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Field Epidemiology Training Program, Division of Epidemiology
Department of Disease Control, Ministry of Public Health, Thailand
Tel: +6625903894, Fax: +6625903845, Email: osireditor@osirjournal.net, http://www.osirjournal.net

Association between Incidence of Road Traffic Accidents and Provincial Economic Status in Thailand: An Application of the Concentration Index

Shaheda Viriyathorn[1*], Nattadhanai Rajatanavin[1], Hathairat Kosiyaporn[1], Vuthiphan Wongmongkol[1], Rapeepong Suphanchaimat[1, 2]

1 International Health Policy Program, Ministry of Public Health, Thailand

2 Division of Epidemiology, Department of Disease Control, Ministry of Public Health, Thailand

*Corresponding author, email address: shaheda@ihpp.thaigov.net

Abstract

In Thailand, various preventive measures have been implemented to control and minimize the volume of road traffic accidents (RTAs). However, the country still faces varying degrees of success in curbing the incidence of RTAs, which has devastating consequences to the Thai economy. Since there are many factors related to the density of RTAs, this study examines the density according to three main causes-humans, the environment, and vehicles-relative to the provincial economic status in Thailand. A time-series cross-sectional design was employed. Descriptive statistics, Spearman's rank correlation, and the concentration index (CI) were used to measure the degree of inequitable distribution of RTAs relative to the provincial economic levels. The cumulative proportion of accidents was measured against the cumulative proportion of provinces ranked by the gross provincial product per capita. A negative value from CI-RTAs indicated a disproportional accumulation of RTAs among the poor. In contrast, a positive value reflected a disproportional concentration of RTAs among the well-off populations. Since 2006, human causes of RTAs (such as driving while under the influence of alcohol and violation of traffic rules) were the main contribution to RTAs. The RTAs were concentrated among the well-off provinces during 2006-2013, as reflected by positive indices and positive CI-RTAs were stronger for human-caused RTAs. Since 2014, the total incidence of RTAs was higher among the less well-off provinces (negative CI-RTAs). The shifting trend of CI-RTAs from among the affluent to the less affluent provinces provided insightful information for policymakers and implementation in the Thai public health arena. However, the statistical significance of the associations between RTAs and economic status was observed only in the early years of the investigation. The reasons behind the varying degree of statistical significance in the association should be investigated further. Additional studies on CIs and RTAs, which could help inform policymakers and academics regarding the prioritization and optimization of RTA preventive measures of each individual area, are recommended.

Keywords: road traffic accidents, cause of road traffic accidents, concentration index, equity, Thailand

Introduction

Road traffic accidents (RTAs) are among the most critical public health problems in many countries. Globally, RTAs are currently the ninth leading cause of death across all age groups and may become the seventh leading cause of death by 2030 if the incidence continues at the current pace.[1] Low- and middle-income countries account for over 90% of all RTAs worldwide.[1]

To respond to this crisis, the 2030 Agenda for Sustainable Development set a target for reducing the number of deaths and injuries from RTAs by 50% in 2020.[2] The World Health Organization (WHO) has played an active role in directing the road safety agenda, as evidenced by the launch of 'the Decade of Action for Road Safety' in 2011, to which over 110 countries have pledged their agreement.[3]

Thailand is an upper-middle income country where RTAs are a critical concern. Deaths from RTAs in Thailand reached 36.2 per 100,000 persons in 2013, the second largest incidence across the globe.[4] The reported number of traffic crashes in 2017 was 817,444. RTAs were the leading cause of disability-adjusted life years (DALYs) lost among late juveniles and early adults, both males and females, aged 15 to 29 years.[5] The estimated annual economic loss from RTAs in 2013 by the Thailand Development Research Institute was around 539,509 million baht (approximately USD 17,559 million).[6]

To curb this catastrophic situation, various preventive measures have been implemented, such as increase stringency of driving laws and extensive road safety campaigns in the media.[7] Despite such efforts, the degree of success in curbing the incidence of RTAs varies across provinces. Areas with high levels of economic activities were, on the face of it, more likely to encounter RTAs than those with relatively lower economic status.[8] There are many factors that affect the provincial economic status such as the selective investment and development of infrastructure in some areas and the structural power that is linked to the development policy.[9] Bangkok, Chon Buri, and Chiang Mai were included in the top five provinces for road crashes and all had a high economic status in 2016. [10,11]

To this end, we hypothesized that the incidence of RTAs is closely related to the economic level of a province. Therefore, this study aimed to examine the concentration of RTAs (CI-RTAs) sorted by various causes relative to provincial economic activities. Concentration index analysis is a useful method proposed by the World Bank to demonstrate inequity of resource allocation of any outcome variables against the inequity in the socioeconomic status.[12] In recent years, there were studies in the public health field that attempted to apply concentration index on health-related outcomes such as assessing equity in maternal and child health services and health workforce distribution.[13,14] Hence, it is hoped that the results from this study can help inform policy makers and academics in prioritizing the intensity and urgency of RTAs preventive measures that fit the economic context in each province.

Methods

Data Sources and Study Design

This study applied a time series quantitative approach and the unit of analysis was set at the provincial level. Data from 2006 to 2015 were retrieved from two sources: 1) the Royal Thai Police, which publishes the RTA figures (injuries and deaths combined) and 2) Office of the National Economic and Social Development Council (NESDC) which publishes the gross provincial product per capita (GPP) and population in each province.[15] The original source of RTA statistics was the Royal Thai Police, but the data are displayed on the website of the National Statistical Office of Thailand.

The RTA data records the number of people who experienced road traffic accidents in each province classified into three groups according to the sources: human causes, environmental causes, and vehicular causes, based on the discretion of the police investigators. Human causes included several risky driving behaviours, such as drink driving, riding without wearing a helmet, and driving without using a seatbelt. Environmental causes included poor road conditions, rain, and inadequate streetlight intensity. Vehicular causes included defective safety devices and steering failure. Each injury was classified only in a single category of causes even though some events might have been attributed to more than one cause. The analysis was confined to 76 provinces (out of 77 provinces in Thailand) between 2006 and 2015 only. The RTA data of Bueng Kan was not included because of no data available between 2006 and 2010.

Data Analysis

The analysis was divided into three sections. The first section presents a descriptive analysis to demonstrate an overview of the incidence and trend of RTAs throughout the whole period. Since there is no information about the size of population at risk in each province (number of drivers or riders), the incidence of RTAs was estimated by the number of accidents in each province divided by the provincial population.

The second section uses Spearman's rank correlation to determine the relationship between the incidence of RTAs and provincial economic status measured by GPP per capita. This statistic was used to test the null hypothesis that RTAs were not correlated with provincial prosperity.

The last section calculates the concentration index (CI) to measure the distribution of RTAs across various provincial economic levels. The concentration index is an indicator used to explain the occurrence of a selected outcome against the economic distribution. The index can be assessed by a visual inspection of the concentration curve, where the diagonal line reflects perfect equality in resource- or outcome-distribution.[16] All analyses were done using Stata 13 (StataCorp, Serial number: 401406358220). The CI was computed using the following equation presented by O'Donnell;[17]

$$2\sigma_r^2\left(\frac{h_i}{\mu}\right) = \alpha + \beta r_i + e_i$$

In detail, β represents the estimated value of the CI; σ_r^2 is the variance of the provincial economy rank; h_i is the incidence of RTA stratified by the three causes of interest; μ is the mean of h_i ; r_i is the provincial economic rank by economic status; and e_i is a vector of independent and identically distributed random error terms. The mean, standard deviation (SD) and interquartile range (IQR) were used as descriptive statistics, while a 95% confidence interval was used to determine statistical significance. In terms of interpretation, the value of CI ranges from -1 to 1.

Negative values indicate pro-poor concentration while positive values reflects pro-rich concentration.[18]

Ethical Approval

Ethics approval to conduct this study was not required because all data were obtained from a public website and all individual data were anonymized and were not reported.

Results

The incidence of RTAs increased from 2006 to 2011 and then saw a stable trend from 2011 to 2015, and not falling back to 2006 levels. In 2015, the highest incidence appeared in northern regions, followed by the northeastern region and Bangkok. The top five provinces of all causes of RTAs were Phrae (377 per 100,000), Amnat Charoen (329 per 100,000), Chiang Rai (230 per 100,000), Lampang (210 per 100,000), and Bangkok (204 per 100,000). Human-related causes constituted the major share of all RTA causes throughout the observed period. The geometric mean of accident incidence from all causes in Thailand was 71.3 cases per 100,000 persons in 2015, about a 1.5 increase from 2006. Human causes accounted for 42.4 cases per 100,000 persons in 2006 and reached 52.2 cases per 100,000 persons in 2015. Environmental and vehicular causes also showed a similar increasing trend, but the annual incidence was still fewer than 26 cases per 100,000 persons throughout the study period. The standard deviations for all causes were large, ranging from 39.9 to 77.5, and was also high for human causes (Table 1 and Figure 1).

Table 1. Mean and geometric mean of incidence of road traffic accidents in 76 provinces in Thailand, stratified by cause and year (2006-2015)

Cause	Year	Mean (standard deviation)	Geometric mean
All causes	2006	63.8 (39.9)	48.0
	2007	67.5 (42.8)	54.8
	2008	55.4 (46.8)	40.6
	2009	60.5 (43.4)	49.4
	2010	68.1 (41.4)	58.7
	2011	81.9 (54.2)	70.4
	2012	78.2 (52.5)	65.9
	2013	91.4 (77.5)	70.6
	2014	83.4 (59.5)	66.9
	2015	91.1 (69.5)	71.3
Humans	2006	42.4 (30.7)	30.7
	2007	43.8 (33.7)	33.8
	2008	35.3 (38.6)	23.4
	2009	37.6 (33.5)	29.4
	2010	41.2 (31.7)	34.3
	2011	45.8 (33.9)	38.3
	2012	44.0 (33.6)	35.9
	2013	49.5 (42.4)	38.3
	2014	45.6 (34.8)	36.2
	2015	52.2 (40.6)	40.9
Environment	2006	13.9 (9.2)	10.2
	2007	14.8 (9.3)	11.4
	2008	12.5 (9.1)	9.0
	2009	14.3 (9.5)	11.1
	2010	16.6 (9.3)	13.7
	2011	22.1 (14.8)	18.7
	2012	20.9 (13.8)	17.4
	2013	25.6 (21.8)	18.6
	2014	23.1 (18.0)	17.3
	2015	23.5 (21.0)	16.7
Vehicles	2006	7.5 (6.6)	5.3
	2007	8.9 (8.3)	5.8
	2008	7.7 (8.0)	4.5
	2009	8.7 (8.8)	5.9
	2010	10.3 (7.9)	7.3
	2011	14.0 (12.9)	10.2
	2012	13.2 (11.3)	9.8
	2013	16.3 (17.4)	10.6
	2014	14.7 (13.4)	10.0
	2015	15.4 (17.2)	9.6

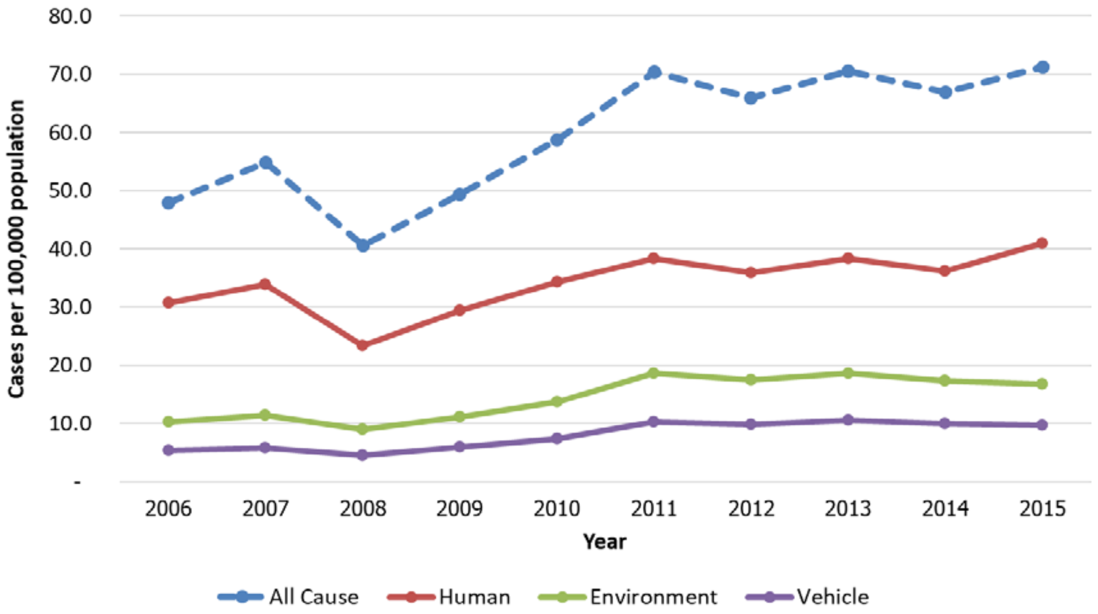

Figure 1. Trend of geometric mean of road traffic accidents in 76 provinces in Thailand by cause, 2006-2015

The degree of correlation between GPP per capita and the incidence of RTAs is displayed in the form of Spearman's correlation coefficients (rs) and shown in Figure 2. A positive relationship between RTAs and GPP per capita was observed during 2006-2013, which meant that GPP per capita and RTAs changed in the same direction (increase or decrease together). By contrast a relatively small negative coefficient presented in 2014 to 2015. The analysis also found that human causes showed a positive coefficient for all years. By contrast, environment and vehicle causes saw a negative coefficient in most years, especially after 2009.

With an in-depth investigation into RTAs at the provincial level, statistical significance was only found in the early study years, especially in all causes (2006-2008) and human causes (2006-2010) whereas environmental causes were statistically significant only in 2015. In later years the coefficient became increasingly negative for environmental causes and vehicular causes, while for all causes and human causes, despite the positive coefficients observed, except in 2014 and 2015, the coefficient became less positive. However, no statistical significance was found in most years, as shown in Table 2.

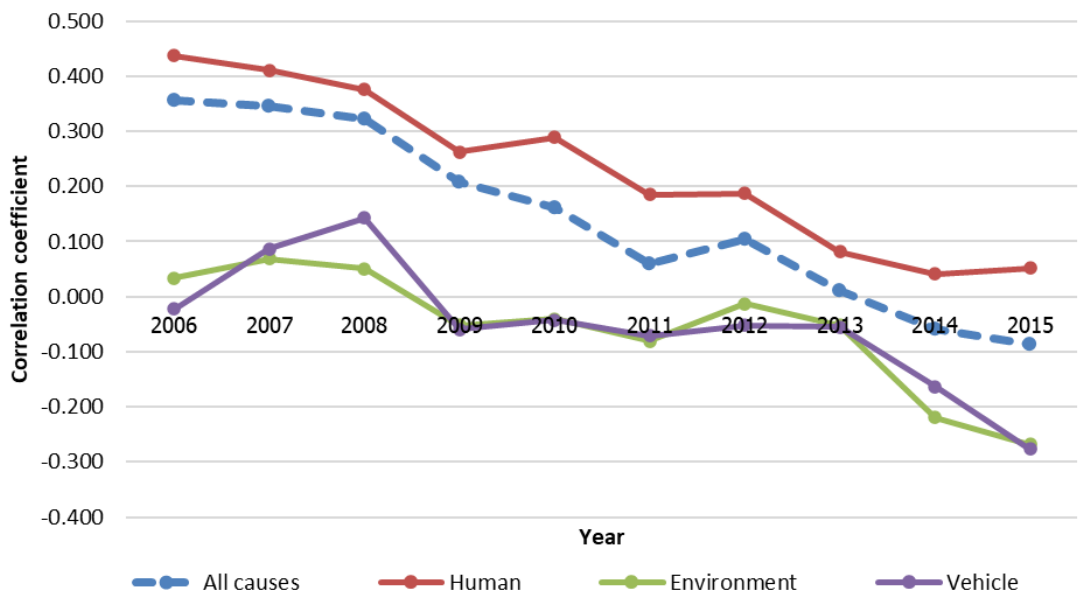

Figure 2. Trend of relationship between road traffic accident incidence and gross provincial product per capita using Spearman's correlation coefficients in 76 provinces in Thailand, 2006-2015

Table 2. Relationship between road traffic accident incidence and gross provincial product per capita using Spearman's correlation coefficients in 76 provinces in Thailand (2006-2015)

Year	All causes		Human		Environment		Vehicle	
	r_s	*p*-value	r_s	*p*-value	r_s	*p*-value	r_s	*p*-value
2006	0.356	0.002	0.437	<0.001	0.034	0.770	-0.023	0.847
2007	0.347	0.002	0.411	<0.001	0.069	0.556	0.087	0.456
2008	0.323	0.004	0.376	0.001	0.051	0.661	0.143	0.218
2009	0.208	0.071	0.263	0.022	-0.052	0.657	-0.059	0.613
2010	0.161	0.165	0.289	0.011	-0.040	0.729	-0.043	0.715
2011	0.059	0.614	0.185	0.110	-0.080	0.490	-0.072	0.539
2012	0.105	0.369	0.187	0.106	-0.013	0.913	-0.052	0.654
2013	0.011	0.926	0.082	0.483	-0.052	0.657	-0.055	0.638
2014	-0.058	0.619	0.041	0.722	-0.220	0.057	-0.164	0.158
2015	-0.086	0.461	0.052	0.658	-0.268	0.019	-0.276	0.016

The CI-RTAs analysis coincides with Spearman's rank correlation above. The years between 2006-2013 saw positive CI-RTAs for all causes, despite an observed downward trend, reflecting that the RTA incidence was mainly concentrated in the well-off provinces in the early years, then shifted towards the less well-off provinces in the later years (CI-RTAs=0.111 in 2009 and 0.022 in 2013). During 2014 to 2015, negative CI-RTAs were observed, indicating that the incidence of RTAs became more concentrated in areas with relatively poor economic levels (CI-RTAs=-0.035 and -0.051 respectively). The negative CI-RTAs were obvious in environmental and vehicular causes with statistical significance (Figure 3). The statistical significance was shown in CI-RTAs for all-causes between 2006 and 2009, and for human causes between 2006 and 2011, as shown in Table 3. The concentration curves in the study periods demonstrate inequity in the incidence of RTAs in provinces with different economic status. The concentration curves were consistent with the CI-RTAs in that the incidence of RTAs tended to be concentrated in less well-off provinces in 2014-2015 (Figure 4).

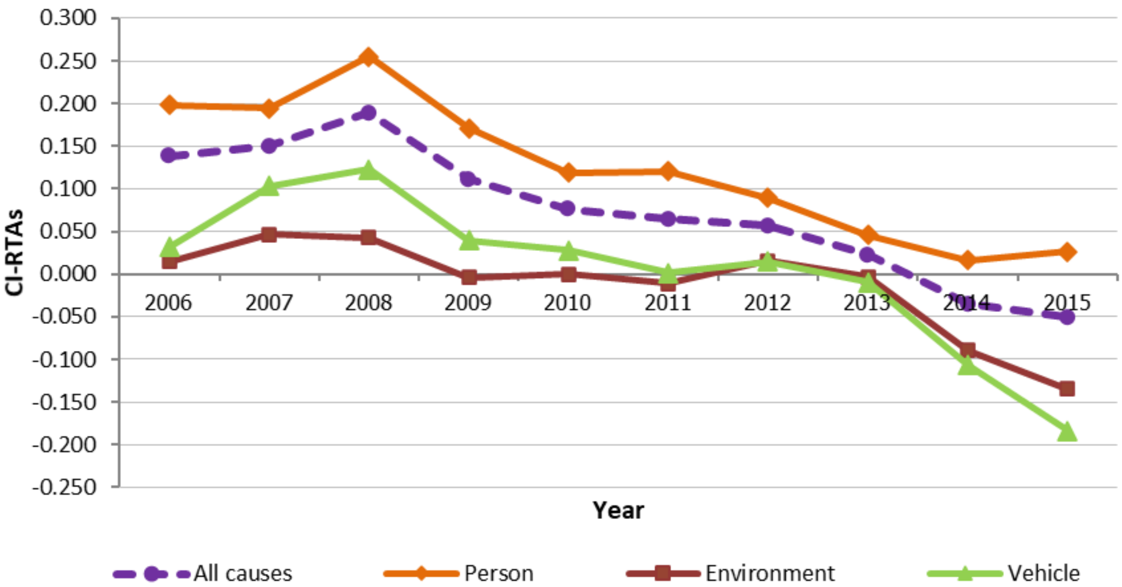

Figure 3. Trend of concentration Index of road traffic accidents by causes, 2006-2015

Table 3. Concentration Index of road traffic accidents by cause in 76 provinces in Thailand, 2006-2015

	All causes				Human				Environment				Vehicle			
Year	CI-RTAs	*p*-value	95% confidence interval		CI-RTAs	*p*-value	95% confidence interval		CI-RTAs	*p*-value	95% confidence interval		CI-RTAs	*p*-value	95% confidence interval	
2006	0.139	<0.001	0.061	0.216	0.198	<0.001	0.112	0.284	0.015	0.740	-0.074	0.103	0.032	0.590	-0.086	0.150
2007	0.150	<0.001	0.072	0.228	0.194	<0.001	0.101	0.288	0.047	0.270	-0.038	0.131	0.103	0.100	-0.020	0.226
2008	0.189	<0.001	0.084	0.294	0.255	<0.001	0.120	0.390	0.043	0.380	-0.055	0.141	0.123	0.080	-0.014	0.260
2009	0.111	0.020	0.018	0.204	0.171	<0.001	0.058	0.285	-0.004	0.940	-0.093	0.086	0.039	0.570	-0.097	0.176
2010	0.076	0.060	-0.004	0.156	0.119	0.020	0.019	0.219	-0.0001	1.000	-0.076	0.076	0.028	0.590	-0.075	0.130
2011	0.065	0.150	-0.023	0.152	0.121	0.010	0.025	0.216	-0.011	0.810	-0.101	0.079	0.001	0.990	-0.124	0.126
2012	0.057	0.210	-0.033	0.146	0.089	0.080	-0.011	0.190	0.016	0.730	-0.073	0.104	0.015	0.800	-0.100	0.130
2013	0.022	0.700	-0.092	0.136	0.046	0.430	-0.069	0.161	-0.003	0.960	-0.117	0.112	-0.010	0.890	-0.154	0.134
2014	-0.035	0.470	-0.131	0.061	0.016	0.760	-0.087	0.119	-0.089	0.090	-0.192	0.014	-0.107	0.080	-0.226	0.013
2015	-0.051	0.320	-0.153	0.051	0.026	0.620	-0.078	0.130	-0.135	0.020	-0.251	-0.019	-0.184	0.010	-0.328	-0.040

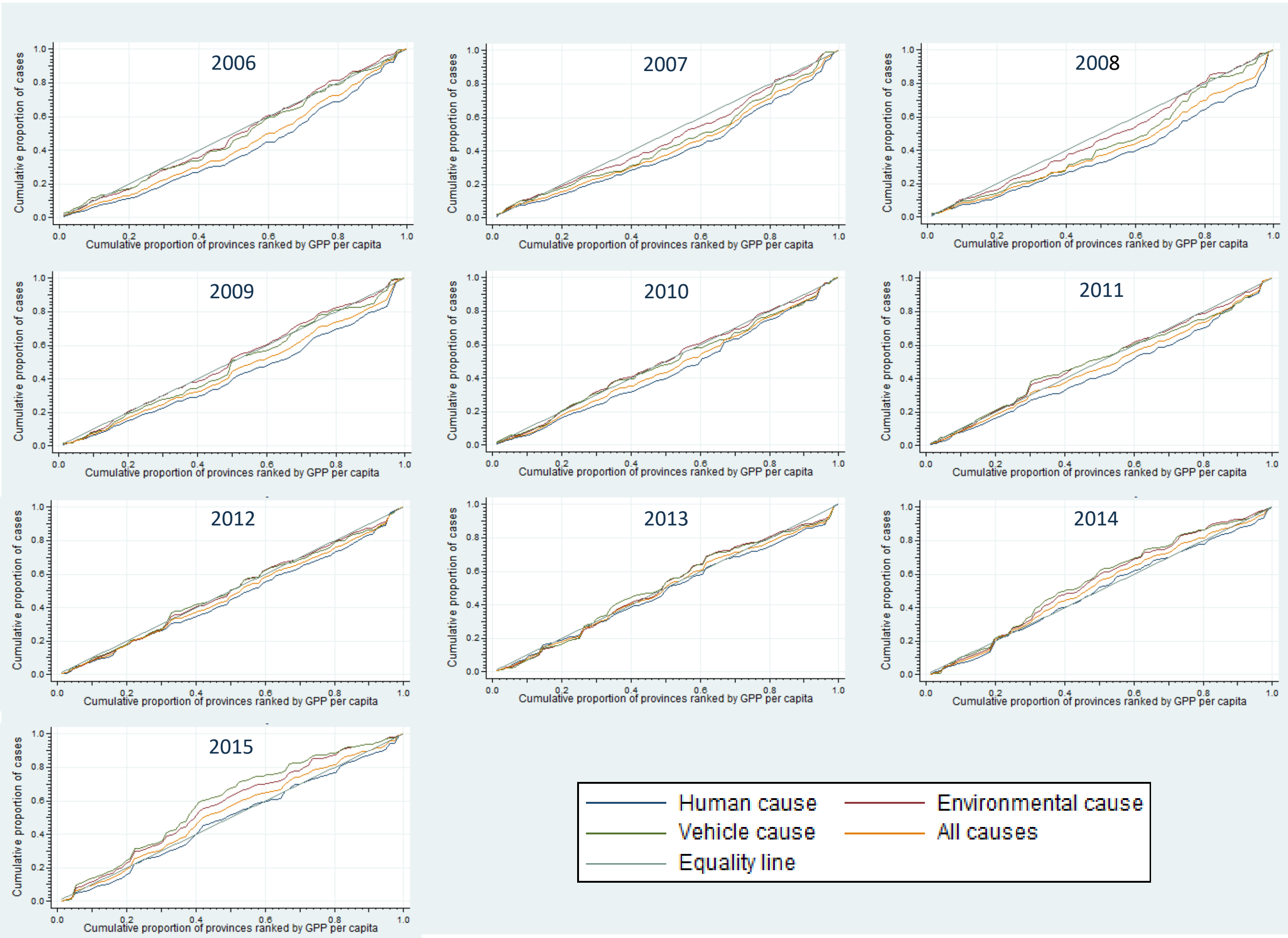

Figure 4. Concentration curves of road traffic accidents by causes, 2006-2015

Discussion

From a macro-perspective, the incidence of RTAs during the study period became less concentrated in the economically well-off provinces and could be seen shifting towards the less well-off areas. This can be confirmed by Spearman's correlation and CI-RTAs, where the coefficients for both analyses became more negative in the latter part of the study. This phenomenon was more apparent in RTAs caused by the environment and defective vehicles.

There are several reasons that provide an explanation for the above findings. First, Thailand has implemented various strategies to curb the high incidence of RTAs and those measures were the focus of intense media campaigns, which are highly accessible to urban populations. Second, most of the campaigns and measures focused heavily on prohibiting risky driving, such as intensifying the punishments given for drink driving[19] and riding a motorcycle without a helmet,[20] while strategies that aimed to correct unsafe environments and vehicle conditions seemed to be less highlighted. Third, around 2010, road safety was declared by the government as a national agenda.[21] During this period, 'Road Safety Group, Thailand' (RSGT) was established to serve as the knowledge generation platform for the government and, at the same time, provide policy recommendations to the wider public on road safety issues.[22] It was noticeable that most campaigns on road safety originated from RSGT started from urban areas. This might explain why urban residents were more likely to benefit from the campaigns than their rural counterparts. Also, the identification of a causal relationship to assess if and to what extent these measures were successful in mitigating RTAs is not straightforward as most of the measures gradually evolved over time rather than being implemented once; and it is not the primary objective of this study. Future studies that assess the effectiveness of RTA-prevention strategies are recommended.

In the past, the majority of road traffic accidents occurred in the better-off provinces such as Bangkok, which had the highest number of registered cars and public motorcycles in Thailand.[23] This study shows that it is necessary for RTA prevention strategies to be made a priority across the country, and not only in affluent provinces such as Bangkok.

The research findings do not indicate that efforts to reduce RTAs in Thailand have been unsuccessful; however, RTA prevention measures should not overlook the less well-off provinces, and that policymakers, given limited time and resource constraints, should intensify different measures in different provinces, taking into account the provincial economy. For instance, more affluent provinces should be given priority with measures that aim to prevent risky behaviors, while for the less well-off provinces, policymakers should first adopt measures to correct problematic environments and intensify vehicle checks. This recommendation extends the value of earlier cross-sectional research by Suphanchaimat et al.,[24] which flags the relatively high concentration index of RTAs caused by unsafe environments and vehicles in the less well-off provinces. The less well-off populations should not be considered as 'the last mile' of RTA prevention policies. A report issued by WHO[25] suggested that health and social impacts from traffic accidents were disproportionately high among the poor and among vulnerable groups. Thus, attempts to promote socioeconomic equality in road safety are of critical importance in the public health arena.

From a methodological point of view, the concentration index is a useful indicator to assess the levels of inequality for various public health problems, including RTAs. However, its interpretation should be made with caution. For instance, the less positive CI-RTAs for human causes in affluent provinces do not mean a reduction in the gross number of RTAs caused by poor driving behaviour. In fact, it reflects a disproportionate concentration of RTAs from that cause relative to the economic disparity across provinces.

Limitations

This study faced some limitations. Firstly, the data analyzed were limited only to cases documented by the Royal Thai Police. It is likely that some cases that were not investigated by the police were missed (for instance, minor accidents or those resulting in minor injuries). Secondly, all the data collected were classified into one of the three main causes conditional upon the discretion of the police investigator in the field. In reality, some incidents can be attributed to various causes simultaneously. Hence, the incidence of RTAs in some causes might be under- or over-estimated due to misclassification bias.

The third limitation lies in the small number of samples. As the unit of analysis is the province, only 76 data points were included. Moreover, an ecological study design such as this one is also a limitation by itself due to the ecological fallacy and a lack of fine-grained analysis that reflects the root causes of RTAs in each individual locality.

Fourthly, results from the CI analysis were subject to change given different proxies of provincial economic level. GPP per capita, despite being useful in representing the provincial economic status, might overly represent industrialized provinces. A better indicator is the asset index, which uses household's goods and assets to measure socio-economic positions of household rather than using income or expenditure;[26] however, the asset index at the provincial level was not publicly available.

Finally, the nature of an RTA study is somewhat different to most routine epidemiological studies. This is because RTAs in a particular area are not a matter of that province only, but also affected by population movement in nearby areas.

Recommendations

The potential bias from data collection points to room for improvement in the nationwide data collecting systems for RTAs in Thailand. The concern on a small number of observations requires further research that delves into the district or sub-district levels, which will provide a clearer insight into the relationship between RTAs and economic status. A primary survey on household economic status in all provinces is recommended to help fill the gaps in knowledge on the provincial economic level. To address the issue that the incidence of RTAs could be affected by the movement of people from nearby areas, further studies that take into account spatial effects are needed.[27] Finally, a more detailed analysis on different types of vehicles and different levels of injuries is recommended to better illuminate the relationship between RTAs and spatial socioeconomic status, and this will help bring about appropriately designed RTA prevention measures in Thailand.

Conclusion

The incidence of RTAs has shifted from the economically well-off provinces to the less well-off provinces. Such findings, shown by the negative CI-RTAs and Spearman's correlation coefficients, point to the need for insightful policy implementation in the Thai public health arena. Provinces with relatively low economic levels should place more emphasis on RTA preventive measures that focus on environmental management and vehicle inspections, while the well-off provinces should put more effort into preventing poor driving behaviour. However, there remained some limitations in this study; for instance, there was a lack of RTA data that were not investigated by the police. This also pointed to room for improvement in the nationwide RTA data collection system. Despite our results, a more detailed analysis on CIs and RTAs, which accounted for the change of RTAs with respect to space and time (temporal and spatial disparities), is likely to be helpful for policy decision making to prioritize the urgency and intensity of various preventive measures to match the economic status of the areas of interest.

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