Research Article

Mortality Rate Model due to Transportation Accidents in Thailand

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Abstract

The mortality from transportation accidents is a major problem that leads to loss of human lives and property. The deaths as a result of transportation accidents are now accepted to be a global phenomenon in virtually all countries concerned about the growth in the number of people killed. The objective was to model and forecast the transportation accident mortality rate in Thailand using death certificate reports.

A retrospective analysis of the transportation accident mortality rate was conducted in this study. This study is based on the records of the national vital registration database for the 10-year period from 2000 to 2009, provided by the Ministry of the Interior and coded as cause-of-death using ICD-10 by the Ministry of Public Health. Multivariate linear regression was used for modeling and forecasting age-specific transportation accident mortality rates in Thailand.

The transportation accident mortality increased higher in males than females. The highest was in males aged 20-29 years. The trend slightly decreases in all other ages. Having a model that provides such forecasts of transportation accident fatalities, even if based purely on statistical data analysis, can provide a useful basis for allocation of resources for transportation accident fatality prevention.

Key Words: Mortality rate; Multivariate linear regression; Transportation accidents

Introduction

The problem of death as a result of road accidents is now acknowledged to be a global phenomenon with authorities in virtually all countries concerned about the growth in the number of people killed and seriously injured on their roads. The World Health Organization reported that about 1.2 million people were killed from road traffic accidents every year and it was estimated that approximately 3,000 people died by road traffic accidents around the world on any given day. World Health Organization revealed a projection of global mortality leading causes of death from 2008 to 2030 that road traffic accidents would rise from the ninth to the fifth of the world's leading causes of death, up from 2.2 % in 2004 to 3.6 % of global deaths (World Health Organization, 2008).

Deaths resulting from road accidents have become a big problem in the developing countries such as Thailand. It reflects not only road safety in Thailand, but also in other Asian countries. In Thailand, road accidents are considered one of the top three public health problems. Despite the Government's best efforts, there are sadly over 13, 000 deaths and more than one million injuries each year as the result of road accidents, with several hundred thousand people disabled. An overwhelming majority of the deaths and injuries involve motorcyclists, cyclists and pedestrians. Most occur between the ages of 20-24 years and 80% of them are from motorcycles. The estimated economic losses due to road accidents are over 100,000 million baht (approximately US$2,500 million) per year (Tanaboriboon 2004). The Royal Thai Government regards this problem to be of great urgency and has accorded its high priority in the national policy. The problem of road traffic injuries is indeed a highly serious one, but can be dealt with and prevented through concerted action among all the parties concerned.

Thailand is a country located at the centre of the Indochina peninsula in Southeast Asia. It is divided into 77 provinces, which are gathered into four groups of regions, Central, North, North-East and South (Wikipedia 2011). It is bordered to the North by Myanmar and Laos, to the East by Laos and Cambodia, to the South by the Gulf of Thailand and Malaysia, and to the West by the Andaman Sea and the Southern extremity of Myanmar. The Thai population is estimated by the Department of Provincial Administration to be 65,479,453 (National Statistics Office, 2010).

There were various studies about models to forecast transportation accident mortality rates. Sriwattanapongse and Khanabsakdi (2011) modeled the patterns of mortality rate due to traffic accident by gender, age and year. The method used linear regression and Poisson regression models to forecast mortality rates due to traffic accident likely to occur in the near future, in order to prevent the mortality rate by using suitable models. Among the models deemed suitable, the best was chosen based on the analysis of deviance. The results of this study showed that additive effects associated with the gender, age group, and year could be used to provide a useful short-term forecast. Kardara and Kondakis (1997) identified trends of road traffic accident deaths and injury rates in Greece from 1981-1991 by using linear regression with logarithmic transformation.

Road traffic accidents cause mortality and disability that lead to public health and social problems such as economic loss, particularly for male of working age. It impacts on the family income and national economy directly and indirectly. The costs of medical care, funerals and loss of income due to mortality or disability can push a family into poverty (Nantulya and Reich, 2003). Therefore, the aim of this research was to model and forecast the transportation accident mortality rate in Thailand, using death certificate reports.

Materials and Methods

Data for registered deaths due to transportation accidents were obtained from the national vital registration database for the 10-year period from 2000 to 2009.The database is provided by the Ministry of Interior and coded as cause-of-death using ICD-10: B20-B24 by the Bureau of Policy and Strategy, Ministry of Public Health.

Age, gender, residential area by region in Thailand and year were selected as the explanatory variables in studying the mortality rates of transportation accidents. Age was divided into nine groups (0-9,10-19,20-29,30-39,40-49,50-59,60-69,70-79 and above 80 yrs). Various approaches have been developed to forecast morbidity and mortality rates. This study focuses upon the model proposed by Lee and Carter (1992) and Lee and Miller (2001) that initially used projections of the age-specific mortality rates in the United States.

The Lee-Carter-based modeling framework is viewed in the current literature as among the most efficient and transparent methods of modeling and projecting mortality improvements (Butt and

Haberman, 2009). This method is also regarded as state-of-the-art in mortality forecasting and has become more and more popular for long-run forecasts of age-specific mortality rates.

Data used in the current study are taken from the national vital registration database for the 10-year period from 2000 to 2009, provided by the Ministry of Interior and coded as cause-of-death using ICD-10. We decided to calculate mortality incidence rates based on the 9 age groups. Mortality rates are based on numbers of deaths registered in a country in a year divided by the size of the corresponding population. Deaths from transport accidents are classified to ICD-10 codes V01-V89

Since transportation accident dead counts based on small cells are often zero cases, it is necessary to make some adjustment to take transformation of 0, so we replaced zero counts by a suitably-chosen small constant greater than 0: the method we use is to define the mortality rate as:

$$m_{x,t} = \left(\frac{(0.5 + n_{x,t})}{P} \times 100,000 \right)^{1/3} , \quad (1)$$

where $n_{x,t}$ is the number of transportation accident death cases in the cell, and P is the population at risk.

For each region and gender combination, multivariate linear regression model was used to investigate and forecast transportation accident mortality by age group and year. The original principal component of the Lee-Carter model is expressed as:

$$\log(m_{x,t}) = a_x + b_x k_t + \varepsilon_{x,t} \quad (2)$$

where $m_{x,t}$ is the central death rate (per 100,000) in age group x and year t for the specified in each gender and geographical region. The factors a_x and b_x describe the level and annual increase, respectively of the age-specific mortality rate, k_t is time of year where Lee - Carter chose constraints to be $\sum k_t = 0$ and where $\varepsilon_{x,t}$ is a set of random disturbances.

Since some cells had no reported cases, to allow log-transformation, we replaced zero counts by a suitably chosen small constant, without changing any value of $m_{x,t}$ greater than 0. The multivariate linear regression model takes into account correlation in the data between age groups.

Results

For each year these data were obtained from the national vital registration database for the 10-year period from 2000 to 2009, provided by the Ministry of Interior and coded as cause-of-death using ICD-10 by the Ministry of Public Health. The fields comprise characteristics of the subject and cause-of-death diagnosis, including dates of death and the subject's age, gender, and address.

The results from demographic variables show that out of 114,790 transport accident cases, 80.44% of transport accident deaths are male and 19.56% female; also, that 25.92% of transport accident deaths are aged 20-29 years. This study finds that the mortality rate of transport accident appears to be highest at 4.12 per 100,000 people in males, aged 20-29, Northern region, year 2003, and the lowest of 1.17 per 100,000 people in females, aged 0-9, North-East region, year 2009. This study finds that the highest average age-specific transport accident mortality rate is 3.11 per 100,000 per year in males, Southern Region, the lowest average age-specific transport accident mortality rate is 1.79 per 100,000 per year in females, North-East Region, and most of the transport accident fatalities are males in Central Region.

The trends of transport accident mortality rates have decreased in females, but it is approximately decreased more than previously. The transport accident mortality decreased mostly in all age groups and regions, with the exception in the South.

We replaced zeros by 0.5 before fitting the model. The two left panels of Figure 1 show the transport accident mortality rates plotted by age group for each year in each gender; the two right panels show the trends plotted by year (2000-2009) for each age group in each gender, together with the forecasts based on the model.

Figure 1 shows that mortality rate in males increases up to age group 20-29 years and decreases slightly before increasing in the age groups 70-79, with the exception of the North-East region. However, the time trends shown in the two right panels indicate that the transport accident mortality rates decrease after 2000 over the seven year period in all age groups, except in the South.

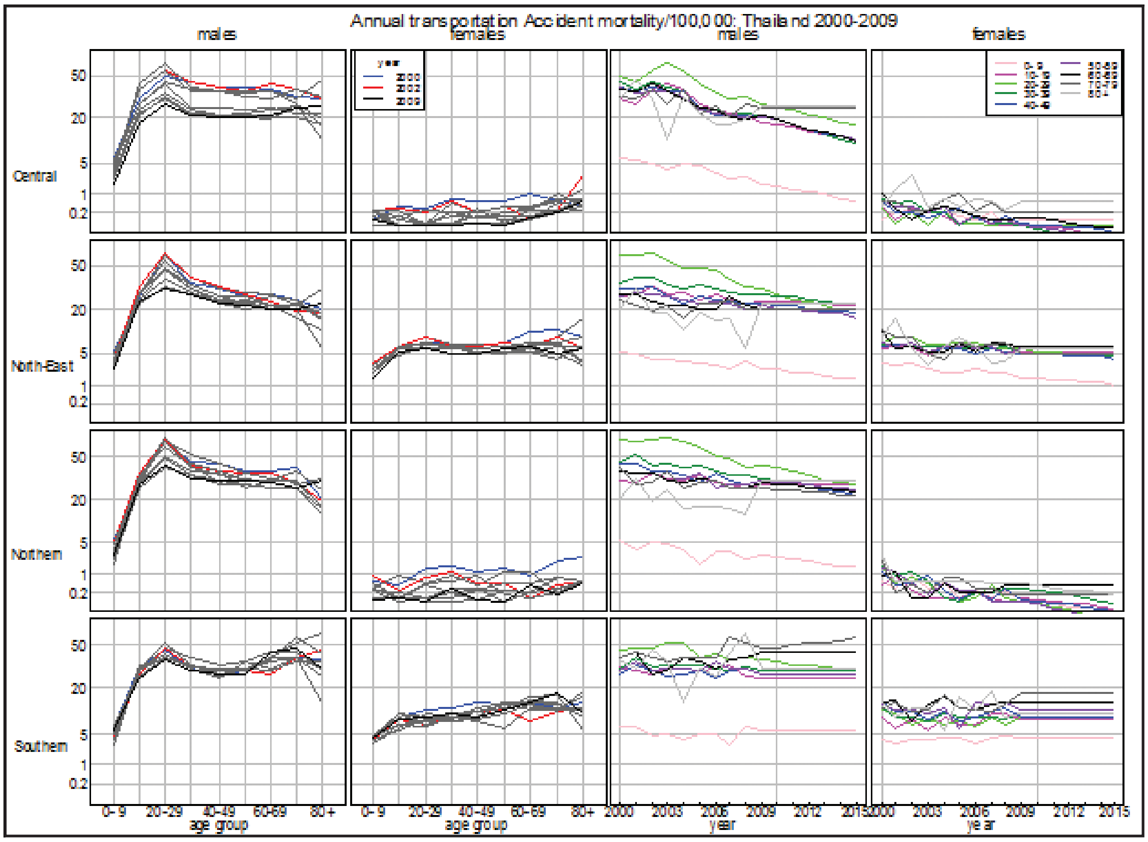

Figure 1 Plot of transportation accident mortality rates by age group for each year (two left panels) and trends with forecasts for each age group (two right panels) for the four regions of Thailand.

Table 1 Results from multivariate linear models of mortality rates by region and gender for each age group

	Age	a1	b1	R-squared	F-statistic(1, 8)	p-value
Central Region and males	0	1.850421	-0.062667	0.8572	48.010	0.00012
	10	3.38182	-0.06977	0.5761	10.870	0.01090
	20	3.87036	-0.08302	0.6371	14.050	0.00564
	30	3.59456	-0.10047	0.875	55.980	7.05E-05
	40	3.50233	-0.09051	0.8822	59.880	5.54E-05
	50	3.43625	-0.0854	0.8714	54.220	7.89E-05
	60	3.49581	-0.09414	0.8652	51.370	9.55E-05
	70	3.26311	-0.04266	0.3604	4.507	0.06651
	80	3.16646	-0.05977	0.2117	2.148	0.18090
Central Region and females	0	0.6011	-0.01929	0.2395	2.519	0.15110
	10	0.66347	-0.04082	0.5535	9.918	0.01361
	20	0.56559	-0.02948	0.3255	3.861	0.08501
	30	0.86482	-0.06998	0.8318	39.560	0.00024
	40	0.7074	-0.03446	0.4949	7.838	0.02321
	50	0.81478	-0.05648	0.7888	29.870	0.00060
	60	0.8073	-0.04493	0.4685	7.051	0.02901
	70	0.84059	-0.0202	0.1794	1.749	0.22250
	80	1.01488	-0.02869	0.1365	1.265	0.29340
NE Region and males	0	1.699949	-0.03863	0.7928	30.610	0.00055
	10	3.102011	-0.021898	0.4236	5.880	0.04153
	20	4.027224	-0.09307	0.9209	93.090	1.11E-05
	30	3.395589	-0.04004	0.8056	33.150	0.00043
	40	3.155347	-0.041001	0.7016	18.810	0.00249
	50	3.084323	-0.039349	0.8485	44.820	0.00016
	60	2.95579	-0.02604	0.3544	4.391	0.06942
	70	2.782492	-0.005427	0.01831	0.149	0.70940
	80	2.77488	-0.05118	0.1927	1.909	0.20440
NE Region and females	0	1.450765	-0.02639	0.6362	13.990	0.00570
	10	1.836698	-0.008844	0.1393	1.295	0.28800
	20	2.035431	-0.026235	0.7167	20.240	0.00200
	30	1.907815	-0.013462	0.5069	8.225	0.02090
	40	1.873416	-0.017265	0.6186	12.980	0.00696
	50	1.917636	-0.0163	0.3763	4.827	0.05926
	60	1.93559	-0.01157	0.07371	0.637	0.44800
	70	2.03733	-0.0305	0.2406	2.534	0.15010
	80	2.08128	-0.0553	0.2659	2.897	0.12710

Table 1 Results from multivariate linear models of mortality rates by region and gender for each age group (continues)

	Age	a_1	b_1	R-squared	F-statistic(1, 8)	p-value
Northern Region and males	0	1.71152	-0.04043	0.533	9.132	0.016510
	10	3.206194	-0.01933	0.3464	4.239	0.073480
	20	4.16056	-0.07712	0.7965	31.310	0.000513
	30	3.638665	-0.05221	0.812	34.550	0.000371
	40	3.48595	-0.05101	0.762	25.610	0.000976
	50	3.315677	-0.03299	0.5767	10.900	0.010830
	60	3.300696	-0.03535	0.7482	23.770	0.001231
	70	3.24222	-0.03281	0.4057	5.461	0.047650
	80	2.78955	-0.0214	0.05254	0.444	0.524100
Northern Region and Females	0	0.8812	-0.04447	0.5948	11.740	0.008995
	10	0.77932	-0.04452	0.5446	9.566	0.014820
	20	0.95264	-0.06489	0.5882	11.430	0.009633
	30	1.0217	-0.05898	0.4395	6.274	0.036670
	40	0.93834	-0.05294	0.5556	10.000	0.013340
	50	1.0556	-0.08177	0.8227	37.120	0.000292
	60	0.8116	-0.02083	0.1059	0.948	0.358800
	70	0.96557	-0.0446	0.3156	3.689	0.091020
	80	1.07281	-0.03794	0.4125	5.618	0.045240
Southern Region and males	0	1.75978	-0.00992	0.04008	0.334	0.579200
	10	3.19195	-0.0136	0.1738	1.683	0.230700
	20	3.73203	-0.03955	0.612	12.620	0.007483
	30	3.296831	-0.01511	0.2905	3.275	0.107900
	40	3.12518	-0.0066	0.05128	0.432	0.529300
	50	3.195324	-0.00552	0.04325	0.362	0.564200
	60	3.304793	0.007286	0.01997	0.163	0.697000
	70	3.35089	0.03693	0.4578	6.754	0.031670
	80	3.18859	0.01686	0.01576	0.128	0.729600
Southern Region and Females	0	1.506459	0.011191	0.3945	5.212	0.051840
	10	1.9225	0.01543	0.1571	1.491	0.256800
	20	2.11064	-0.01862	0.2356	2.466	0.155000
	30	2.135315	-0.01131	0.152	1.434	0.265400
	40	2.20787	-0.01254	0.084	0.734	0.416600
	50	2.225303	0.006165	0.0116	0.094	0.767100
	60	2.308202	0.008418	0.02548	0.209	0.659600
	70	2.29403	0.01015	0.04418	0.367	0.560000
	80	2.267775	-0.00164	0.00036	0.003	0.958500

Discussion

In this study, the multivariate linear regression was appropriate to model transport accident mortality in Thailand. In another way, the multiple regression and Poisson regression are commonly used for modeling the mortality rates and number of deaths in a specific population. However, Pocock et al. (1981) pointed out that unweighted multiple regression was not appropriate for modeling mortality rates in different areas which varied in population size. In addition, fully weighted regression was usually too extreme. Thus, they introduced an intermediate solution via maximum likelihood for modeling death rates. Tsauo et al. (1996) examined the effect of age, period of death and birth cohort in motor vehicle mortality in Taiwan from 1974 - 1992, using data from Vital Statistics. Log-linear regression was used for fitting the model to perform the effects of variables.

In addition, Lix et al. (2004) used Poisson regression to investigate the relation of demographic, geographical, and temporal explanatory variables with mortality in difference regions of Manitoba, Canada between 1985 and 1999, using data from Vital Statistics records and the provincial health registry. Yang et al. (2005) used Poisson regression modeling to examine and compare age- and sex-specific mortality rates due to injuries in the Guangxi Province in South Western China in 2002, based on death certificate data. However, this study focused only on small areas. Congdon (2006) described a method for modeling mortality over area, age and time dimensions that took account of spatial correlation, interactions between dimensions, and cohort as well as age effects, by applying Poisson regression.

Although Poisson regression are commonly used for modeling mortality due to road traffic accident death, it cannot be used for modeling when many of observed are zeros due to having small sample size. Lee et al. (2002) suggested that when many of observed were zeros, the zero-inflated Poisson and the negative binomial were more appropriate than the standard Poisson model. In addition, a study of Lord (2006) exposed that low sample mean combined with a small sample size of crash database could affect the goodness of fit of the negative binomial model.

Alternatively, Bride (1995) presented model of forecasting and monitoring the development in the number of fatalities in traffic. The model had been created through time series analysis covering the years 1977-1991. The model was simple, with the number of fatalities as the dependent variable and with time and traffic as the only predictors. The time factor described the cumulative effect of changes such as better roads, vehicles, drivers, etc. The model was multiplicative and permitted a non-proportional relationship with traffic volume. Taking into account the purely random fluctuations in the number of fatalities, the historical fit for the period 1977-1991 was very good. Also the forecasts for 1992 and 1993 had proved very accurate. The model would be revised as new annual data were received. At present, the model points to a favorable development. Neill and Mohan (2002) conducted studies to reduce the numbers of crash deaths and injuries, and countries need to adopt a broad array of research based measures in the US. Almost all the demonstrable gains produced by changing road user behavior have resulted from properly-enforced traffic safety laws.

After 2000, the transport accident mortality rates declined in all age groups, as the Policy and Strategy of Government introduced strong control measures and prevent transport accidents in the previous 10 years. For this investigation, the data have been interpreted accurately and objectively. The Government can use the results of this study to decrease surveillance transport accidents, especially those occuring at festival times.

Future study of transportation accident fatalities was shown by GIS. Jonesa et al. (2008), investigated data on road traffic fatalities, serious casualties and slight casualties in each local authority district in England and Wales for the period 1995-2000. District-level data were assembled for a large number of potential explanatory variables relating to population numbers and characteristics, traffic exposure, road length, curvature and junction density, land use, elevation and hilliness, and climate. Multilevel negative binomial regression models were used to identify combinations of risk factors that predicted variations in mortality. Statistically significant explanatory variables were the expected number of casualties derived from the size and age structure of the resident population, road length and traffic counts in the district, the percentage of roads classed as minor, average cars per capita, material deprivation, the percentage of roads through urban areas and the average curvature of roads. This study demonstrated that a geographical approach to road traffic crash analysis can identify contextual associations that conventional studies of individual road sections would miss. An urban-rural difference in traffic injuries has been recorded with a higher rural case-fatality rate. A number of known behavioral risk factors have been identified, i.e., drunk driving, speeding, substance abuse and failure to use helmets and seat belts (Suriyawongpaisal and Kanchanasut, 2003).

The limitation of this research is that the data has many zero cases in small cells, 23,590 of 42,300 (55.77%) cells. In further study, we should use other methods of analysis, such as multiple imputations technique to solve this problem (Sterne et al., 2009).

Conclusions

The objective of this study was to model and forecast transportation accident mortality rates in Thailand using death certificate reports.

The multivariate linear regression was used for modeling and forecasting age-specific transportation accident mortality rates in Thailand in order to prevent road accident fatalities by using suitable measures. Having a model that provides such forecasts of transportation accident mortality rates, even if based purely on statistical data analysis, can provide a useful basis for allocation of resources for road accident fatalities prevention.

Road accident in Thailand is a major social and economic problem, which causes a lot of losses in lives and injuries each year. Increasing transport service demands result in increasing the number of vehicle kilometers and road traffic accidents. Even though the trend of road accidents is increasing, the severity is tending to decrease. Fatality rate is a common use as the primary indicator in ranking the severity of the road safety situation in Thailand.

Strategies for reducing the mortality rate due to transportation accidents involve not only gaining a better understanding of the risk factors for mortality but also finding measures to prevent transportation accidents as well.

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