	9.32 (8.84 - 10.06)	7.52 (6.98 - 8.18)
Low-middle SDI	11.57 (9.92 - 13.87)	10.82 (9.6 - 12.69)	9.59 (8.41 - 11.3)	7.99 (6.8 - 9.58)
Low SDI	11.48 (9.27 - 14.01)	10.6 (9.06 - 12.54)	9.64 (8.48 - 11.26)	8.29 (7.24 - 9.64)

PIs: pedestrian road traffic injuries, UI: Uncertainty Intervals, SDI: Socio-demographic Index. All figures are age-standardised rates per 100,000 population

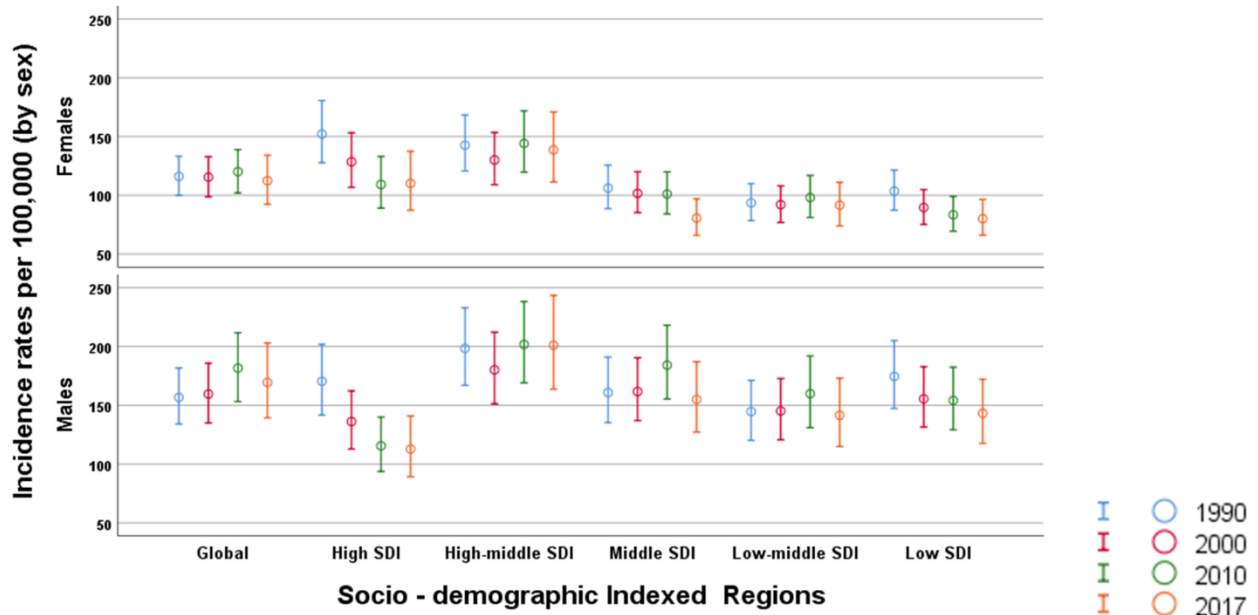
**Table 2.** Incidence (A) and mortality trends (B) for pedestrian road traffic injuries (PIs) 1990-2017.

Category	A. Percentage Change in Incidence (95%UI)		
	1990 to 2017	2000 to 2017	2010 to 2017
Global	3.31 (-9.94 to 16.56)	2.49 (-9.99 to 14.97)	-6.58 (-14.25 to 1.09)
High SDI	-21.39 (-35.03 to -7.74)	-7.23 (-20.16 to 5.7)	-1.79 (-9.75 to 6.17)
High-middle SDI	4.29 (-9.81 to 18.39)	6.03 (-7.41 to 19.47)	-12.38 (-20.64 to -4.11)
Middle SDI	26.62 (8.87 to 44.36)	12.5 (-4.28 to 29.28)	2.24 (-8.25 to 12.73)
Low-middle SDI	9.4 (-6.93 to 25.73)	1.08 (-15.27 to 17.43)	-7.04 (-16.63 to 2.55)
Low SDI	-9.86 (-25.26 to 5.54)	-6.96 (-22.39 to 8.47)	-9.53 (-18.58 to -0.47)
Category	B. Percentage Change in Mortality (95%UI)		
	1990 to 2017	2000 to 2017	2010 to 2017
Global	-37.12 (-45.19 to -29.04)	-32.28 (-40.31 to -24.24)	-18.61 (-23.32 to -13.89)
High SDI	-62.19 (-70.48 to -53.89)	-46.51 (-54.84 to -38.17)	-15.07 (-19.95 to -10.18)
High-middle SDI	-44.68 (-52.97 to -36.38)	-41.74 (-50.21 to -33.26)	-25.12 (-30.19 to -20.04)
Middle SDI	-36.27 (-43.23 to -29.3)	-32.67 (-42.32 to -23.01)	-19.31 (-25.92 to -12.69)
Low-middle SDI	-30.94 (-37.56 to -24.31)	-26.15 (-34.6 to -17.69)	-16.68 (-22.41 to -10.94)
Low SDI	-27.78 (-34.61 to -20.94)	-21.79 (-29.91 to -13.66)	-14 (-19.41 to -8.58)

PIs: pedestrian road traffic injuries, UI: Uncertainty Intervals, SDI: Socio-demographic Index. All figures are age-standardised rates per 100,000 population

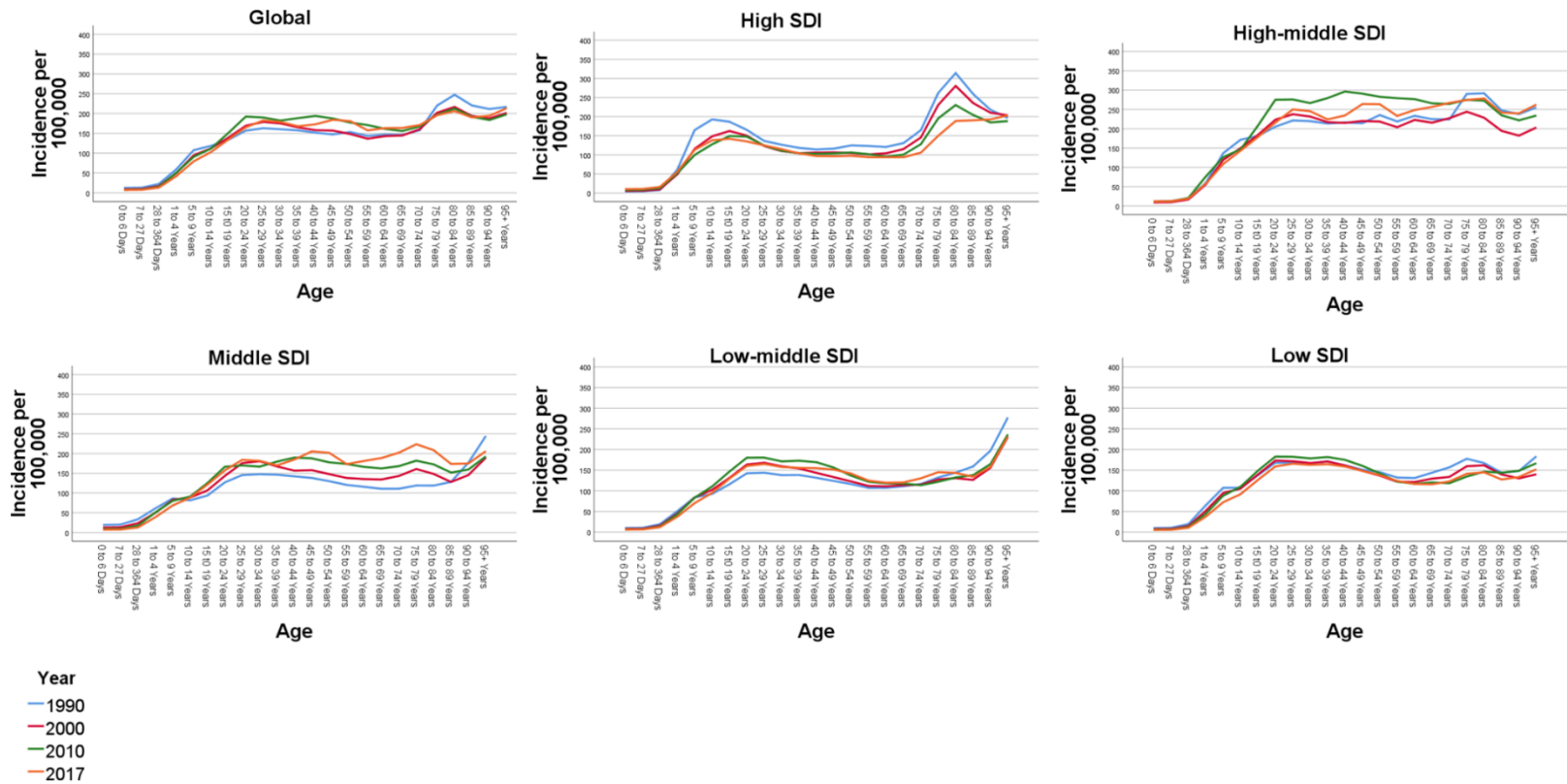
### 3.2. Incidence and Trends by Age and Sex

Between 1990 and 2017 globally, men had a higher incidence of PIs, 169.47 (139.27 to 202.93), compared to women 112.37 (92.36 to 134.14). HMSDI countries showed the highest rate of PIs in men compared to other SDI categories. Incidences and trends of PIs by SDI are shown in Figure 1.



**Figure 1.** Incidence Trends due to pedestrian road traffic injuries by Socio-demographic Indexed regions 1990-2017.

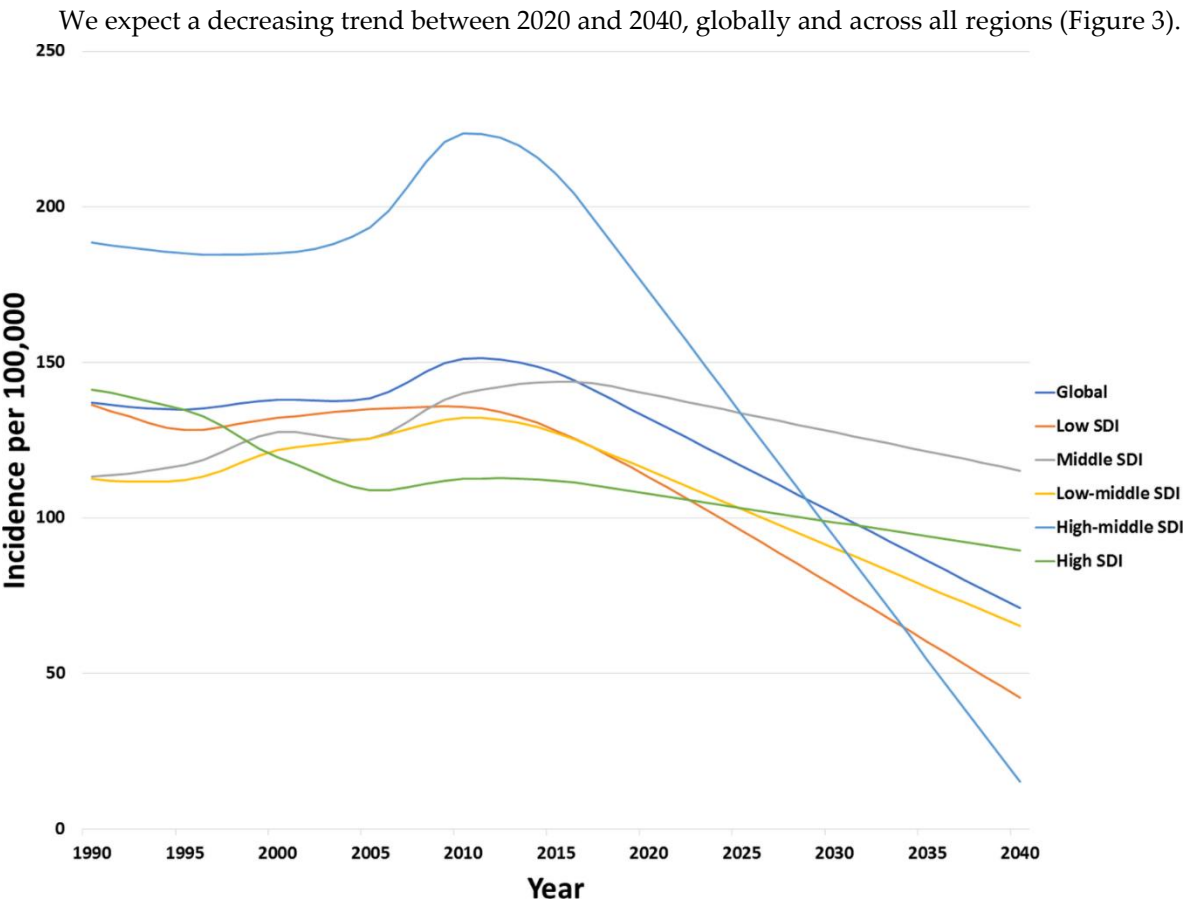
Globally, all trend lines were ascending from the age of one to 20 years. There was a steady occurrence between 20 to 75 years. The second increase in trend lines was seen after 75 years of age. The trend line pattern was similar between 1990 and 2017 (Figure 2). The highest incidence was seen in the age group of 80 to 84 years, 247.56 (184.29 to 325.79). Above the age of 75 years, an average of 210 incidents were recorded per 100,000 population. Of those under 65 years of age, the 25 to 29 age group recorded the highest incidence of 162.94 per 100,000. There were incidence and trend variations between each SDI region and age group. Trends for the age-specific prevalence of PIs by SDI categories are presented in Figure 2.



**Figure 2.** Trends for age-specific incidence rates for pedestrian road traffic injuries per 100,000 across Socio-demographic Indices 1990-2017. SDI: Socio-demographic Index.



3.3. Forecasted Incidence Trends



**Figure 3.** Forecasted trends for Age-standardized incidence rates for pedestrian road traffic injuries per 100,000 population across Socio-demographic Indices 1990-2017.

We forecasted an incidence rate of 132.02 (127.37 to 136.66) in 2020, compared to 101.52 (65.99 to 137.05) in 2030, and 71.02 (−10.62 to 152.65) in 2040 per 100,000 population. Surprisingly, the HMSDI category showed the highest forecasted incidence rate 172.8 (62.52 to 183.08), compared to the lowest forecasted in the HSDI category 107.72 (103.9 to 111.54) for the year 2020. The highest expected incidence was seen in 2030 is the MSDI category 127.56 (65.96 to 189.16), and the lowest expected incidence rate was seen in the LSDI 78.16 (35.38 to 120.94). In 2040, the MSDI is still higher than the global average 115.25 (−33.2 to 263.71), and, interestingly, the lowest expected incidence in 2040 is to be seen in the HMSDI 15.11 (−165.59 to 195.8).

3.4. Mortality and Trends

In 2017, the estimated mortality was 6.25 (5.77 to 6.94) per 100,000 population, which is translated into nearly half a million deaths globally due to PIs. The LSDI category recorded the highest rate of 8.29 (7.24 to 9.64), while HSDI regions showed the lowest rate 1.69 (1.64 to 1.76) of mortality in 2017. The mortality rates and trends for PIs by SDI in 1990, 2000, 2010, and 2017 are shown in Tables 1B and 2B.

Globally across all SDIs, there was a decreasing trend in mortality due to PIs with a global estimated percentage reduction of 37.12% (−45.19 to −29.04) between 1990 and 2017. However, the highest reduction was seen in HSDI category 62.19% (−70.48 to −53.89), as compared to the reduction in LSDI category 27.78% (−34.61 to −20.94) (Table 2). In the last seven years, the highest reduction in mortality was observed in the HMSDI category 25.12% (−30.19 to −20.04). The lowest reduction was in the LSDI category 14% (−19.41 to −8.58).

### 3.5. Mortality Trends by Age and Sex

In Figure 4 we show the trends for age-specific mortality across SDI categories between 1990 and 2017. Globally, there is an increasing trend starting from the age of 10 to 14 years. Though mortality has reduced globally across all the regions, it is essential to note that the patterns in age trends have not changed in the last three decades.

In Figure 5 we depict the mortality trends by sex per 100,000 population. Globally, across all SDI categories, men had a higher mortality rate than women over time. Globally, the death rate for men in 2017 was 8.90 (8.21 to 9.95) as compared to women 3.62 (3.35 to 3.95), which translates approximately to 150% more deaths in men. Also, in 2017, the lowest sex difference in mortality rate was observed in the HSDI category, which was twice as high in men 2.32 (2.25 to 2.42), compared to women 1.07 (1.03 to 1.11).



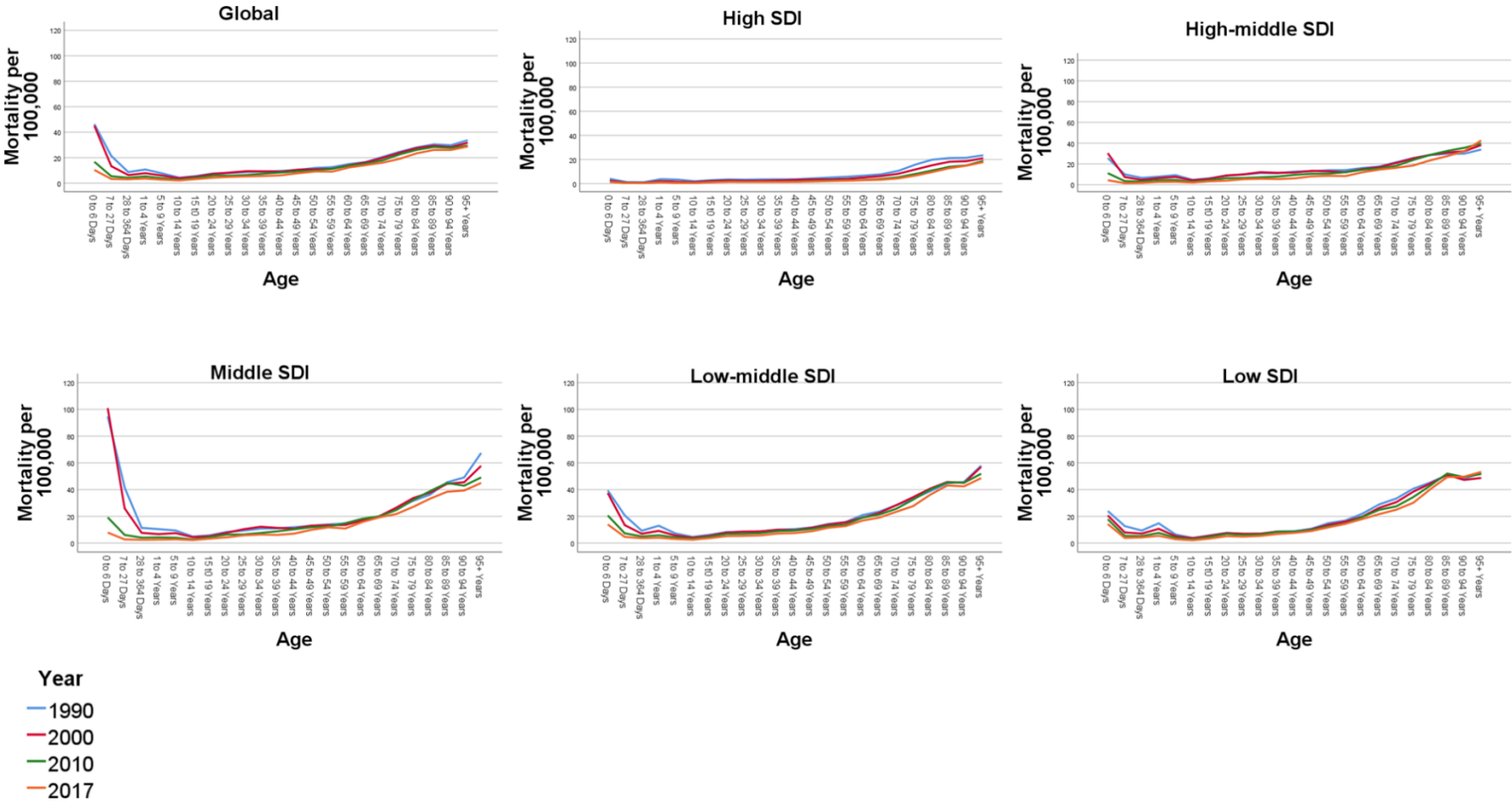
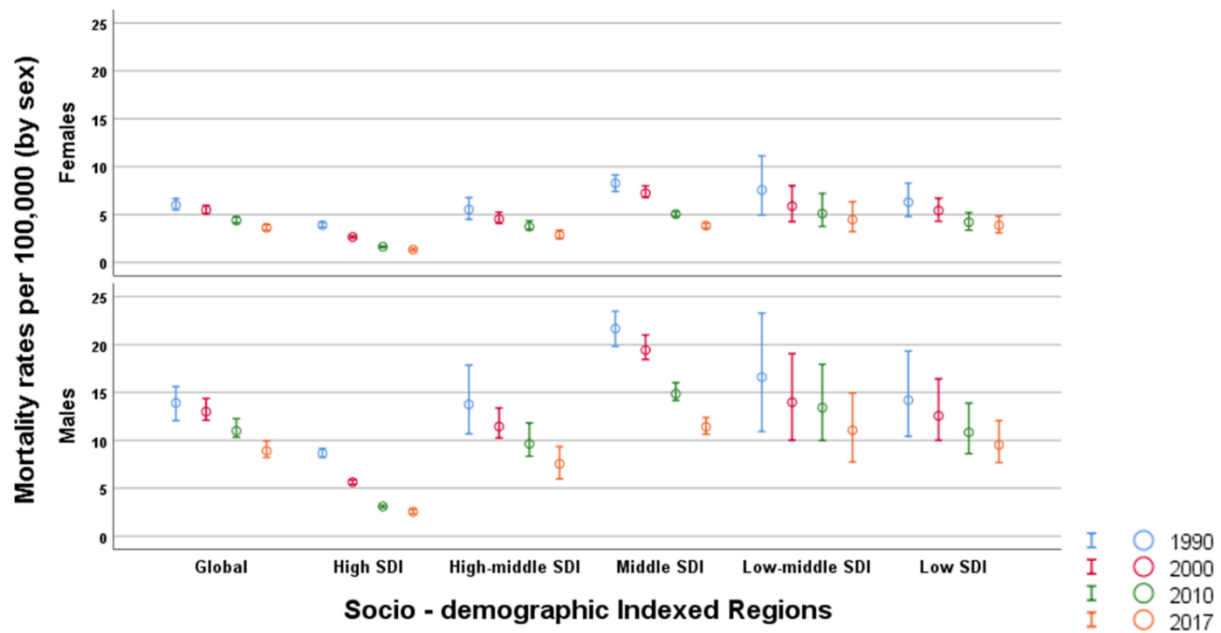


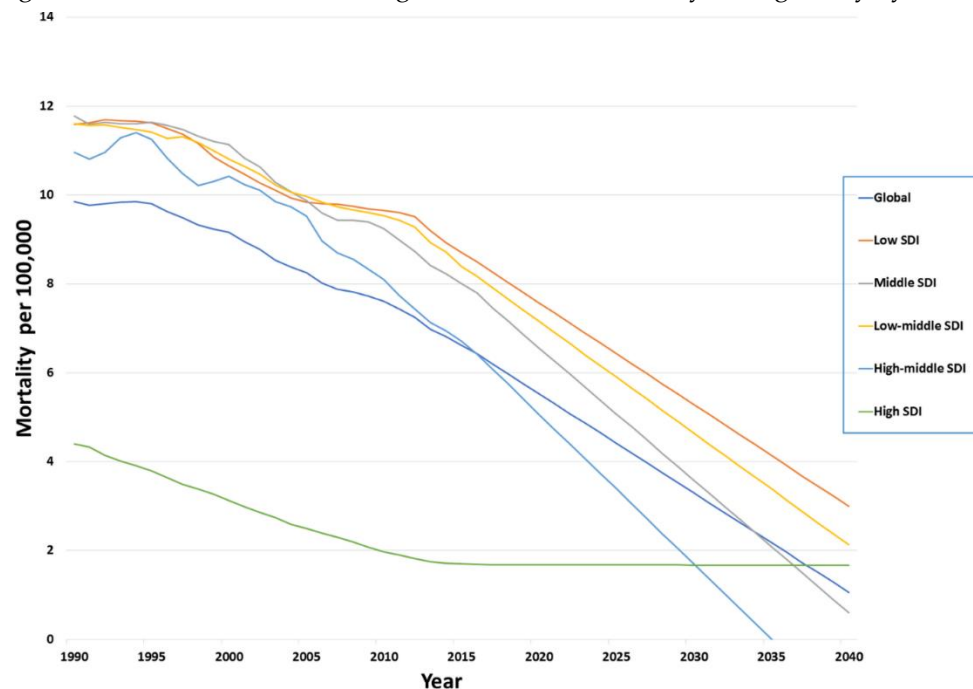
Figure 4. Trends for age-specific mortality rates for pedestrian road traffic injuries per 100,000 across Socio-demographic Indices 1990-2017.



**Figure 5.** Mortality trends due to pedestrian road traffic injuries by Socio-demographic Indices 1990-2017.

### 3.6. Forecasted Trends of Mortality

In Figure 6 we show the forecasted age-standardized mortality rates globally by SDI categories.



**Figure 6.** Forecasted trends for Age-standardized mortality rates for pedestrian road traffic injuries per 100,000 across Socio-demographic Indices 1990-2017.

The prediction across SDI regions indicates a generalized decrease in trends in the age-standardized mortality rates. HSDI categories have a plateau in mortality as compared to a sharper decline in other SDIs. Though the trend in declining mortality rates is observed in the LSDI category, it is at a much slower pace when compared to the other SDI categories. Globally the forecasted death rate in 2020 is 5.53 (5.1 – 5.96) per 100,000 population. Globally, we are forecasting approximately 280,000 deaths in 2020, which are still preventable. In 2030 the expected global mortality rate is 3.3

(0.31 to 6.28) and in 2040 1.06 (−5.69 to 7.81). The predicted mortality trend in 2030 with the SDI categories in LSDI is 5.29 (1.44 to 9.13), the MSDI 3.58 (−0.54 to 7.7), the LMSDI 4.64 (1.92 to 7.37), the HMSDI 1.7 (−8.77 to 12.17), and the HSDI 1.67(0.69 to 2.66) per 100,000 population, respectively. In 2040 however, across all regions, the death rate is close to one per 100,000 population with the exception of LMSDI, which appears to be twice the global average, and in the LSDI category, where the death rate is still three per 100,000 population.

#### 4. Discussion

The current study showed that incidence, trends, and mortality rates of PIs varied between different SDI categories. HMSDI countries showed the highest incidence, while LSDI countries showed the highest mortality in 2017. Our forecast revealed that incidence and mortality rates will continue to decrease until the predicted year 2040. Age-standardized and sex-specific incidence and mortality rates showed similar patterns in each SDI category. The 20 to 75 age group along with males are highly prone to have a pedestrian injury in each SDI category. Mortality rates in children and the elderly are highest compared to other age groups.

Global data on pedestrian injuries are often poorly reported by most countries; thus, the actual statistics may be higher for the most vulnerable road users than reported. In 2013, at least one-fifth of pedestrians died in road traffic collisions [19]. According to the World Health Organization (WHO), the Global Status Report on Road Safety published in 2018, 23% of pedestrians worldwide died because of road traffic collisions. Overall pedestrian mortality from 2013 to 2018 was almost constant, which may be attributed to progress using road safety measures [1]. There is considerable geographical heterogeneity with respect to pedestrian mortality, with the Americas, Europe, West Pacific, and South-East Asia having lower mortality rates at 22%, 27%, 22% and 14%, respectively, and Africa having the highest pedestrian fatality rate at 40% followed by the Eastern Mediterranean region at 34% [1]. It must be noted that these variations in pedestrian mortality rates across regions are related to variations in numbers of road users, with pedestrian deaths in low-income countries being disproportionately higher than high-income countries when adjusted to population and motor vehicle numbers [1]. The assumption that pedestrian mortality may be under-reported emphasizes the need for more accurate data from regions, countries, and the local areas.

Globally, there were 1,243,068 deaths out of 54,192,330 road injuries in 2017 [8]. Pedestrians are vulnerable road users and carry the highest risk of being severely injured [5, 6,19, 20]. According to the WHO report (2013), 99% of motor vehicles in the world were located in high (47%) and middle-high income countries (52%), while low-income countries had 1%. However, the HMSDI category has the highest incidence of PIs compared to the HSDI category. This might be because of the paucity of developments affecting pedestrian injury or the lack of implementation of preventive measures. Furthermore, although low-income countries have a limited number of vehicles, and the LSDI category showed the lowest incidence in 2017, its mortality is the highest among all categories. These results should be evaluated differently than HSDI and HMSDI results. For example, LSDI country figures could be due to a lack of injury prevention efforts, absence of pedestrian sidewalks or crossings, or facilities to take care of injuries.

There are various factors affecting incidence and mortality of pedestrian injuries, including vehicle design, speed control, road infrastructure, and traffic law enforcement [2]. Although incidence and mortality vary between countries [22], literature supports that these factors are similar in different countries regardless of their SDI category. Grouping by SDI allows the measuring of injury within the context of similar socio-demographic development. Such group stratification may help develop appropriate strategies to reduce pedestrian injuries and implement policies for prevention.

Similar to the trends we showed in this study, pedestrian injuries with high severity in various contexts in children and the elderly are reported to be on the higher side [23–26]. Children in preschool and elementary schools show increased incidence. Children who are socially disadvantaged or have low socioeconomic status are more prone to pedestrian injury compared to those in schools with a high socioeconomic status [27, 28]. There is evidence that people living in affluent regions are less

likely to be injured compared to those living in deprived areas [29]. Likewise, males are dominant in children's PIs [30]. Children do not need high-speed traffic incidents to be injured or die. Children younger than three years old are susceptible to death even with low-speed incidents, as their somatosensory system is less matured and is underdeveloped. Children under 12 years are not able to use visual and vestibular information as effectively as adults [31, 32]. Similar to children, the elderly are susceptible to PIs and their fatal complications due to a reduced reflex time, decreased sensory-motor coordination, and the associated auditory and visual impairment of age, resulting in a slow walk time when crossing streets [26, 33–36]. Geriatric injury increases as the population ages [25]. Sadeghi-Bazargani reported that the elderly are almost seven times more likely to die due to PIs [37]. The elderly show the highest mortality trend in almost every SDI category in our study. These results are similar to Demetriades' study [38]. One of the important messages of Demetriades' study is that injury severity increases with age. They found injury severity scores of 15 and higher in the elderly age group in 36.8% compared to the pediatric age group (11.2%) [38].

There are various mechanisms and causes for PIs that are mentioned in the literature. Motorcycle collisions with pedestrians are highlighted as being responsible for the majority of deaths [20, 34, 39, 40]. However, some studies highlight other factors such as buses, trucks, freeways, weather conditions, time of day, road density, lack of appropriate signaling, zebra crossings, crossing the highway, walking on the pavement, bus stops, and speed [24, 26, 35, 40, 41].

Although controlling and fixing all factors is not realistic, decreasing the incidence and mortality associated with PIs is possible by modifying behavioral, social, and environmental risk factors [28]. Reports from HSDI countries such as Germany highlight that modifications of car front design reduce pedestrian injury and severity [42]. Not every country has similar developmental stages as HSDI countries. Therefore, implementing similar modifications to their car industry or importing newly designed vehicles may not be a solution. However, some other simple measures can be taken in to consideration including education. McLaughlin reported that increasing awareness and knowledge about PIs among elementary school children with interactive educational sessions reduced PIs occurrence by 60% [43]. Some experts highlighted that even as little as one and a half hours of virtual pedestrian environment training reduced the pedestrian error rate in children [44]. Interestingly, educational programs mainly consider children as a target population. However, in our results, we saw that incidence and mortality increased with age and are also high in the elderly. Therefore, educational activities should be continued for all age categories and repeated on a periodic basis [45]. Alcohol and other drug effects on injuries are undeniable [46]. Increasing alcohol and drug screening among high-risk groups is essential and may also decrease PIs [47].

In addition, implementing speed limits and traffic road design, along with calming measures are also very effective [26, 41, 48, 49]. A decrease of as little as 10 kilometers per hour in the speed limit has resulted in a favorable decrease of PIs in Japan [41]. Similar findings have been reported from the United Kingdom of a 15% reduction in mean speed led to reduced injury rates by 21% and fatalities by 75% [50]. A report from Russia highlighted that changing the structure of roads with signalization decreases the PIs rate [51].

In our study on the incidence and mortality of PIs, we predicted that, though the incidence and mortality due to PIs are decreasing, they are showing a slow reduction over time. The outlined United Nations Sustainable Development Goals targeting to reduce global injuries and deaths by 50% appear to be overambitious, based on our study, unless robust national and worldwide strategies are introduced according to the needs of each SDI region and country. Otherwise, there is a strong possibility that the countries within the LSDI regions will end up with higher rates of mortality due to failures to adopt such global plans [52].

## 5. Limitations

To our knowledge, this study provides the first overview of global patterns and trends of incidence and mortality of PIs by different SDI regions. However, our results should be reviewed with consideration of the following limitations. First, this study was undertaken using the secondary data from the GBD 2017 and could possibly have inconsistent coding, non-coding or under-reporting

of PIs, leading to overestimation or underestimation of PIs. Such coding errors are especially prevalent in under-resourced SDI regions like the LSDI and LMSDI countries. However, with the GBD methodology, there is a clear framework to take care of such sampling and non-sampling errors [11]. Also, we predicted the future incidence and mortality trends of PIs based on the results obtained from 1990 to 2017. Further studies are required with primary data obtained from nationwide observational studies or trauma registries to verify our findings. Accordingly, trends in the pattern of incidence and mortality may change if national policies and other parameters related to PIs are modified.

## 6. Conclusions

In this study, we showed that PIs continue to be a burden for all SDI categories and corresponding countries. SDI categories show variation between incidence and mortality rates. Charters' systematic review reveals the variation in incidence and mortality between regions and countries, even between cities in the same country [22]. Although incidence and mortality are predicted to be reduced globally, according to our forecasting exercise, some specific SDI categories and their corresponding countries should be the primary focus because of their high mortality rates. Similar attention should be given to specific age groups. Accordingly, prevention efforts should be tailored for specific age groups, as noted in the discussion. Therefore, more research is needed to elaborate on specific problems and solutions in different SDI categories, regions and countries.

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