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# Vehicle Ownership and Road Crashes in Cambodia: Results from Three Nationwide Surveys

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## Introduction

Cambodia has made remarkable economic progress over the past two decades. A rapid rise in vehicle ownership and road traffic crashes accompanies this advancement. This study investigated the social determinants of road crashes, including increasing vehicle ownership in Cambodia.

## Methods

This is a retrospective analysis of household data from three rounds (2005, 2010, and 2014) of the Cambodia Demographic and Health Survey, a nationally representative survey. We estimated the independent associations between household vehicle ownership (bicycles, motorcycles, and cars or trucks) and the reporting of injury or death from road crashes by any household member. Multivariable logistic regression analysis evaluated the adjusted associations between reporting road crashes and vehicle ownership while controlling for other household and environmental factors.

## Results

A combined total of 45,513 households were surveyed within the study period (2005 to 2014). The proportion of households reporting road crash-related injury or death increased from 3.9% in 2005 to 5.5% in 2014 [p<0.0001]. Among different types of vehicles, households that own motorcycles were 72% [AOR: 1.72 95% CI (1.55 - 1.92)] more likely to report having a victim of a road crash after adjusting for the location of the household, wealth index, education level, and gender of the head of the household.

## Conclusion

An increasing motorized vehicle ownership appears to drive Cambodia's worsening road safety. The threat of deteriorating road safety is worse in countries experiencing rapid economic development, while improvement to physical infrastructure and regulatory frameworks is lagging. As Cambodia continues its journey towards economic prosperity, road safety should receive additional attention. Efforts should especially focus on motorcycles.

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## Introduction

Road crashes are a leading public health problem worldwide. [1,2] According to a World Health Organization (WHO) report of 2023, there is an annual estimated road crash-related death of 1.2 million globally, and for each road crash-related mortality, many more are injured or disabled. Road traffic crashes are the principal cause of death for individuals aged 15 – 29 years and the ninth cause of death among all age groups combined. [2] By 2025, road traffic crashes are projected to be the third leading cause of death and disability worldwide. [1,3]

From 2000 to 2015, the global trend of road crash-related mortality increased from 1.1 million to nearly 1.4 million. In contrast, total malaria, tuberculosis, and HIV/AIDS-related mortalities declined. Malaria: 0.9 million to about 0.4 million; Tuberculosis: 1.65 million to 1.4 million; and HIV/AIDS: 1.45 million to 1.1 million. [4] Countries with high rates of road crashes lose up to 3% of their Gross Domestic Product (GDP) to road crash-related costs, [1,4] and a substantial economic burden is placed on individuals and families from the cost of treatment to the loss of productivity following a road crash. [4]

Low and middle-income countries shoulder a disproportionate burden of road crashes globally. In 2013, traffic crash-related mortality rates were 24.1, 18.4, and 9.2 per 100,000 among low-income, middle-income, and high-income countries, respectively. [1] At the individual level, gender and socioeconomic disparities in risk and outcomes of road crashes also exist; males have a higher risk, and individuals from lower socioeconomic strata tend to suffer worse outcomes. [1] Previous studies have also reported that in addition to individual-level determinants, household sociodemographic factors such as wealth and education may influence the risk of mortality from road crashes. [6-8] Therefore, it is conceivable that as countries develop economically and in terms of physical infrastructure, the sociodemographic factors associated with road crashes are likely to change as well.

Cambodia made remarkable economic progress over the past two decades; it was one of the world's fastest-growing economies from 1995 to 2019. [4] Poverty rates plummeted from nearly 50% in 2007 to 13.5% in 2014 [5]. According to the World Bank Group, Cambodia belongs to the category of low-middle-income countries. However, this economic progress has presented different public health challenges. While the population’s per capita vehicle ownership has increased, the road infrastructure and the framework for traffic regulation have lagged. [6] Like many other countries that have made swift economic progress, Cambodia's physical infrastructure, needed to improve road safety, is lagging. [9]

Furthermore, according to Commandeur's [10] projection, if the 2000 to 2010 trend were maintained, there would be at least a 3-fold increase in motor vehicle ownership in Cambodia from 2010 to 2020. The same study also projected an associated two-fold increase in motor vehicle-related fatalities based on the expected rise in the number of motor vehicles. [10] Similarly, Roehler [11] reported an increase in both the proportion of motorcycle-related crashes and motorcyclist death rates from 2007 to 2011 in Cambodia. In addition, the global annual road safety report of 2017 also highlighted the relationship between motorcycle ownership and road crashes. The report described the worsening road safety parameters and an explosion of motorcycle ownership in Cambodia, where motorcycles make up to 80% of the road fleet. [12]

However, while the analysis by Commandeur [10] considered fatalities from registered vehicles only, the study by Roehler [11] exclusively considered road crashes reported to the official state registry. Critically, neither study considered nor adjusted for other sociodemographic determinants of road crashes in their analyses. Yet, to develop and better target interventions aimed at combating the growing challenge of road crashes in Cambodia's rapidly expanding economy, policymakers need to understand the relationships between road crashes, vehicle ownership, and other sociodemographic factors such as economic status, education, gender, and the urban-rural variations.

This study fills that gap and investigates vehicle ownership trends while exploring the associations between vehicle ownership and road crashes in Cambodia, controlling for other social factors. We hypothesize that at the household level, vehicle ownership is associated with the occurrence of road crashes after controlling for socioeconomic and geographical factors.

## Methods

### *Study Design and Sampling*

This is a cross-sectional analysis of data from three rounds (2005, 2010, and 2014) of the Cambodia Demographic and Health Survey (DHS). The DHS surveys are nationally representative conducted in collaboration between the host countries and international partners. During each DHS round in Cambodia, the Royal Government collaborates with numerous global and multinational partners to survey eligible women and men, where a wide range of demographic and health-related information is obtained. The Cambodia DHS survey mapped the entire country into nineteen sampling domains from which eligible households were selected to produce a nationally representative sample. Structured questionnaires were then administered to the head of each household. Rutstein and Rojas [13] provide further detailed information about the sampling and other DHS techniques during its survey rounds. Analyses reported in this study were conducted at Texas A&M University School of Public Health between June and August 2019. Texas A&M University's Institutional Review Board (IRB) exempted this study from full ethics review.

### *Measures and Statistical Analysis*

Three distinct types of questionnaires were administered during each round of the DHS survey. The first was administered to all women aged 15-49 years living in selected households. The next was administered to a subsample of men selected from households included in the survey. The third was the household questionnaire, administered to the head of the household (regardless of gender). This study exclusively used information from the household questionnaire. All questionnaires were validated and administered by trained interviewers after the voluntary consent of each respondent.

This analysis merged data from three surveys (2005, 2010, and 2014). Having a victim of a road crash-related death or injury in the twelve months before each round of the survey was the dependent variable in this analysis. This information was obtained from the head of the household's response to a question: "Did any member of this household sustain any injury or die from accidents over the last 12 months?" Heads of households that answered affirmatively to the above question received a follow-up question regarding the cause of the accident; the dependent variable was dichotomized into "Yes" or "No," representing households that reported a deceased or injured victim of road crashes vs. those without, respectively. There were three household factors of interest in this study, including 1) household ownership of a bicycle, 2) household ownership of a motorcycle, and 3) household ownership of a car or truck. Each factor was dichotomized to represent households with reported vehicle ownership versus those without.

Other potential confounding variables representing household and environmental factors were controlled for in the analysis, including the gender of the head of household (male or female), the highest educational attainment of the head of the household (categorized into no education, primary level education, secondary level education, and higher education), the wealth of the household (grouped into low, middle, and high), and the location of the household (rural or urban residence).

All analyses were weighted using the appropriate weighting measures provided for the household data on DHS. Along with conducting descriptive analyses comparing households based on selected baseline characteristics, we used Pearson's chi-square test (X2) to assess bivariate relationships. A multivariable logistic regression model predicting the likelihood of reporting road crash-related mortality or injury was used to estimate the association between the dependent variable and the exposures of interest. All covariates in the model, including the exposures of interest and the household and environmental factors, were added simultaneously using the standard approach. We included the survey year as a covariate to control for the variations in reporting road crashes by survey year. We explored the interaction between ownership of each vehicle and the location of the household and reported only statistically significant interactions. To explore the potential variability in the effects of vehicle ownership on road crashes by year of survey (from 2005 to 2014), we conducted similar univariable and multivariable analyses for

each year separately. All statistical analyses were performed using SAS version 9.3, while p-values less than 0.05 and 95% Confidence Limits (CLs) not including the null value were interpreted to indicate a statistically significant difference.

## Results

**Table 1** displays the results from the descriptive analysis; within the study period, 45,513 households were surveyed. Most households were rural (85.6%). The proportion of households that reported road crash-related mortality or injury increased from 3.9% to 5.5% over the ten-year study period. During the same period, there was a concomitant increase in the proportion of households owning vehicles. The proportion of households owning cars or trucks increased over three-fold, from 3.9% to 14.1%, and the percentage of motorcycle ownership nearly doubled from 34.7% to 68.0%, while bicycle ownership decreased slightly from 68.3% to 64.2%.

***Table 1**: Sociodemographic Characteristics of Cambodia Households (2005 – 2014)*

| Characteristics | Year of Survey | | |
|---|---|---|---|
| | **2005 [N (%)]** | **2010 [N (%)]** | **2014 [N (%)]** |
| **Households with a deceased or injured victim of road crash** | | | |
| *Yes* | 547 (3.9) | 804 (5.2) | 868 (5.5) |
| *No* | 13609 (96.1) | 14752 (94.8) | 14957 (94.5) |
| **Ownership of Bicycle** | | | |
| *Yes* | 9672 (68.4) | 10179 (65.5) | 10155 (64.2) |
| *No* | 4478 (31.7) | 5373 (34.6) | 5670 (35.8) |
| **Ownership of Motorcycle** | | | |
| *Yes* | 4915 (34.7) | 8325 (53.5) | 10762 (68.0) |
| *No* | 9235 (65.3) | 7227 (46.5) | 5062 (32.0) |
| **Ownership of Car/Truck** | | | |
| Yes | 550 (3.9) | 1009 (6.5) | 2227 (14.1) |
| No | 13600 (96.1) | 14539 (93.5) | 13596 (85.9) |
| **Gender – head of household** | | | |
| *Male* | 10809 (76.4) | 11326 (72.8) | 11573 (73.1) |
| *Female* | 3347 (23.6) | 4230 (27.2) | 4252 (26.9) |
| **Wealth Quintiles** | | | |
| *Low* | 5812 (41.1) | 6424 (41.3) | 6527 (41.2) |
| *Middle* | 2884 (20.4) | 3149 (20.2) | 3147 (19.9) |
| *High* | 5461 (38.6) | 5983 (38.5) | 6151 (38.9) |
| **Location of household** | | | |
| *Rural* | 12117 (85.6) | 12917 (83.0) | 13542 (85.6) |
| *Urban* | 2039 (14.4) | 2639 (17.0) | 2284 (14.4) |
| **Education - head of household** | | | |
| *No education* | 3102 (21.9) | 3289 (21.2) | 2927 (18.5) |
| *Primary* | 7618 (53.9) | 7787 (50.1) | 8174 (51.7) |
| *Secondary* | 3182 (22.5) | 4085 (26.3) | 4303 (27.2) |
| *Higher* | 239 (1.7) | 391 (2.5) | 418 (2.6) |
| Total | **14,156** | **15,556** | **15,825** |

**Table 2** shows the results of the univariate analyses assessing the unadjusted associations between reporting a road crash-related mortality or injury and ownership of vehicles at the household level. Households with reported ownership of any vehicle (bicycle, motorcycle, car, or truck) were significantly more likely to report a road crash-related mortality or injury throughout the study period (Table 2). Specifically, household ownership of a motorcycle doubled the likelihood of a reported road crash-related death or injury, from 3.2% (among those without motorcycles) to 6.4% (among those owning a motorcycle) [p<0.0001]. [p<0.0001].

***Table 2:*** *Univariate Analysis for Associations between a Road Crash and Vehicle Ownership in Cambodia*

| Characteristic | Households with Road Crash-Related Injury or Death [N (%)] | Households without Road Crash-Related Injury or Death [N (%)] | P-value |
|---|---|---|---|
| **Ownership of Bicycle** | | | 0.043 |
| *Yes* | 16 (5.0) | 28499 (95.0) | |
| *No* | 713 (4.6) | 14808 (95.4) | |
| **Ownership of Motorcycle** | | | <0.0001 |
| *Yes* | 1528 (6.4) | 22474 (93.6) | |
| *No* | 691 (3.2) | 20832 (96.8) | |
| **Ownership of Car/Truck** | | | 0.035 |
| *Yes* | 211 (5.6) | 3575 (94.4) | |
| *No* | 2008 (4.8) | 39726 (95.2) | |
| **Gender - head of household** | | | <0.0001 |
| *Male* | 1730 (5.1) | 31977 (94.9) | |
| *Female* | 489 (4.1) | 11340 (95.9) | |
| **Wealth Quintiles** | | | <0.0001 |
| *Low* | 696 (3.7) | 18066 (96.3) | |
| *Middle* | 404 (4.4) | 8775 (95.6) | |
| *High* | 1119 (6.4) | 16476 (93.6) | |
| **Location of household** | | | <0.0001 |
| *Urban* | 431 (6.2) | 6532 (93.8) | |
| *Rural* | 1789 (4.6) | 36787 (95.4) | |
| **Education - head of household** | | | <0.0001 |
| *No education* | 351 (3.8) | 8967 (96.2) | |
| *Primary* | 1165 (4.9) | 22414 (95.1) | |
| *Secondary* | 655 (5.7) | 10914 (94.3) | |
| *Higher* | 48 (4.6) | 999 (95.4) | |
| **Year of Survey** | | | <0.0001 |
| *2005* | 547 (3.9) | 13609 (96.1) | |
| *2010* | 804 (5.2) | 14752 (94.8) | |
| *2014* | 868 (5.5) | 14957 (94.5) | |

From the multivariate analysis (Table 3-Model I), households with motorcycle ownership had 72% higher adjusted odds of reporting a victim of a road crash [AOR: 1.72 95% CI (1.55 - 1.92)]. However, the interaction between owning a motorcycle and a household's location was statistically significant (Table 3-Model II), suggesting that the location of the household modified the motorcycle effect; rural households owning motorcycles had reduced odds of reporting road crashes compared to urban households.

Household ownership of a bicycle [AOR bicycle = 1.03: 95% CI (0.94 - 1.13)] and a car or truck [AOR car or truck = 0.87: 95% CI (0.74 - 1.01)] was not associated with reporting road crash-related mortality or injury after adjusting for other factors. However, the household wealth index was a significant predictor of reporting a victim of a road crash; households within the "high" category had 36% higher odds of reporting road crash-related mortality or injury [AOR = 1.36: 95% CI (1.21 - 1.53)] when compared to the "low" category. Similarly, female-headed households had 11% lower adjusted odds of reporting road crash-related injury or death [AOR = 0.89: 95% CI (0.79 - 0.99)]. The education level of the head of the household determined in part whether the household would report a victim of a road crash. Compared to those with no education, household heads with a "higher" level of education were 30% less likely to report a victim of a road crash [AOR = 0.70: 95% CI (0.51 – 0.97)]. However, households with a head having a primary level of education had a 13% increase in adjusted odds of reporting a road crash victim [AOR = 1.13: 95% CI (1.00 – 1.28)]. The year of the survey remained a significant independent predictor of reporting a road crash victim.

***Table 3:*** *Multivariate Analysis for Associations between Road Crash and Vehicle Ownership in Cambodia (2005 – 2014)*

| | **Model I** | **Model II*** |
|---|---|---|
| **Characteristics** | **Adjusted Odds of Reporting Road Crash-Related Injury or Death (95% Confidence Limits)** | **Adjusted Odds of Reporting Road Crash-Related Injury or Death (95% Confidence Limits)** |
| **Ownership of Bicycle** | | |
| *No* | Reference | Reference |
| *Yes* | 1.03 (0.94 - 1.13) | 1.03 (0.94 - 1.13) |
| **Ownership of Motorcycle** | | |
| *No* | Reference | Reference |
| *Yes* | 1.72 (1.55 - 1.92) | 1.48 (1.30 - 1.71) |
| **Ownership of Car/Truck** | | |
| *No* | Reference | Reference |
| *Yes* | 0.87 (0.74 - 1.01) | 0.89 (0.76 - 1.04) |
| **Gender - head of household** | | |
| *Male* | Reference | Reference |
| *Female* | 0.89 (0.79 - 0.99) | 0.89 (0.79 - 0.99) |
| **Wealth Quintiles** | | |
| *Low* | Reference | Reference |
| *Middle* | 1.01 (0.89 - 1.15) | 0.99 (0.87 - 1.12) |
| *High* | 1.36 (1.21 - 1.53) | 1.32 (1.17 - 1.48) |
| **Location of household** | | |
| *Urban* | Reference | Reference |
| *Rural* | 1.09 (0.97 - 1.23) | 1.25 (1.12 - 1.41) |
| **Education - head of household** | | |
| *No education* | Reference | Reference |
| *Primary* | 1.13 (1.00 – 1.28) | 1.13 (1.00 – 1.28) |
| *Secondary* | 1.06 (0.921 – 1.22) | 1.06 (0.92 – 1.23) |
| *Higher* | 0.70 (0.51 – 0.97) | 0.72 (0.52 – 1.00) |
| **Year of Survey** | | |
| *2005* | Reference | Reference |
| *2010* | 1.24 (1.11 - 1.39) | 1.24 (1.11 – 1.39) |
| *2014* | 1.25 (1.11 - 1.40) | 1.24 (1.11 - 1.39) |
| Interaction *Motorcycle*Location of Household* | N/A | 0.79 (0.70 - 0.90) |

**Model II included the significant interaction term between motorcycle ownership and a household's location*

***Table 4:*** *Multivariate Analysis for Associations between Road Crash and Vehicle Ownership in Cambodia 2005 – 2014 (Unmerged Data)*

| | **2005** | **2010** | **2014** |
|---|---|---|---|
| **Characteristic** | **Adjusted Odds of Reporting Road Crash-Related Injury or Death (95% Confidence Limits) [N=547]** | **Adjusted Odds of Reporting Road Crash-Related Injury or Death (95% Confidence Limits) [N=804]** | **Adjusted Odds of Reporting Road Crash-Related Injury or Death (95% Confidence Limits) [N=868]** |
| Ownership of Bicycle | | | |
| *No* | Reference | Reference | Reference |
| *Yes* | 1.24 (1.01 - 1.53) | 1.00 (0.75 - 1.31) | 0.84 (0.68 - 1.03) |
| Ownership of Motorcycle | | | |
| *No* | Reference | Reference | Reference |
| *Yes* | 2.20 (1.80 – 2.73) | 1.73 (1.45 – 2.07) | 1.36 (1.14 – 1.62) |
| Ownership of Car/Truck | | | |
| *No* | Reference | Reference | Reference |
| *Yes* | 0.79 (0.52 - 1.21) | 0.95 (0.81 – 1.10) | 1.00 (0.87 – 1.16) |
| Gender - head of household | | | |
| *Male* | Reference | Reference | Reference |
| *Female* | 0.90 (0.71 – 1.13) | 0.95 (0.80 – 1.13) | 0.82 (0.70 – 0.98) |

***Table 4:*** *Continued*

| | 2005 | 2010 | 2014 |
|---|---|---|---|
| **Characteristic** | **Adjusted Odds of Reporting Road Crash-Related Injury or Death (95% CI) [N=547]** | **Adjusted Odds of Reporting Road Crash-Related Injury or Death (95% CI) [N=804]** | **Adjusted Odds of Reporting Road Crash-Related Injury or Death (95% CI) [N=868]** |
| Wealth Quintiles | | | |
| *Low* | Reference | Reference | Reference |
| *Middle* | (0.76 - 1.33) | 1.15 (0.92 - 1.43) | 0.91 (0.74 - 1.14) |
| *High* | 1.39 (1.08 - 1.80) | 1.42 (1.15 - 1.75) | 1.25 (1.05 - 1.50) |
| Location of household | | | |
| *Urban* | Reference | Reference | Reference |
| *Rural* | 1.05 (0.97 - 1.23) | 1.17 (0.96 - 1.43) | 1.05 (0.85 - 1.29) |
| Education - head of household | | | |
| *No education* | Reference | Reference | Reference |
| *Primary* | (0.83 – 1.36) | 1.03 (0.84 – 1.25) | 1.31 (1.06 – 1.62) |
| *Secondary* | 0.92 (0.69 – 1.24) | 0.91 (0.72 – | 1.34 (1.05 – 1.70) |
| *Higher* | 0.98 (0.53 – 1.83) | 1.16) | 0.82 (0.48 – 1.38) |
| | 1.06 | 0.49 (0.29 – 0.85) | |

## Discussion

This study found a significant increase in households reporting road crashes in three consecutive nationwide surveys from Cambodia. We also found that households owning motorcycles had a significantly higher likelihood of reporting a victim of road crashes. This is the first study that utilized nationally representative survey data to examine the relationship between vehicle ownership and road crashes in Cambodia while controlling for social factors such as wealth and education. This finding is valuable as injuries and deaths from road crashes continue to pose a significant public health threat, especially in countries with limited infrastructure [14]. Designing and implementing effective road safety interventions relies on understanding the trends of road crashes and appreciating the factors driving worsening road safety.

Among the different kinds of motorized vehicles used for transportation, motorcycles are the most abundant in Cambodia. In general, they provide a faster means of transportation than bicycles and are more affordable than other motorized vehicles such as cars and trucks. However, multiple factors, including lack of physical/structural protection compared to cars and trucks, render motorcycle riders at a higher risk of injury. [15,16] Our findings showed that the proportion of households owning motorcycles almost doubled within ten years. Within the same time, there was a significant increase in household-reported road crash-related mortality or injury, suggesting that increasing motorcycle ownership may be the driving factor in the observed rise in road-crash-related injuries and deaths. The fact that the association between motorcycle ownership and road crashes persist even when the data from the three survey years were analyzed separately has added to the validity of our findings.

Motorcycle ownership was similarly associated with rising trends of road crashes in previous studies from Southeast Asia. [17] Roehler (2015) reported an increase of up to 30% in all motorcyclist-related road fatalities from 2007 to 2011 in Cambodia. [11] The study also reported an increase in motorcyclists' road crash fatality rates by at least two percentage points. However, the following highlight the differences between our study and the previous studies: we used household-reported injuries and fatalities from three nationally representative surveys instead of official registries and included other social determinants of road crashes in the analysis. In addition, we examined the potential modification of the effects of motorcycles by location of households. These unique peculiarities helped us to provide a more comprehensive description of the role of motorcycles in road crashes and highlight the influence of other social factors.

Even though the rising number of vehicles (in this case, motorcycles) appears to be the driver of worsening road safety, it could be argued that the problem is much more complex and likely a manifestation of an interplay between multiple factors. For instance, enforcement of road traffic regulations is a challenge in many lower and middle-income countries, including Cambodia. [18] In many cities, motorcycle riders do not obey traffic rules that are viewed chiefly as unnecessary delays for an otherwise efficient way to skirt around traffic. [19] Additionally, the infrastructure and technology for traffic rules enforcement are rudimentary; despite its recent remarkable economic progress, [5] Cambodia has significant physical infrastructural challenges, especially in road infrastructure. [19,20]

Another factor influencing road safety in Cambodia is public policy. It is an official policy that a driver's license is not a universal requirement in Cambodia; riders of motorcycles with specific engines are exempted from needing a license [21]. According to Yamaguchi (2018), 73% of reported motorcycle fatalities among the youths in Cambodia involved unlicensed riders [19]. Similarly, helmet use, a safety measure universally demonstrated to reduce the risk of both fatal and non-fatal head injuries among motorcycle riders, is unpopular in Cambodia [11,21,22].

Furthermore, Ericson and Kim (2011) studied the socioeconomic effects of road crashes among households in Cambodia and reported a widening of the gender income gap and an increase in childhood school dropout rates among families with victims of road crashes [23]. These discouraging socioeconomic indicators have the potential to negate the economic progress made in Cambodia. Our findings showed a decrease in household ownership of bicycles over

the ten years. This is likely a result of multiple factors, such as increasing population and rapid urbanization fueled by a booming economy. Previous studies from Southeast Asia had suggested that urbanization and public policy may have promoted the use of motorized vehicles at the expense of non-motorized ones. [24] This study found no relationship between household-reported road crashes and bicycle ownership. We speculate that education levels lead to higher income, which enables those individuals to purchase motorcycles instead of bicycles, leading to more miles traveled at higher speeds.

Compared with other vehicles (Bicycles and Motorcycles), ownership of cars and or trucks was relatively low but doubled within ten years, reflecting Cambodia's rapid economic growth. The apparent lack of popularity of using cars and trucks as means of transportation in Cambodia could explain why household ownership of such vehicles was not associated with reporting road crash-related mortality or injury in this study.

This study found a significant interaction between motorcycle ownership and a household's location, suggesting that the association between motorcycle ownership and road crashes was less impactful among rural households when compared to urban households. This may imply that a greater amount of traffic in urban areas is more dangerous to motorcyclists than the limited road infrastructure in rural areas. [25] Even though the gender and education level of the crash victims were not available in the DHS data, the gender and education level of the household head were associated with having a victim of road crashes among surveyed households in this analysis. Speculatively, findings from previous studies suggest that female drivers may be safer than their male counterparts, [26,27] may explain the association between the gender of the household head and road crashes found in this study. Female-headed households are more likely to have female drivers who are shown to be safer than their male counterparts. [26] However, any definitive conclusion on the dynamics of the relationship between gender and level of education of the head of households and road crashes is challenging and would require future studies to evaluate further.

## Limitations

This study has some limitations. Household-level survey data was used; thus, we were unable to assess the actual usage of the vehicles reportedly owned by each household. However, vehicle usage within homes may not be equal; different household members are likely to use vehicles at different rates. Similarly, the data does not provide information about the victims of the reported road crashes, which limited our ability to describe the injured and the deceased population in terms of relevant sociodemographic factors. Another limitation is in the cross-sectional nature of the survey data, we have no way of knowing whether vehicle ownership preceded the reported road crash.

## Conclusion

Increased reliance on motorcycles as a means of transportation, coupled with a lagging investment in road safety infrastructure and safety regulations, drives the worsening of road safety in Cambodia. As motorcycle ownership becomes more popular, policymakers must put additional efforts into improving road safety. This research has added to the existing evidence on the effects of a widespread increase in motorcycle ownership on road safety in Cambodia; authorities must review the policies regulating motorcycle ownership and usage.

## Data Availability

Data supporting the results presented in this research are available free from The DHS Program (The DHS Program. Link: https://dhsprogram.com/data/Terms-of-Use.cfm). Interested parties can register and request these data after agreeing with the data sharing policy of The DHS Program.

## Authorship Contributions

The authors confirm their contributions to the paper as follows: **Study conception, design and data analysis**: Ibrahim Gwarzo. **Interpretation of results**: Ibrahim Gwarzo, David Washburn, Jay Maddock, Firsdausi Matawalle. **Draft manuscript preparation**: Ibrahim Gwarzo, Firdausi Matawalle. All authors reviewed the design and results and provided critical feedback regarding the study's execution. The authors have collectively approved the final version of the manuscript.

## Disclaimer

The information or content and conclusions of this research are those of the authors and should not be construed as the official position or policy of, nor should any endorsements be inferred by Texas A&M University where the study was conducted.

## Conflict of Interest Disclosures

The authors have no conflict of interest to declare

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## References


[1] World Health Organization. Road traffic injuries [Internet]. World Health Organization. 2023. Available from: https://www.who.int/news-room/fact-sheets/detail/road-traffic-injuries
[2] Mathers, C. D., & Loncar, D. (2006). Projections of global mortality and burden of disease from 2002 to 2030. PLoS Medicine, 3(11), e442.
[3] Binder, S., & Runge, J. W. (2004). Road safety and public health: A US perspective and the global challenge. Injury Prevention, 10(2), 68-69.
[4] World Bank. Cambodia Overview [Internet]. World Bank. 2023. Available from: https://www.worldbank.org/en/country/cambodia/overview
[5] Cambodia Poverty. Available from: https://actiononpoverty.org/our-impact/where-we-work/cambodia/
[6] Kitamura, Y., Hayashi, M., & Yagi, E. (2018). Traffic problems in Southeast-Asia featuring the case of Cambodia's traffic accidents involving motorcycles. IATSS Research,
[7] Grimm, M., & Treibich, C. (2010a). Socio-economic determinants of road traffic accident fatalities in low- and middle-income countries. ISS Working Paper Series/General Series, 504, 1-44.
[8] Sehat, M., Naieni, K. H., Asadi-Lari, M., Foroushani, A. R., & Malek-Afzali, H. (2012a). Socioeconomic status and incidence of traffic accidents in metropolitan tehran: A population-based study. International Journal of Preventive Medicine, 3(3), 181.
[9] Santoso, D. S., & Soeng, S. (2016). Analyzing delays of road construction projects in Cambodia: Causes and effects. Journal of Management in Engineering, 32(6), 05016020.
[10] Commandeur, J. J., Wesemann, P., Bijleveld, F., Chhoun, V., & Sann, S. (2017). Setting road safety targets in Cambodia: A methodological demonstration using the latent risk time series model. Journal of Advanced Transportation, 2017
[11] Roehler, D. R., Ear, C., Parker, E. M., Sem, P., & Ballesteros, M. F. (2015). Fatal motorcycle crashes: A growing public health problem in Cambodia. International Journal of Injury Control and Safety Promotion, 22(2), 165-171.
[12] Janstrup, Kira Hyldekær. "Road Safety Annual Report 2017." Technical University of Denmark (2017).
[13] Rutstein, S. O., & Rojas, G. (2006a). Guide to DHS statistics. Calverton, MD: ORC Macro, 38
[14] Chandran, Aruna, Adnan A. Hyder, and Corinne Peek-Asa. "The global burden of unintentional injuries and an agenda for progress." Epidemiologic reviews 32.1 (2010): 110-120.
[15] Lardelli-Claret, P., Jimenez-Moleon, J. J., de Dios Luna-del-Castillo, J., García-Martín, M., Bueno-Cavanillas, A., & Gálvez-Vargas, R. (2005). Driver dependent factors and the risk of causing a collision for two wheeled motor vehicles. Injury Prevention, 11(4), 225-231.
[16] Wells, S., Mullin, B., Norton, R., Langley, J., Connor, J., Jackson, R., & Lay-Yee, R. (2004). Motorcycle rider conspicuity and crash related injury: Case-control study. Bmj, 328(7444), 857.
[17] Zhang, J., Norton, R., Tang, K. C., Lo, S. K., Jiatong, Z., & Wenkui, G. (2004). Motorcycle ownership and injury in China. Injury Control and Safety Promotion, 11(3), 159-163.
[18] Afukaar, F. K. (2003). Speed control in developing countries: Issues, challenges and opportunities in reducing road traffic injuries. Injury Control and Safety Promotion, 10(1-2), 77-81.
[19] Bachani, A. M., Branching, C., Ear, C., Roehler, D. R., Parker, E. M., Tum, S., . . . Hyder, A. A. (2013). Trends in prevalence, knowledge, attitudes, and practices of helmet use in Cambodia: Results from a two-year study. Injury, 44, S31-S37.
[20] Santoso, D. S., & Soeng, S. (2016). Analyzing delays of road construction projects in Cambodia: Causes and effects. Journal of Management in Engineering, 32(6), 05016020.
[21] Yamaguchi, T. (2018). The need for building role models for motorcycle riders' education in the kingdom of Cambodia. IATSS Research,
[22] Bachani, A. M., Branching, C., Ear, C., Roehler, D. R., Parker, E. M., Tum, S., . . . Hyder, A. A. (2013). Trends in prevalence, knowledge, attitudes, and practices of helmet use in Cambodia: Results from a two-year study. Injury, 44, S31-S37.
[23] Ericson, M., & Kim, P. (2011). How road traffic injuries affect household welfare in Cambodia using the millennium development goals benchmarks. Asian Studies Review, 35(2), 209-234.
[24] Replogle, M. (1991). Non-motorized vehicles in Asia: Lessons for sustainable transport planning and policy. Non-Motorized Vehicles in Asian Cities, World Bank Technical Report, 162
[25] Zwerling, C., Peek-Asa, C., Whitten, P. S., Choi, S., Sprince, N. L., & Jones, M. P. (2005). Fatal motor vehicle crashes in rural and urban areas: Decomposing rates into contributing factors. Injury Prevention, 11(1), 24-28.
[26] Bener, A. and Crundall, D., 2008. Role of gender and driver behaviour in road traffic crashes. International Journal of Crashworthiness, 13(3), pp.331-336.
[27] The influence of gender in motor vehicle fatalities |Allen and Allen| Available from: https://www.allenandallen.com/blog/the-influence-of-gender-in-motor-vehicle-fatalities/#:~:text=Who%20gets%20into%20more%20car