Motorized 2-3 Wheelers Death Rates Over a Decade: A Global Study

Yasin J Yasin

UAE University

Michal Grivna

UAE University

Fikri Abu-Zidan (✉ fabuzidan@uaeu.ac.ae)

UAE University

Research Article

Keywords: Global, 2-3 Wheelers, Motorcycle, Death, Road traffic collision, Road safety

Posted Date: November 30th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-1112772/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Abstract

Background: Motorized 2-3 wheelers-related death are high due to the exposed body of the driver/passenger and the high speed. The United Nation (UN) Decade of Action for road safety aimed to reduce road traffic deaths by 50% by the year 2020. We aimed to study the factors affecting the death rates of motorized 2-3 wheelers injured victims and whether the reduction of the death rates has met the UN target.

Methods: Data were retrieved from the WHO Global Status Reports on Road Safety published over 2009 to 2018 which covered the years of 2007 to 2016. Studied variables included motorized 2-3 wheelers death rates, percentage of helmet-wearing rate, helmet law enforcement, speed law enforcement, gross national income per capita, vehicles/person ratio, motorized 2-3 wheelers/person ratio. A mixed linear model was used to define factors affecting the change of motorized 2-3 wheelers death rates over time.

Results: Global mortality rates of motorized 2-3 wheelers increased by 6.5% over 10 years which was not statistically significant. Factors that affected mortality included GNI ($p=0.025$), motorized 2-3 wheelers per person ratio ($p < 0.0001$), percentage of helmet wearing rate ($p=0.046$), and the interaction between vehicle/person ratio and motorized 2-3 wheelers/person ratio ($p=0.016$). There was a significant increase in the death rates over time in the low-income countries (170.2 %, $p=0.019$, Friedman test), and middle-income countries (56.1 %, $p < 0.0001$, Friedman test), compared with a significant decrease in the high-income countries (17.8 %, $p < 0.0001$, Friedman test).

Conclusions: Global mortality of motorized 2-3 wheelers has increased by 6.5% over a recent decade. The UN target of reducing death was not met. The increase was related to the increase of motorized 2-3 wheelers per person ratio and economic inequity which has to be addressed globally. The economic global gap significantly impacts the mortality rates of motorized 2-3 wheelers.

Introduction

Over the last decade, more than 13 million people died from road traffic collisions (RTCs) [1]. Around 2 billion vehicles are used globally of which 30 % are motorized 2-3 wheelers [1-3]. Low and middle-income countries (LMICs) use 88% of these wheelers of which 75% are in South-East Asia [3]. There is a rapid increase of the use of motorized 2-3 wheelers worldwide because of their availability, flexibility, and affordability with the highest growth rate is in South-East Asia (39%) [3-6]. Riding a motorized 2-3 wheeler is very risky because of the high speed and the exposed bodies of the driver and passenger. The risk of death from a crash is 28 to 34 times higher than for a car occupant [7, 8]. A quarter of road traffic deaths involve motorized 2-3 wheelers, with approximately 3.2 million deaths over the past decade [1, 3, 9, 10].

In response to this growing burden, the United Nations (UN) approved a Global Plan for the Decade of Action for Road Safety 2011-2020 aiming to reduce road deaths by half in 2020 [11]. Continuous evaluation of the global changes is essential to find whether the action plan is properly progressing [12]. The World Health Organization (WHO) Global Status Reports on Road Safety plays an important role in this evaluation [1, 9, 10, 13]. Although previous studies have examined the factors affecting the global motorized 2-3 wheeler-related deaths, they neither used repeated time global data nor examined the factors affecting the change over time [14]. Thus, we aimed to study the factors affecting the death rates of motorized 2-3 wheeler injured victims over time and whether the reduction of death rates has met the UN target.

Methods

Ethical consideration

Data used in this study are publicly available data from the WHO Global Status Report on Road Safety and do not need approval from a Human Research Ethics Committee.

Definition of 2-3 wheelers

Motorized 2-3 wheelers refers to powered two- and three- wheelers [3]. According to the WHO definition "motorized 2-3 wheelers or powered two- and three-wheelers (PTWs) are motor-operated two- and three-wheeled vehicles, powered by either a combustion engine or rechargeable batteries". These included motorcycles, scooters, e-bikes, tricycles motor- rickshaws or e-rickshaws [3].

Data collection

Data were retrieved from the WHO Global Status Reports on Road Safety for years 2007, 2010, 2013, and 2016, which were published in 2009, 2013, 2015, and 2018, respectively [1, 9, 10, 13]. These reports had data on 178, 182, 180, and 175 countries, respectively, with complete data on motorized 2-3 wheelers death on 115 (64.6%), 123 (67.6%), 117 (65.0%), and 122 (69.7%) countries, respectively. The area of countries was retrieved from the infoplease.com website [15].

Studied variables

Studied variables included the percentage of estimated helmet-wearing rate, the effectiveness of helmet law enforcement, the effectiveness of speed law enforcement, estimated road traffic deaths rate per 100 000 population, percentage of motorized 2-3 wheelers death, country population, Gross National Income (GNI) per capita in US dollars, number of registered vehicles, and percentage of motorized 2-3 wheelers in each country.

The percentage of motorized 2-3 wheelers death included all riders (drivers or passengers). The percentage of estimated helmet-wearing rate in our study included all riders. However, if data was not available on all riders, we used instead the reported percentage of estimated helmet-wearing rate of drivers.

Information on the overall effectiveness levels of both helmet law enforcement and speed limit enforcement were scored on a scale of 0 to 10, where 0 is “not effective” and 10 is “highly effective” based on professional consensus in each country.

Data entry

Data collected during all studied years were coded and entered into the MS Excel program in two formats: vertical data format (the same variables in all studied years were entered into a single column in order of years with an added year variable), and horizontal data format (each variable in each studied year entered into a separate column). Data were rechecked for accuracy and consistency and exported into SPSS for analysis.

Calculations

The population density was calculated by dividing the total population by country area (number of people/mile square). The number of motorized 2-3 wheelers was calculated by multiplying the percentage of motorized 2-3 wheelers by the total number of registered vehicles. Motorized 2-3 wheelers death rate was calculated by multiplying the percentage of motorized 2-3 wheelers death by the estimated traffic road death rates per 100 000 population. Vehicle per person ratio was calculated by dividing the total number of registered vehicles by the total population. Motorized 2-3 wheelers per person ratio was calculated by dividing the total number of motorized 2-3 wheelers by total population.

Statistical analysis

Mortality rates were highly skewed to the left. Accordingly, median (interquartile range, IQR) were used in reporting the data. We used a mixed linear model (MLM) to assess the factors affecting motorized 2-3 wheelers death rates over time. Death rates were transformed to a normal distribution to fulfill the requirements of the MLM. Log transformation had the best normal distribution over time and within each year and was used as the outcome variable.

The MLM analyses data of repeated measures (years) of each country (subject) separately, taking into account both the slope and intercept of each linear line of a country (within-subjects correlation). Studying the slope has an important advantage of addressing missing data and the nonlinear relationship between different factors. MLM assumes a normal distribution of the outcome (dependent) variable. The logarithmic transformation of death rate was the dependent variable of the MLM model, while independent covariates do not need to have a normal distribution which can be ordinal, continuous, or categorical data.

The used MLM model was a strict unstructured, main-effects model with repeated measures. It included a fixed effect, type III sum of squares error (due to the unbalanced data), and random effects for the independent variables (factors and covariates). These strict requirements assume that the variance of each studied year and the covariance (correlation) between the studied independent factors are different. The change of the outcome dependent variable (death rate) was studied over time by entering the studied years as a categorical factor (factor = year) while independent variables as covariates. These included continuous variables (population density, GNI per capita, vehicle per person ratio, and motorized 2-3 wheelers per person ratio) and ordinal variables (speed law enforcement (0-10) and helmet law enforcement (0-10)). We tested different interactions in the model, excluded non-significant and included significant interactions in the final MLM model. Accordingly, the interaction between vehicle per person ratio and motorized 2-3 wheelers per ratio was added to the final main effects model.

After achieving the results of the final MLM model, several univariate post-hoc analyses were performed to explain our findings. Spearman rank correlation test was used to study the correlation between different continuous or ordinal variables. Wilcoxon signed-rank test was used to compare the continuous or ordinal data of two dependent groups. Friedman test was used to compare the continuous or ordinal data of more than two dependent groups. Mann-Whitney U test was used to compare the continuous or ordinal data of two independent groups, while Kruskal Wallis test was used to compare the continuous or ordinal data of more than two independent groups. Data were analyzed with the IBM SPSS Statistics version 26 (SPSS Inc, Chicago, IL, USA). A p-value of less than 0.05 was accepted as statistically significant.

Results

Table 1 shows the results of the mixed linear model. The model showed factors that affected the log transformation of motorized 2-3 wheelers death rates. The significant factors were GNI ($P = 0.025$), motorized 2-3 wheelers per person ratio ($p < 0.0001$), percentage of helmet wearing rate ($p = 0.046$), and the interaction between vehicle per person ratio and motorized 2-3 wheelers per person ratio ($p = 0.016$). No significant differences in mortality were seen over time. This was confirmed using post hoc analysis ($p = 0.38$, Friedman test) (**Figure 1**). The overall percentage of increase of mortality rate was 6.5% globally over the decade.

Despite the above finding, there was a significant difference in the death rates depending on the income level. There was a statistically significant increase in mortality rate (170.2%) in low-income countries over time ($p = 0.019$, Friedman test, **Figure 2A**). There was a statistically significant change in the mortality rate in middle-income countries over time ($p < 0.0001$, Friedman test, **Figure 2B**). Overall, the percentage of motorized mortality rates was increased by 56.1% in MICs over the last 10 years. The increase was significant between years 2007 and 2010 ($p = 0.001$, Wilcoxon signed-rank test). However, there was a significant drop between 2013 and 2016 ($p = 0.003$, Wilcoxon signed-rank test). There was a significant decrease in death rate in the high-income countries (17.8%) over time ($p < 0.0001$, Friedman test, **Figure 2C**).

Table 2 shows the correlations between 2-3 wheelers per person ratio, helmet usage, and GNI, with death rate (**Table 2**). All these correlations were highly significant within 2007, 2010, 2013, and 2016 (**Figures 3-5**). The post-hoc comparisons between low-income, middle-income, and high-income countries confirmed these correlations. There was a highly significant difference in the death rate, 2-3 wheelers per person ratio, and percentage of helmet-wearing rate between these countries. Death rate decreased, 2-3 wheelers per person ratio increased, while helmet usage increased with increased income (**Figure 6**).

Discussion

Our study has shown that there was no significant reduction in the motorized 2-3 wheelers death rates over the studied period which has even globally increased by 6.5%. The UN target was not met. The death rate increased because of the the increase of the motorized 2-3 wheelers and was reduced by helmet compliance and wealth. Nevertheless, there was a significant difference in the death rates between the the three levels of income of countries with 170% increase in the low-income countries, 56% increase in the middle-income countries, and 18% decrease in the high-income countries. These differences in the direction of change between the three levels explain why there was no overall global significant difference in the death rates when combined together. Other studies showed that the UN target was not met [16-18] and even suggested that mortality from motorized 2-3 wheelers would even increase globally by 11% over the coming 10 years [19].

The increased death rates were related to the increased motorized 2-3 wheelers in our study which was supported by others [14, 20, 21]. The use of motorized 2-3 wheelers increase the chances of getting a job in poor countries. Understandably, their increased number and travel time on unsafe roads would increase the RTCs [4, 22-24]. This would be even worse if safety rules were not followed like using helmets. Helmet compliance significantly reduced the death rate of the 2-3 wheeler drivers and riders in our study. Helmets reduce the impact of head injuries which have high mortality in the 2-3 wheeler-related injuries [8, 14]. Low GCS, indicating severe head injury, is one of the most important factors predicting mortality in RTCs [25-27].

The increased GNI reduced the overall mortality overtime in our study. Although the GNI significantly increased the number of 2-3 wheelers, it was highly correlated with an increase of helmet use in the population within each studied year. The MLM will consider all these interactions to define the overall effect. Several previous studies showed that the increase of motorized 2-3 wheeler per person ratio is associated with initial rise of GNI. This ratio declines later on when the GNI increases more. Cars will be preferred at this satge because they are safer and more comfortable [6, 21, 28 29 30]. The increased GNI is also related to the effective implementation of road safety regulations (including helmet law), and improvement in medical care [28, 31].

Limitation of the study

Our study has certain limitations. *First*, our analysis depended on the WHO reports. The availability and accuracy of this data can be affected by the political agenda and the health informatics infrastructure. The World Bank highlighted a profound difference between government-reported road deaths and WHO-estimated road deaths, with under-reporting of 84% in the low-income countries, 51% in middle-income countries, and 11% in high-income countries, [5]. We have used the estimated death rates of the WHO reports as it is more accurate. Nevertheless, this carries the risk of theoretical assumptions and modelling. *Second*, some important factors related to road deaths are not included in the analysis like the driver behavior, age, gender, drug/alcohol use, educational level, riding experience, and using visibility aids [8, 32]. Our study is based on a country level and not on individual levels. Factors that apply to a particular person are difficult to quantify on a country level. *Third*, publishing WHO reports takes up to 3 years. The report for the recent 3 years has not yet been published and is not included in our current analysis. This is most properly related to the COVID-19 pandemic where more WHO resources were used to address the pandemic challenges. We are awaiting this global report as it may highlight the impact of COVID-19 pandemic on the RTC safety [26, 33]. *Finally*, the GNI is a single collective factor with varying effects at different stages of the economic development. Although GNI in general was associated with the reduced motorized 2-3 wheelers deaths in our study, the rise of GNI at early stages would increase motorized 2-3 wheeler per person ratio while the law enforcement of safety regulations usually comes after the initial increase of mortality.

Conclusion

Global mortality of motorized 2-3 wheelers has increased by 6.5% over a recent decade. The UN target of reducing death was not met. The increase was related to the increase of motorized 2-3 wheelers per person ratio and economic inequity which has to be addressed globally. The economic global gap significantly impacts the mortality rates of motorized 2-3 wheelers.

Abbreviations

CI: Confidence interval

GNI: Gross national income

LMICs: Low- and middle-income countries

LL: Lower limit

MIC: Middle-income countries

MLM: Mixed linear model;

RTC: Road traffic collision

SE: Standard error

SPSS: Statistical package for the social sciences

UL: Upper limit

UN: United Nations

US: United States

USA: United States of America

WHO: World Health Organization

Declarations

Authors' contributions: Conceived and designed the experiments: YJY, MG, FAZ. Retrieved and coded the data: YJY. Analyzed the data: YJY, FAZ. Wrote the paper: YJY. Critically edited the paper: FAZ, Critically read the paper: YJY, MG, FAZ. All authors approved the final version: of the paper.

Ethics approval and consent to participate: This is public published data of the WHO, which is exempt from the approval of the human research ethics committee.

Funding There was no funding for this research study.

Availability of data and material: Original data are published by the WHO and available on the website references [1, 9, 10, 13].

Consent for publication: Not applicable

Competing interests: The authors declare that they have no competing interests.

Authors' informational (optional): Not applicable

Acknowledgments: None

References

1. World Health Organization. The Global status report on road safety. Vol. 2, Geneva. 2018. Available at: https://www.who.int/violence_injury_prevention/road_safety_status/2018/en/. Accessed 27 October 2021.
2. Peden M. Saving lives through vehicle safety. *Lancet Glob Heal*. 2020;8:e746–7.
3. World Health Organization. Powered two- and three-wheeler safety: A road safety manual for decision-makers and practitioners. 2017. Available at: <https://apps.who.int/iris/rest/bitstreams/1081388/retrieve>. Accessed 27 October 2021.
4. Kumar A. Understanding the emerging role of motorcycles in African cities. *Sub-Saharan Africa Transp Policy*. 2011. Available at: <https://openknowledge.worldbank.org/bitstream/handle/10986/17804/669410NWP0DP130IC00Role0Motorcycles.pdf;sequence=1>. Accessed 27 October 2021.
5. World Bank. Guide for road safety opportunities and challenges: Low- and middle-income country profiles. Washington, DC, USA; 2020. Available at: <https://www.ssatp.org/sites/ssatp/files/publication/Guide-for-Road-Safety-Opportunities-and-Challenges-Low-and-Middle-Income-Country-Profiles.pdf>. Accessed 07 November 2021.
6. Law TH, Hamid H, Goh CN. The motorcycle to passenger car ownership ratio and economic growth: A cross-country analysis. *J Transp Geogr*. 2015;46:122–8.
7. National Highway Traffic Safety Administration. Traffic safety facts 2016 (DOT HS 812 554). 2018. Available at: <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812492>. Accessed 05 November 2021.
8. Lin MR, Kraus JF. A review of risk factors and patterns of motorcycle injuries. *Accid Anal Prev*. 2009;41:710–22.
9. World Health Organization. Global status report on road safety. Vol. 15, Geneva. 2015. Available at: https://www.afro.who.int/sites/default/files/2017-06/9789241565066_eng.pdf. Accessed 27 October 2021.
10. World Health Organization. Global status report on road safety: Supporting a decade of action. Vol. 19, Geneva. 2013. Available at: http://www.who.int/violence_injury_prevention/road_safety_status/2013/en/%5Cnhttp://www.who.int/violence_injury_prevention/road_safety_status/2013/en/. Accessed 27 October 2021.
11. United Nations. Global plan for the Decade of Action for Road Safety 2011–2020. Geneva: WHO. 2010. p. 25. Available at: <http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Global+Plan+for+the+Decade+of+Action+for+Road+Safety+2011-2020#0>. Accessed 28 October 2021.
12. James SL, Lucchesi LR, Bisignano C, Castle CD, Dingels Z V, Fox JT, et al. Morbidity and mortality from road injuries: results from the Global Burden of Disease Study 2017. *Inj Prev*. 2019;1–11.
13. World Health Organization. Global status report on road safety: time for action. Geneva. 2009. Available at: http://apps.who.int/iris/bitstream/handle/10665/44122/9789241563840_eng.pdf;jsessionid=80D4774FE6C0CA3666010581CD4B9C1F?sequence=1. Accessed 27 October 2021.
14. Abbas AK, Hefny AF, Abu-Zidan FM. Does wearing helmets reduce motorcycle-related death? A global evaluation. *Accid Anal Prev*. 2012;49:249–52.
15. InfoPlease. Area and population of countries: Available at: <https://www.infoplease.com/world/population-statistics/area-and-population-countries>. Accessed 15 October 2021.

16. Bhalla K, Mohan D, O'Neill B. How much would low- and middle-income countries benefit from addressing the key risk factors of road traffic injuries? *Int J Inj Contr Saf Promot.* 2020;27:83–90.
17. Peden MM, Puvanachandra P. Looking back on 10 years of global road safety. *Int Health.* 2019;11:327–30.
18. Swedish Transport Administration. Saving Lives Beyond 2020: The Next Steps. Recommendations of the Academic Expert Group for the 3rd Global Ministerial Conference on Road Safety. 2019. Available at: https://www.roadsafetysweden.com/contentassets/c65bb9192abb44d5b26b633e70e0be2c/200113_final-report-single.pdf. Accessed 29 October 2021.
19. Inada H, Li Q, Bachani A, Hyder AA. Forecasting global road traffic injury mortality for 2030. *Inj Prev.* 2019;1–5.
20. Pal C, Hirayama S, Narahari S, Jeyabharath M, Prakash G, Kulothungan V. An insight of World Health Organization (WHO) accident database by cluster analysis with self-organizing map (SOM). *Traffic Inj Prev.* 2018;19:S15–20.
21. Bastos SQA, Gama F, de Paula Assis T, Milosz M. Is there a relationship between the use of motorcycles and the level of development of countries? *Bull Geogr Socio-economic Ser.* 2020;50:43–53.
22. Karema FM, Irandu EM, Moronge JM. The role of commercial motorcycles in alleviating poverty in rural areas: A case study of Laikipia East Sub-County, Kenya. *World Rev Intermodal Transp Res.* 2017;6:155–76.
23. Ali M, Saeed MMS, Ali MM, Haidar N. Determinants of helmet use behaviour among employed motorcycle riders in Yazd, Iran based on theory of planned behaviour. *Injury.* 2011;42:864–9.
24. Umaru IG. Commercial Motorcycle Activity, Value Creation and the Environment in the Developing World: The Case of Nasarawa State, Nigeria. *Int J Soc Sci Res.* 2013;1:122.
25. Eid HO, Barss P, Adam SH, Torab FC, Lunsjo K, Grivna M, Abu-Zidan FM. Factors affecting anatomical region of injury, severity, and mortality for road trauma in a high-income developing country: lessons for prevention. *Injury.* 2009;40:703-7.
26. Yasin YJ, Alao DO, Grivna M, Abu-Zidan FM. Impact of the COVID-19 Pandemic on road traffic collision injury patterns and severity in Al-Ain City, United Arab Emirates. *World J Emerg Surg* 2021;16:57.
27. Al-Kuwaiti A, Hefny AF, Bellou A, Eid HO, Abu-Zidan FM. Epidemiology of head injury in the United Arab Emirates. *Ulus Travma Acil Cerrahi Derg.* 2012;18:213-8.
28. Law TH, Noland RB, Evans AW. Factors associated with the relationship between motorcycle deaths and economic growth. *Accid Anal Prev.* 2009;41:234–40.
29. Chu MY, Law TH, Hamid H, Law SH, Lee JC. Examining the effects of urbanization and purchasing power on the relationship between motorcycle ownership and economic development: A panel data. *Int J Transp Sci Technol.* 2021. <https://doi.org/10.1016/j.ijtst.2020.12.004>.
30. Pongthanaisawan J, Sorapipatana C. Relationship between level of economic development and motorcycle and car ownerships and their impacts on fuel consumption and greenhouse gas emission in Thailand. *Renew Sustain Energy Rev.* 2010;14:2966–75.
31. Sirajudeen AO, Law TH, Wong SV, Jakarni FM, Ng CP. The sources of the Kuznets relationship between the road deaths to road injuries ratio and economic growth. *J Safety Res.* 2021;78:262–9.
32. Sumit K, Ross V, Brijis K, Wets G, Ruiter RAC. Risky motorcycle riding behaviour among young riders in Manipal, India. *BMC Public Health.* 2021;21:1954.
33. Yasin YJ, Grivna M, Abu-Zidan FM. Global impact of COVID-19 Pandemic on road traffic collisions. *World J Emerg Surg.* 2021;16:51.

Tables

Table 1: Linear mixed effect model of factors affecting log transformation of motorized 2-3 wheelers death rate globally over 2007–2016

Variable	Estimate	SE	t-value	p-value	LL 95% CI	UL 95% CI	
Year 2007	0.017	0.130	0.133	0.896	-0.266	0.301	<i>SE standard error, LL lower limit, CI confidence interval, UL upper limit</i>
Year 2010	0.059	0.100	0.591	0.558	-0.144	0.262	
Year 2013	-0.003	0.083	-0.041	0.968	-0.170	0.163	
Density of population	5.779 ⁻⁵	5.536 ⁻⁵	1.044	0.302	-5.370 ⁻⁵	0.169 ⁻³	Table 2: Spearman rank correlations between the significant factors that affected motorized 2-3 wheelers death rate globally over 2007–2016
GNI	-1.220 ⁻⁵	5.239 ⁻⁶	-2.329	0.025	-2.280 ⁻⁵	-1.602 ⁻⁶	
Vehicle per person ratio	0.545	0.489	1.114	0.268	-0.427	1.517	
Motorized 2-3 wheelers/person ratio	7.851	1.725	4.552	0.000	4.433	11.270	
Enforcement of speed	-0.039	0.023	-1.666	0.103	-0.087	0.008	
Enforcement of helmet	0.011	0.021	0.531	0.599	-0.031	0.053	<i>GNI Gross National Income/capita (US dollars)</i>
Percentage of helmet wearing rate	-0.004	0.002	-2.047	0.046	-0.008	-7.898 ⁻⁵	
Vehicle/person ratio * motorized 2-3 wheelers/person ratio	-4.792	1.953	-2.454	0.016	-8.667	-0.916	Figures
Intercept	0.637	0.249	2.558	0.012	0.143	1.131	

Variable	2-3-wheelers per person ratio		Percentage of helmet wearing rate		GNI per capita	
	rho	p-value	rho	p-value	rho	p-value
Year 2007						
Motorcycle 2-to 3-wheelers death rate	0.408	$P < 0.0001$	- 0.342	$P = 0.019$	- 0.048	$P = 0.610$
GNI	0.494	$P < 0.0001$	0.390	$P = 0.002$	-	.
Year 2010						
Motorcycle 2-to 3-wheelers death rate	0.35	$P < 0.0001$	- 0.389	$P = 0.003$	- 0.263	$P = 0.004$
GNI	0.443	$P < 0.0001$	0.538	$P < 0.0001$	-	.
Year 2013						
Motorcycle 2-to 3-wheelers death rate	0.382	$P < 0.0001$	- 0.422	$P = 0.001$	- 0.366	$P < 0.0001$
GNI	0.420	$P < 0.0001$	0.669	$P < 0.0001$	-	.
Year 2016						
Motorcycle 2-to 3-wheelers death rate	0.324	$P = 0.001$	- 0.661	$P < 0.0001$	- 0.312	$P < 0.0001$
GNI	0.294	$P < 0.0001$	0.732	$P < 0.0001$	-	.

Figure 1

Box-and-whiskers plot of motorized 2-3 wheelers death rate per 100 000 population of years 2007-2016. The box resembles the 25th percentile and the 75th percentile Interquartile Range (IQR). While the line within the box resembles the median. Black circles represent the outliers. P-value = Friedman test for

comparison of more than two dependent groups and Wilcoxon signed-rank test for comparison of two dependent groups.

Figure 2

(A-C): Box-and-whiskers plot of motorized 2-3 wheelers death rate per 100 000 population of years 2007-2016 by the level of income of countries (A = low income countries, B = middle income countries, and C = high income countries). The box resembles the 25th percentile and the 75th percentile Interquartile Range (IQR). While the line within the box resembles the median. P-value = Friedman test for comparison of more than two dependent groups and Wilcoxon signed-rank test for comparison of two dependent groups.

Figure 3

The correlation (Scatter plot) between motorized 2-3 wheelers death rate per 100 000 population and GNI per capita in US dollars within each years of 2007, 2010, 2013, and 2016.

Figure 4

The correlation (Scatter plot) between motorized 2-3 wheelers death rate per 100 000 population and motorized 2-3 wheelers/person ratio within each years of 2007, 2010, 2013, and 2016.

Figure 5

The correlation (Scatter plot) between motorized 2-3 wheelers death rate per 100 000 population and percentage of helmet wearing rate within each years of 2007, 2010, 2013, and 2016.

Figure 6

Box-and-whiskers plot of motorized 2-3 wheelers death rate per 100 000 population, motorized 2-3 wheelers/person ratio, and percentage of helmet wearing rate of years 2007-2016 by the level of income of countries. The box resembles the 25th percentile and the 75th percentile Interquartile Range (IQR). While the line within the box resembles the median. P-value = Mann-Whitney U test for comparison of two independent groups and Kruskal Wallis for comparison of more than two independent groups.