CHAPTER 3

Details of the studies

For this thesis, three manuscripts were produced. The first manuscript, entitle "A Logistic Regression Model for Estimating Transport Accident Deaths Using Verbal Autopsy Data" was published online in Asia-Pacific Journal of Public Health on 14 April, 2014. DOI: 10.1177/1010539514529810 http://aph.sagepub.com/content/early/2014/04/10/1010539514529810.citation. The second manuscript, entitled "Estimating External Causes of Death in Thailand 1996-2009 based on the 2005 Verbal Autopsy study" was published in Songklanakarin Journal of Science and Technology, Vol. 36, No. 6 (Nov. – Dec., 2014). The third manuscript, entitled "Epidemiological Patterns of Transport Accident Mortality in Thailand" was submitted in Southeast Asian Journal of Tropical Medicine and Public Health on November 3, 2014. The full manuscripts are shown in Appendix 1. This chapter describes the results from the analyses which are not included in the manuscripts.

3.1 Article I: A Logistic Regression Model for Estimating Transport Accident Deaths Using Verbal Autopsy Data (Klinjun *et al*., 2014a)

3.1.1 Preliminary results

This section starts with a description of correspondence between VR reported causes of deaths and VA-assessed causes of transport accident deaths following the overall characteristics of the Thai 2005 VA data selected all variables.

A total of 9,644 deaths in the Thai 2005 VA study, 546 (5.7%) were from transport accidents. Of those, the VR reported causes of deaths match the VA causes of deaths for 259 deaths (47.4%) and the VR reported causes of deaths were accurate for 259 deaths of 267 reported deaths (97.0%). Therefore, the death registries in VR reports were under-reported by 287 deaths (52.6%), of which 27.1% were unspecified event and undetermined intent (Y34), 9.9% were exposure to unspecified factor (X59) and 4.4% were other ill-defined and unspecified causes of mortality (R99) as shown in Table 3.1.

Table 3.1 Number and percent of VR reported causes of transport accident deaths attribute to other VA-assessed causes of deaths

Cause of death	Number (546 deaths)	Percent
Transport accident	259	47.4
All other (156 deaths)		
Unspecified event, undetermined intent (Y34)	148	27.1
Contact with blunt object, undetermined intent (Y29)	5	0.9
Other local infections of skin and subcutaneous (L08)	2	0.4
Sequelae of other accident (Y86)	1	0.2
Other accidents (W00-W99,X00-X59) (64 deaths)		
Exposure to unspecified factor (X59)	54	9.9
Unspecified drowning and submersion (W74)	10	1.8
Ill-defined (R00-R99) (33 deaths)		
Other ill-defined and unspecified causes of mortality (R99)	24	4.4
Haemorrhage, not elsewhere classified (R58)	4	0.7
Senility (R54)	4	0.7
Syncope and collapse (R55)	1	0.2

Table 3.1 (cont.)

Cause of death	Number (546 deaths)	Percent
Stroke (I60-I69) (13 deaths)		
Intracerebral haemorrhage (I61)	12	2.2
Cerebral infarction (I63)	1	0.2
Respiratory (J00-J99) (8 deaths)		
Pneumonia, organism unspecified (J18)	6	1.1
Pneumothorax (J93)	1	0.2
Other pleural conditions (J94)	1	0.2
Mental, Nervous (F00-F99, G00-G99) (5 deaths)		
Other paralytic syndromes (G83)	3	0.5
Hemiplegia (G81)	1	0.2
Other degenerative diseases of nervous system, not elsewhere classified (G31)	1	0.2
Septicaemia: Other septicaemia (A41)	3	0.5
Other CVD (2 deaths)		
Essential (primary) hypertension (I10)	1	0.2
Cardiac arrest (I46)	1	0.2
Endocrine: Unspecified diabetes mellitus (E14)	1	0.2
Digestive: Other diseases of digestive system (K92)	1	0.2
Suicide: Intentional self-poisoning by and exposure to pesticides (X68)	1	0.2

Transport accident deaths as a proportion of all deaths varied between 4.5% and 8.4% among the nine provinces. The highest proportion of transport accident deaths was among males aged 10-19 years. The VR cause-location were more likely to correctly assign transport accident as cause of death for deaths in hospital (98.9%) and for deaths outside hospital (96.0%) as shown in Table 3.2.

Table 3.2 Percentage deaths due to transport accident deaths in each province, gender-age group and VR cause-location group

Determinants	Other deaths (9,098 cases)	Transport accident death (546 cases)	Total VA data (9,644 cases)	Percent
Province				
Bangkok	833	39	872	4.5
Nakhon Nayok	593	54	647	8.4
Ubon Ratchathani	2,299	119	2,418	4.9
Loei	814	63	877	7.2
Phayao	561	30	591	5.1
Chiang Rai	1,379	70	1,449	4.8
Suphan Buri	1,517	110	1,627	6.8
Chumphon	299	17	316	5.4
Songkhla	803	44	847	5.2
Gender-age group				
Male	**5,025**	**449**	**5,474**	**8.2**
0-9 years	111	10	121	8.3
10-19 years	63	96	159	60.4
20-29 years	190	115	305	37.7
30-39 years	478	82	560	14.6
40-49 years	553	62	615	10.1
50-59 years	670	40	710	5.6
60-69 years	935	22	957	2.3
$\geq$ 70 years	2,025	22	2,047	1.1
Female	**4,073**	**97**	**4,170**	**2.3**
0-9 years	64	7	71	9.9
10-19 years	33	22	55	40.0
20-29 years	106	15	121	12.4

Table 3.2 (cont.)

Determinants	Other deaths (9,098 cases)	Transport accident death (546 cases)	Total VA data (9,644 cases)	Percent
30-39 years	216	15	231	6.5
40-49 years	280	11	291	3.8
50-59 years	409	11	420	2.6
60-69 years	674	10	684	1.5
≥ 70 years	2,291	6	2,297	0.3
VR cause-location group				
Deaths outside hospital	**5,995**	**333**	**6,328**	**5.3**
Transport accident	7	168	175	96.0
Other accidents	126	36	162	22.2
Stroke	99	4	103	3.9
Respiratory	251	4	255	1.6
Ill-defined	3,347	24	3,371	0.7
All other	98	89	187	47.6
Other groups	2,067	8	2,075	0.4
Deaths in hospital	**3,103**	**213**	**3,316**	**6.4**
Transport accident	1	91	92	98.9
Other accidents	47	28	75	37.3
Stroke	253	9	262	3.4
Respiratory	353	4	357	1.1
Ill-defined	438	9	447	2.0
All other	112	67	179	37.4
Other groups	1,899	5	1,904	0.3

3.1.2 Statistical model

A logistic regression model was developed to compare the effects of study factors between the crude percentages of transport accident death from the VA data and adjusted percentages of VA-assessed transport accident death from the model. The logistic regression model was fitted based on sum contrasts which were used to obtain 95% CI as shown in Table 3.3.

Table 3.3 Coefficients and standard errors for three determinants based on logistic regression model fitted to transport accident deaths in Thailand

Determinants	Coefficient	Std. Error	z value	P-value
Constant	-2.25	0.14	-15.69	<0.001***
Provinces				
Bangkok	0.29	0.22	1.32	0.186
NakhonNayok	0.92	0.23	4.03	<0.001***
Ubon Ratchathani	-0.15	0.17	-0.89	0.371
Loei	0.26	0.22	1.17	0.242
Phayao	-0.09	0.30	-0.30	0.766
Chiang Mai	-0.03	0.20	-0.15	0.883
Suphan Buri	0.35	0.17	2.06	0.040*
Chumphon	-1.36	0.48	-2.82	0.005**
Songkhla	-0.19	0.23	-0.83	0.405
gender-age group				
Male				
0-9	-0.56	0.47	-1.19	0.234
10-19	1.90	0.26	7.45	<0.001***
20-29	1.26	0.20	5.75	<0.001***
30-39	0.47	0.20	2.30	0.022*

Table 3.3 (cont.)

Determinants	Coefficient	Std. Error	z value	P-value
40-49	0.46	0.21	2.24	0.025
50-59	-0.06	0.25	-0.25	0.800
60-69	-0.64	0.29	-2.22	0.026*
≥70	-1.17	0.29	-4.00	<0.001***
Female				
0-9	-0.20	0.68	-0.30	0.765
10-19	1.33	0.38	3.52	<0.001***
20-29	-0.01	0.43	-0.02	0.983
30-39	0.53	0.36	1.46	0.145
40-49	0.24	0.38	0.63	0.530
50-59	-0.31	0.43	-0.71	0.481
60-69	-0.74	0.37	-1.97	0.048
≥70	-2.37	0.47	-5.00	<0.001***
VR cause-location group				
Death outside hospital				
Transport accident	5.06	0.39	12.95	<0.001***
Other accidents	0.42	0.23	1.86	0.064
Stroke	-0.93	0.50	-1.86	0.063
Respiratory	-1.88	0.49	-3.84	<0.001***
Ill-defined	-1.84	0.24	-7.63	<0.001***
All other	1.12	0.19	5.96	<0.001***
Other groups	-3.24	0.36	-9.18	<0.001***
Death in hospital				
Transport accident	6.84	0.96	7.12	<0.001***
Other accidents	1.40	0.28	4.98	<0.001***
Stroke	-0.85	0.35	-2.44	0.015*
Respiratory	-2.01	0.49	-4.14	<0.001***
Ill-defined	-1.56	0.34	-4.58	<0.001***

Table 3.3 (cont.)

Determinants	Coefficient	Std. Error	z value	P-value
All other	1.02	0.20	5.06	<0.001***
Other groups	-3.57	0.43	-8.23	<0.001***

*** p-value ≤ 0.001, ** p-value ≤ 0.01, * p-value ≤ 0.05

The coefficients from table 3.3 were converted into percentages, and therefore used to create a bar chart. Figure 3.1 shows the bar chart of the crude percentages and model-based 95% confidence intervals (CI) of the adjusted percentage of VA-assessed estimates from transport accidents for each of the three determinants compared with the overall percentage of deaths from accidents (shown as horizontal red line). The bar charts show percentages of the three cause group deaths corresponding to each determinant. The figure shows relatively small province effects. The highest proportion of transport accident deaths was in Nakhon Nayok province. Males ages 10-19 years had the highest percent of transport accident deaths. More than 95% of transport accident deaths both in and outside hospital were consistent with the VR reported. The figure clearly shows that there is no confounding after adjusting for all factors.

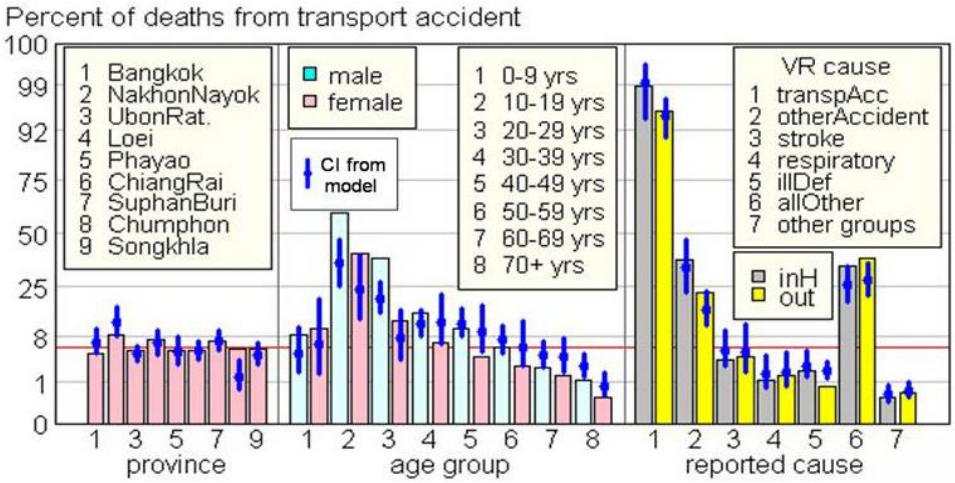

Figure 3.1 Bar chart crude percentages and 95% CI of adjusted percentages of transport accident deaths by province, gender-age group and VR cause-location group

Table 3.4 shows the likelihood-ratio test for the logistic regression model. The model gave the result of comparing the residual deviance after omitting each determinant. The p-values of all determinants are highly statistically significant. This indicated that the logistic regression model with three determinants can certainly be used to estimate the number of transport accident deaths.

Table 3.4 Likelihood-ratio test for logistic regression model of transport accident deaths by province, gender-age group and VR cause-location group

Determinants	Deviance reduction	df	P-value
Province	28.9	8	0.0003***
Gender-age group	152.5	15	<0.001***
VR cause-location group	1,524.7	13	<0.001***
Error	1,468.1	9,607	

*** p-value $\leq$ 0.001

The ROC curve confirmed that the logistic regression model could be used to predict transport accident deaths as it had high value of area under the curve (AUC) of 0.97, high sensitivity of 73.8% and a low false positive rate of 1.6% as shown in Figure 3.2

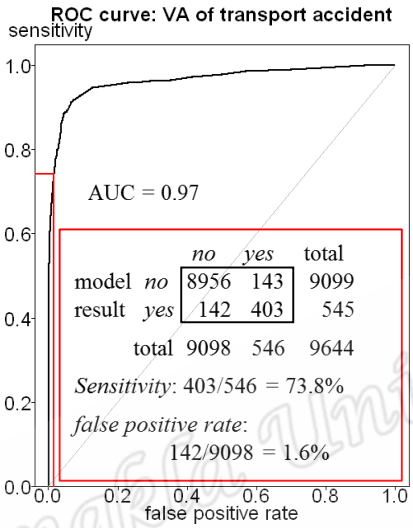

Figure 3.2 ROC curve for the logistic regression model of transport accident death

The sensitivity and the false positive rate based on the logistic regression model could be used to predict errors for individual transport accident deaths in 2005 as shown in Figure 3.3. VR reported a total of 393,345 deaths in Thailand in 2005 and found true positives for 16,437 deaths, false positives for 5,832 deaths, false negatives for 5,792 deaths and true negatives for 365,284 deaths.

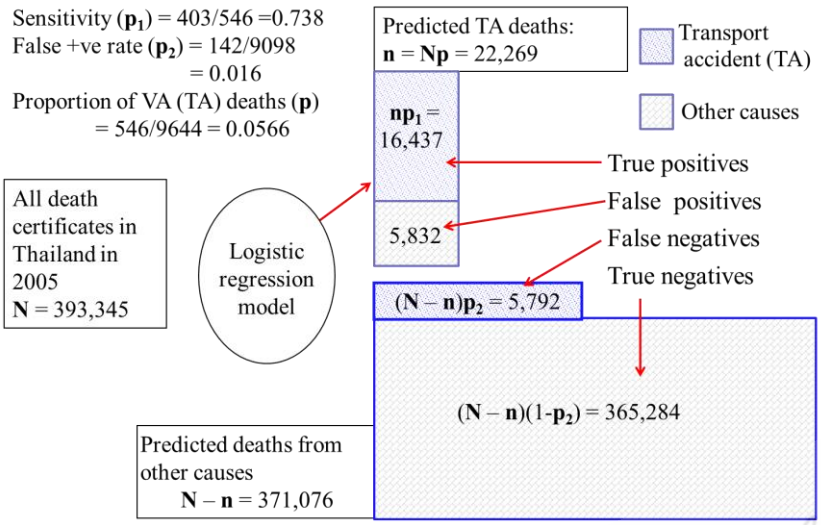

Figure 3.3 Sensitivity and false positive rate based on logistic regression model were used to predict errors for individual of transport accident deaths year 2005

The model used is based on the nine provinces of the VA study, this means that a method is needed to extend the model for estimating deaths for the other 67 provinces apart from the sample. The logistic regression model was then fitted based on treatment contrasts to get the nine province coefficients compared to the reference province (Bangkok) in shown in Table 3.5.

Table 3.5 Coefficients and standard errors of logistic regression model fitted based on treatment contrasts

Determinants	Coefficient	Std. Error	z value	P-value
Constant	2.54	0.65	3.89	<0.001***
Provinces				
Bangkok	0.00			
NakhonNayok	0.63	0.33	1.92	0.055
UbonRatchathani	-0.45	0.28	-1.59	0.112

Table 3.5 (cont.)

Determinants	Coefficient	Std. Error	z value	P-value
Loei	-0.04	0.32	-0.11	0.911
Phayao	-0.38	0.39	-0.97	0.332
Chiang Mai	-0.32	0.30	-1.07	0.287
SuphanBuri	0.06	0.28	0.20	0.842
Chumphon	-1.65	0.58	-2.82	0.005**
Songkhla	-0.49	0.33	-1.48	0.139
gender-age group				
Male				
0-9	0.00			
10-19	2.47	0.55	4.46	<0.001***
20-29	1.69	0.53	3.21	0.001**
30-39	1.03	0.53	1.95	0.052
40-49	1.03	0.53	1.93	0.054
50-59	0.50	0.55	0.91	0.366
60-69	-0.07	0.58	-0.13	0.897
≥70	-0.60	0.58	-1.04	0.299
Female				
0-9	0.36	0.87	0.42	0.678
10-19	1.90	0.63	3.02	0.003**
20-29	0.55	0.67	0.83	0.407
30-39	1.09	0.62	1.75	0.0805
40-49	0.80	0.64	1.26	0.206
50-59	0.26	0.67	0.38	0.702
60-69	-0.17	0.63	-0.28	0.783
≥70	-1.803	0.706	-2.554	0.011*

Table 3.5 (cont.)

Determinants	Coefficient	Std. Error	z value	P-value
VR cause-location group				
Death outside hospital				
Transport accident	0.00			
Other accidents	-4.64	0.45	-10.31	<0.001***
Stroke	-5.99	0.66	-9.08	<0.001***
Respiratory	-6.94	0.65	-10.65	<0.001***
Ill-defined	-6.90	0.46	-14.89	<0.001***
All other	-3.94	0.43	-9.19	<0.001***
Other groups	-8.29	0.54	-15.39	<0.001***
Death in hospital				
Transport accident	1.78	1.10	1.62	0.106
Other accidents	-3.66	0.48	-7.56	<0.001***
Stroke	-5.91	0.54	-11.00	<0.001***
Respiratory	-7.07	0.65	-10.88	<0.001***
Ill-defined	-6.62	0.53	-12.47	<0.001***
All other	-4.04	0.44	-9.24	<0.001***
Other groups	-8.63	0.61	-14.27	<0.001***

*** p-value $\leq$ 0.001, ** p-value $\leq$ 0.01, * p-value $\leq$ 0.05

Thus, the nine province coefficients from the model in Table 3.5 were used to interpolate values for the other 67 province coefficients in Thailand using a triangulation method. The map on the left of Figure 3.4 presents the nine province coefficients from the model as presented in black. The values presented in blue are the average coefficients from nearby provinces. The thematic map on the right shows the interpolated values for all 76 provinces coefficients in Thailand. It indicates that

transport accident deaths happened more frequently in most of the Central region and two provinces of the Northeast region.

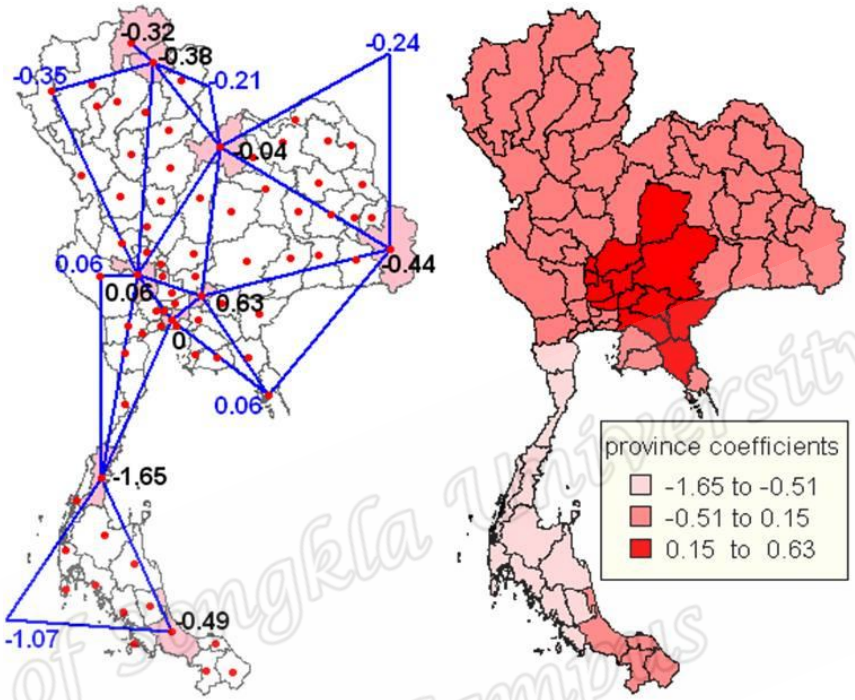

Figure 3.4 Plot of the nine province coefficients from the model and a thematic map of values interpolated from the coefficients in the logistic regression model for all 76 provinces for transport accident deaths in 2005

After that, the estimated probabilities of transport accident deaths from the logistic regression model were extended to the VR data for males and females by age groups from 1996 to 2009 as shown in Figure 3.5. Over the 14-year period, the estimated numbers of transport accident deaths were 269,745 deaths in males and 66,510 deaths in females. These were 2.1 and 2.2 times higher than VR reported totals of 128,743 deaths in males and 30,652 deaths in females.

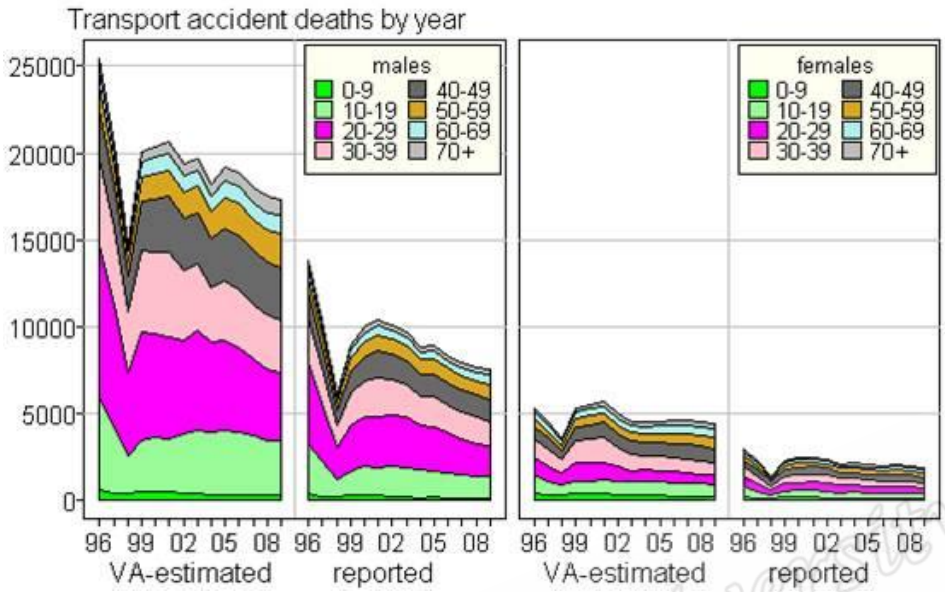

Figure 3.5 Area plot for comparing number of transport accident deaths between VA-estimated and VR reported for males and females by age groups from 1996 to 2009

The ratio of VA-estimated to VR reported transport accident deaths between 1996 and 2009 were between 1.8 to 2.4 times, as shown in Table 3.6.

Table 3.6 Ratio of VR reported and VA-estimated of transport accident deaths years 1996 to 2009

Years	Total deaths in VR	Number of transport accident deaths in VR	Number of estimated VR data	Ratio (IF)
1996	341,136	16,756	30,748	1.8
1997	296,713	12,660	24,903	2.0
1998	305,559	7,528	18,386	2.4
1999	358,420	11,199	25,315	2.3
2000	358,325	12,481	25,919	2.1
2001	368,233	12,889	26,299	2.0

Table 3.6 (cont.)

Years	Total deaths in VR	Number of transport accident deaths in VR	Number of estimated VR data	Ratio (IF)
2002	366,658	12,559	24,322	1.9
2003	367,705	11,790	24,200	2.1
2004	366,712	10,969	22,644	2.1
2005	393,354	10,914	23,689	2.2
2006	389,583	10,393	23,462	2.3
2007	393,116	10,051	22,637	2.3
2008	397,256	9,707	21,958	2.3
2009	393,877	9,499	21,774	2.3
Total	5,096,647	159,395	336,256	2.1

3.2 Article II: Estimating External Causes of Death in Thailand 1996-2009 based on the 2005 Verbal Autopsy Study (Klinjun *et al*., 2014b)

3.2.1 Preliminary results

Of a total 9,644 deaths in the Thai 2005 VA study, 341 (3.5%) were from other accidents and 158 (1.6%) were from suicide. Of those, the VR reported causes of deaths match the VA causes of deaths for 143 deaths (41.9%) in other accident deaths and 90 (57.0%) in suicide. The accuracy of the VR reported causes of deaths were 143 deaths of 237 reported deaths (60.3%) in other accident deaths and 90 deaths of 107 reported deaths (84.1%) in suicide. Therefore, the death registries in VR reports were under-reported by 198 other accident deaths (58.1%), of which 16.4% were VR coded as other ill-defined and unspecified causes of mortality (R99), 10.3% were senility

(R54) and 7.0% were unspecified event, undetermined intent (Y34) as shown in Table 3.7

Table 3.7 Number and percent of VR reported causes of other accident deaths attributed to other VA-assessed causes of deaths

Cause of death	Number (341 deaths)	Percent
Other accidents	143	41.9
Ill-defined (R00-R99) (97 deaths)		
Other ill-defined and unspecified causes of mortality (R99)	56	16.4
Senility (R54)	35	10.3
Haemorrhage, not elsewhere classified (R58)	3	0.9
Syncope and collapse (R55)	2	0.6
Fever of other and unknown origin (R50)	1	0.3
All other (41 deaths)		
Unspecified event, undetermined intent (Y34)	24	7.0
Assault by other and unspecified firearm discharge (X95)	10	2.9
Other and unspecified firearm discharge, undetermined intent (Y24)	3	0.9
Hanging, strangulation and suffocation, undetermined intent (Y20)	1	0.3
Contact with blunt object, undetermined intent (Y29)	1	0.3
Other specified events, undetermined intent (Y33)	1	0.3
Other congenital malformations of brain (Q04)	1	0.3
Stroke (I60-I69) (14 deaths)		
Intracerebral haemorrhage (I61)	10	2.9

Table 3.7 (cont.)

Cause of death	Number (341 deaths)	Percent
Subarachnoid haemorrhage (I60)	2	0.6
Cerebral infarction (I63)	1	0.3
Stroke, not specified as haemorrhage or infarction (I64)	1	0.3
Respiratory (J00-J99) (11 deaths)		
Pneumonia, organism unspecified (J18)	6	1.8
Other respiratory disorders (J98)	2	0.6
Other diseases of upper respiratory tract (J39)	1	0.3
Pneumonitis due to solids and liquids (J69)	1	0.3
Other pleural conditions (J94)	1	0.3
Septicaemia: Other septicaemia (A41)	8	2.3
GU (N00-N99) (5 deaths)		
Unspecified renal failure (N19)	4	1.2
Hyperplasia of prostate (N40)	1	0.3
Suicide (X60-X84) (5 deaths)		
Intentional self-harm by hanging, strangulation and suffocation (X70)	4	1.2
Intentional self-harm by other and unspecified firearm discharge (X74)	1	0.3
Transport accident (V01-V99) (3 deaths)		
Motorcycle rider injured in collision with fixed or stationary object (V27)	1	0.3
Motorcycle rider injured in noncollision transport accident (V28)	2	0.6
Occupant of pick-up truck or van injured in noncollision transport accident (V58)	1	0.3

Table 3.7 (cont.)

Cause of death	Number (341 deaths)	Percent
Digestive (K00-K93) (3 deaths)		
Other diseases of intestine (K63)	1	0.3
Fibrosis and cirrhosis of liver (K74)	1	0.3
Other diseases of digestive system (K92)	1	0.3
Other cancer (C00-C14, C40-C97, D00-D48) (2 deaths)		
Leukaemia of unspecified cell type (C95)	1	0.3
Benign neoplasm of thyroid gland (D34)	1	0.3
Endocrine: Unspecified diabetes mellitus (E14)	2	0.6
Ischemic (I20-I25) (2 deaths)		
Acute myocardial infarction (I21)	1	0.3
Chronic ischaemic heart disease (I25)	1	0.3
Other infectious: Diarrhoea and gastroenteritis of presumed infectious origin (A09)	1	0.3
Other digestive: Malignant neoplasm of other and unspecified parts of biliary tract (C24)	1	0.3
Mental, Nervous: Epilepsy (G40)	1	0.3
Other CVD: Complications and ill-defined descriptions of heart disease (I51)	1	0.3

The death registries in VR reports were under-reported 68 deaths (43.0%) by suicide, of which 12.0% were hanging, strangulation and suffocation, undetermined intent (Y20) and 4.4% each of poisoning by and exposure to pesticides, undetermined intent (Y18), other symptoms and signs involving the circulatory and respiratory systems (R09) and other ill-defined and unspecified causes of mortality (R99) as shown in Table 3.8.

Table 3.8 Number and percent of VR reported causes of suicide deaths attributed to other VA-assessed causes of deaths

Cause of death	Number (158 deaths)	Percent
Suicide	90	57.0
All other (32 deaths)		
Hanging, strangulation and suffocation, undetermined intent (Y20)	19	12.0
Poisoning by and exposure to pesticides, undetermined intent (Y18)	7	4.4
Unspecified event, undetermined intent (Y34)	2	1.3
Assault by other and unspecified firearm discharge (X95)	2	1.3
Poisoning by and exposure to other and unspecified chemicals and noxious substances, undetermined intent (Y19)	1	0.6
Contact with blunt object, undetermined intent (Y29)	1	0.6
Ill-defined (R00-R99) (18 deaths)		
Other symptoms and signs involving the circulatory and respiratory systems (R09)	7	4.4
Other ill-defined and unspecified causes of mortality (R99)	7	4.4
Senility (R54)	2	1.3
Fever of other and unknown origin (R50)	1	0.6
Haemorrhage, not elsewhere classified (R58)	1	0.6
Septicaemia: Other septicaemia (A41)	2	1.3
Endocrine (E00-E90) (2 deaths)		
Other disorder of fluid, electrolyte and acid-base balance (E87)	2	1.3

Table 3.8 (cont.)

Cause of death	Number (158 deaths)	Percent
Disorder of purine and pyrimidine metabolism (E79)	1	0.6
Mental, Nervous: Other disorders of brain (G93)	2	1.3
Stroke (I60-I69) (2 deaths)		
Intracerebral haemorrhage (I61)	1	0.6
Sequelae of cerebrovascular disease (I69)	1	0.6
GU: Chronic renal failure(N18)	2	1.3
Other accidents: Unspecified drowning and submersion (W74)	2	1.3
Other digestive: Malignant neoplasm of other and ill-defined digestive organs (C26)	1	0.6
Lung cancer: Malignant neoplasm of bronchus and lung(C34)	1	0.6
Other cancer: Malignant neoplasm without specification of site(C80)	1	0.6
Digestive: Other diseases of stomach and duodenum (K31)	1	0.6
Transport accident: Occupant of railway train or railway vehicle injured in transport accident (V81)	1	0.6

Other accident deaths varied between 2.4% and 4.8% among the nine provinces. The highest proportion of other accident deaths was found in males aged 0-9 years. The VR cause-location due to other accident deaths were more likely to be reported as other accidents 64.8% in deaths outside hospital and 50.7% in deaths in hospital as shown in Table 3.9.

Table 3.9 Percentage deaths of other accident deaths in each province, gender-age group and VR cause-location group

Determinants	Other deaths (9,303 cases)	Other accident deaths (341 cases)	Total VA data (9,644 cases)	Percent
Province				
Bangkok	851	21	872	2.4
Nakhon Nayok	618	29	647	4.5
Ubon Ratchathani	2,340	78	2,418	3.2
Loei	843	34	877	3.9
Phayao	567	24	591	4.1
Chiang Rai	1,404	45	1,449	3.1
Suphan Buri	1,565	62	1,627	3.8
Chumphon	301	15	316	4.8
Songkhla	814	33	847	3.9
Gender-age group				
Male	**5,241**	**233**	**5,474**	**4.3**
0-9 years	95	26	121	21.5
10-19 years	149	10	159	6.3
20-29 years	284	21	305	6.9
30-39 years	525	35	560	6.3
40-49 years	577	38	615	6.2
50-59 years	676	34	710	4.8
60-69 years	930	27	957	2.8
$\geq$ 70 years	2,005	42	2,047	2.1
Female	**4,062**	**108**	**4,170**	**2.6**
0-9 years	63	8	71	11.3
10-19 years	47	8	55	14.5

Table 3.9 (cont.)

Determinants	Other deaths (9,303 cases)	Other accident deaths (341 cases)	Total VA data (9,644 cases)	Percent
20-29 years	117	4	121	3.3
30-39 years	228	3	231	1.3
40-49 years	282	9	291	3.1
50-59 years	412	8	420	1.9
60-69 years	670	14	684	2.0
≥ 70 years	2,243	54	2,297	2.4
VR cause-location group				
Deaths outside hospital	**6,086**	**242**	**6,328**	**3.8**
Other accidents	57	105	162	64.8
Ill-defined	3,289	82	3,371	2.4
Stroke	96	7	103	6.8
Respiratory	251	4	255	1.6
Septicaemia	51	3	54	5.6
GU	215	4	219	1.8
All other	213	22	235	9.4
Other groups	1,914	15	1,929	0.8
Deaths in hospital	**3,217**	**99**	**3,316**	**3.0**
Other accidents	37	38	75	50.7
Ill-defined	432	15	447	3.4
Stroke	255	7	262	2.7
Respiratory	350	7	357	2.0
Septicaemia	465	5	470	1.1
GU	159	1	160	0.6
All other	179	19	198	9.6
Other groups	1,340	7	1,347	0.5

The proportion of suicide deaths varied between 0.9% and 3.1% among the nine provinces. The highest proportion of suicide deaths was found among females aged 30-39 years. The VR cause-location due to suicide deaths were more likely to be reported as suicide 95.8% for deaths in hospital and 80.7% for deaths outside hospital as shown in Table 3.10.

Table 3.10 Percentage deaths due to suicide deaths in each province, gender-age group and VR cause-location group

Determinants	Other deaths (9,486 cases)	Suicide deaths (158 cases)	Total VA data (9,644 cases)	Percent
Province				
Bangkok	861	11	872	1.3
NakhonNayok	641	6	647	0.9
Ubon Ratchathani	2,392	26	2,418	1.1
Loei	853	24	877	2.7
Phayao	580	11	591	1.9
Chiang Rai	1,404	45	1,449	3.1
Suphan Buri	1,603	24	1,627	1.5
Chumphon	313	3	316	0.9
Songkhla	839	8	847	0.9
Gender-age group				
Male	**5,352**	**122**	**5,474**	**2.2**
5-29 years	557	28	585	4.8
30-39 years	530	30	560	5.4
40-49 years	591	24	615	3.9
50-59 years	695	15	710	2.1

Table 3.10 (cont.)

Determinants	Other deaths (9,486 cases)	Suicide deaths (158 cases)	Total VA data (9,644 cases)	Percent
60-69 years	943	14	957	1.5
≥ 70 years	2,036	11	2,047	0.5
Female	**4,134**	**36**	**4,170**	**0.9**
5-29 years	240	7	247	2.8
30-39 years	216	15	231	6.5
40-49 years	289	2	291	0.7
50-59 years	418	2	420	0.5
60-69 years	678	6	684	0.9
≥ 70 years	2,293	4	2,297	0.2
VR cause-location group				
Deaths outside hospital	**6,212**	**116**	**6,328**	**1.8**
Suicide	16	67	83	80.7
Ill-defined	3,355	16	3,371	0.5
All other	211	24	235	10.2
Other groups	2,630	9	2,639	0.3
Deaths in hospital	**3,274**	**42**	**3,316**	**1.3**
Suicide	1	23	24	95.8
Ill-defined	445	2	447	0.4
All other	190	8	198	4.0
Other groups	2,638	9	2,647	0.3

3.2.2 Statistical model

The residuals deviance together with degree of freedom (df) and p-value from logistic regression model of other accident deaths are shown in Table 3.11. For other accident

deaths, the p-values of all determinants are statistically significant except province. However, this indicates that the logistic regression model with three determinants can be used to estimate the number of other accident deaths.

Table 3.11 Likelihood-ratio test for logistic regression model of other accident deaths by province, gender-age group and VR cause-location group

Determinants	Deviance reduction	df	P-value
Province	4.2	8	0.843
Gender-age group	37.3	15	0.001**
VR cause-location group	724.2	15	<0.001***
Error	2,065.7	9,605	

***p-value ≤ 0.001, **p-value ≤ 0.01

For suicide deaths, the p-values of all determinants are statistically significant. This indicates that the logistic regression model with three determinants is appropriate for estimating the number of suicide deaths as shown in Table 3.12.

Table 3.12 Likelihood-ratio test for logistic regression model of suicide deaths by province, gender-age group and VR cause-location group

Determinants	Deviance reduction	df	P-value
Province	16.8	8	0.032*
Gender-age group	40.5	11	<0.001***
VR cause-location group	682.4	7	<0.001***
Error	723.3	9,617	

***p-value ≤ 0.001, **p-value ≤ 0.01, *p-value ≤ 0.05

To estimate the total number of deaths for the three cause groups in the population, different values for the cut-off point (*c*) probability are needed to match the numbers of VA deaths predicted by the logistic regression model for each the three cause groups as shown in Figure 3.6

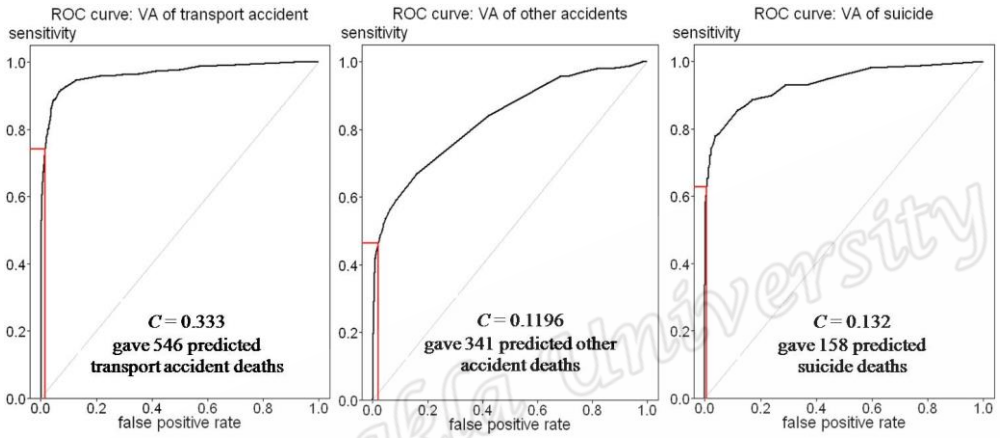

Figure 3.6 Cut-off point of ROC curves for logistic regression model of three cause groups

For other accident deaths, sensitivity is 46.3%, false positive rate is 2.0%, and suicide deaths, sensitivity is 62.0%, and false positive rate is 0.6% as shown in Figure 3.7.

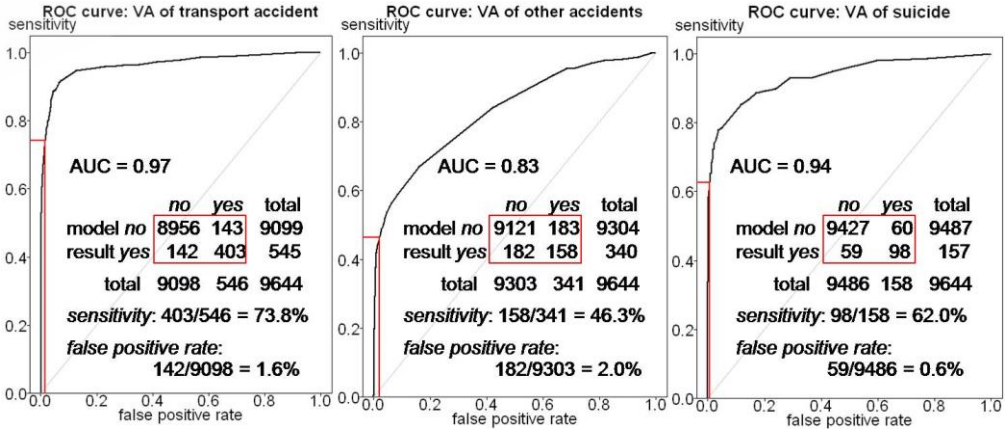

Figure 3.7 ROC curve for logistic regression models of three cause groups

To estimate the number of deaths for each of the three cause groups in the target population in 2005, Figure 3.8 shows age distributions of VR reported deaths after adjusting for misreporting (VA-estimated) based on the three logistic regression models, separated by male and female.

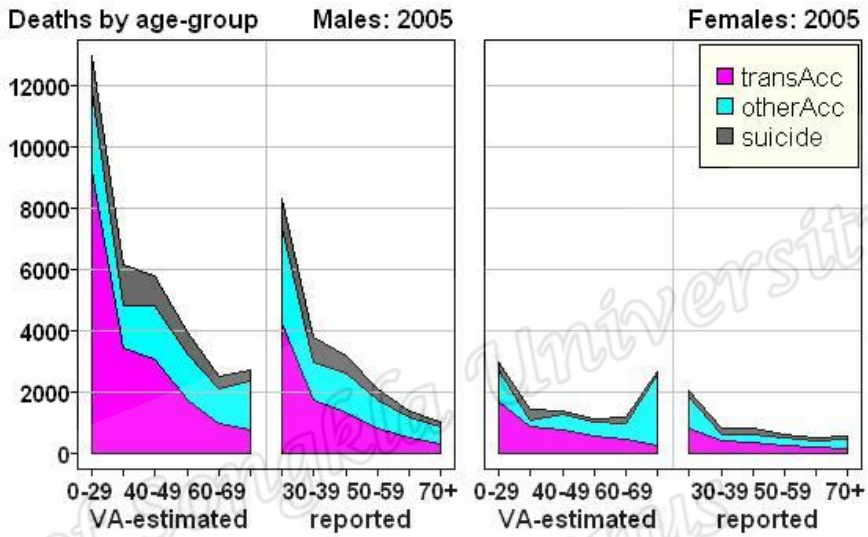

Figure 3.8 Area plots of estimated deaths in the target population in Thailand's 2005

The results show that deaths in the three cause groups were substantially under-reported for both male and female as shown in Table 3.13.

Table 3.13 Ratios of VA-estimated deaths from models and VR-reported deaths, 2005

Cause groups	Males			Females		
	VA-estimated	VR-reported	Ratio (IF)	VA-estimated	VR-reported	Ratio (IF)
Transport accident	19,134	8,876	2.2	4,554	2,038	2.2
Other accident	9,960	7,784	1.3	4,930	2,351	2.1
Suicide	4,886	3,017	1.6	1,208	903	1.3

The ratio of VA-estimated to VR reported for the three cause groups between 1996 and 2009 revealed that all three cause groups were under-reported over time except other accident deaths years in 1996 and 1997. Transport accident deaths had higher under-reported proportions than other accidents and suicide as shown in Table 3.14.

Table 3.14 Ratio of VR reported deaths to VA-estimated deaths for three cause groups during the years 1996 to 2009

Years	Transport accident			Other accidents			Suicide		
	VR-reported	VA-estimated	Ratio (IF)	VR-reported	VA-estimated	Ratio (IF)	VR-reported	VA-estimated	Ratio (IF)
1996	16,756	30,748	1.8	17,574	16,215	0.9	4,519	6,610	1.5
1997	12,660	24,903	2.0	15,446	14,308	0.9	4,126	6,033	1.5
1998	7,528	18,386	2.4	8,782	12,037	1.4	4,859	7,119	1.5
1999	11,199	25,315	2.3	9,397	13,907	1.5	5,220	8,240	1.6
2000	12,481	25,919	2.1	10,091	14,491	1.4	5,070	7,972	1.6
2001	12,889	26,299	2.0	9,712	14,502	1.5	4,790	7,710	1.6
2002	12,559	24,322	1.9	10,046	14,518	1.4	4,696	6,908	1.5
2003	11,790	24,200	2.1	9,470	14,102	1.5	4,252	6,422	1.5
2004	10,969	22,644	2.1	10,407	14,543	1.4	3,995	5,908	1.5
2005	10,914	23,689	2.2	10,135	14,890	1.5	3,920	6,093	1.6
2006	10,393	23,462	2.3	10,314	15,037	1.5	3,600	5,822	1.6
2007	10,051	22,637	2.3	9,491	14,543	1.5	3,755	5,864	1.6
2008	9,707	21,958	2.3	9,054	14,329	1.6	3,777	5,892	1.6
2009	9,499	21,774	2.3	9,275	14,428	1.6	3,787	5,828	1.5
Total	159,395	336,256	2.1	149,194	201,848	1.4	60,366	92,419	1.5

3.3 Article III: Epidemiological Patterns of Transport Accident Mortality in Thailand (Appendix III)

3.3.1 Preliminary results

Of the 2,333,893 total deaths recorded by the VR system in the years 2004 to 2009, there were 61,533 (2.6%) reported transport accident deaths. After adjustment using VA this number increased to 136,164 (5.8%). The estimated numbers of transport accident deaths were 2.1 to 2.3 times higher than the VR data, and the estimated transport accident mortality rates ranged from 32.5 to 36.4 per 100,000 population as shown in Table 3.15.

Table 3.15 Transport accident deaths from VR-reported and VA-estimated by year

Year	Estimated population (All ages)	Reported total deaths	Reported deaths (VR)	Estimated deaths (VA)	Estimated mortality rate (per 100,000)	Ratio VA/VR (IF)
2004	64,533,735	366,712	10,969	22,644	35.1	2.1
2005	65,101,369	393,354	10,914	23,689	36.4	2.2
2006	65,574,251	389,583	10,393	23,462	35.8	2.3
2007	66,041,268	393,116	10,051	22,637	34.3	2.3
2008	66,481,676	397,256	9,707	21,958	33.0	2.3
2009	66,902,853	393,877	9,499	21,774	32.5	2.3

3.3.2 Statistical model

A Poisson regression model was used for analyzing the data by gender-age group and province-year group. Thus, the Poisson coefficients of province-year group and the slope of the simple regression were used to explore trend patterns of transport

accident mortality rates in Thailand from 2004 to 2009. The results of these methods could be separated the trend patterns of transport accident mortality rates years 2004 to 2009 into nine groups as shown in Figure 3.9

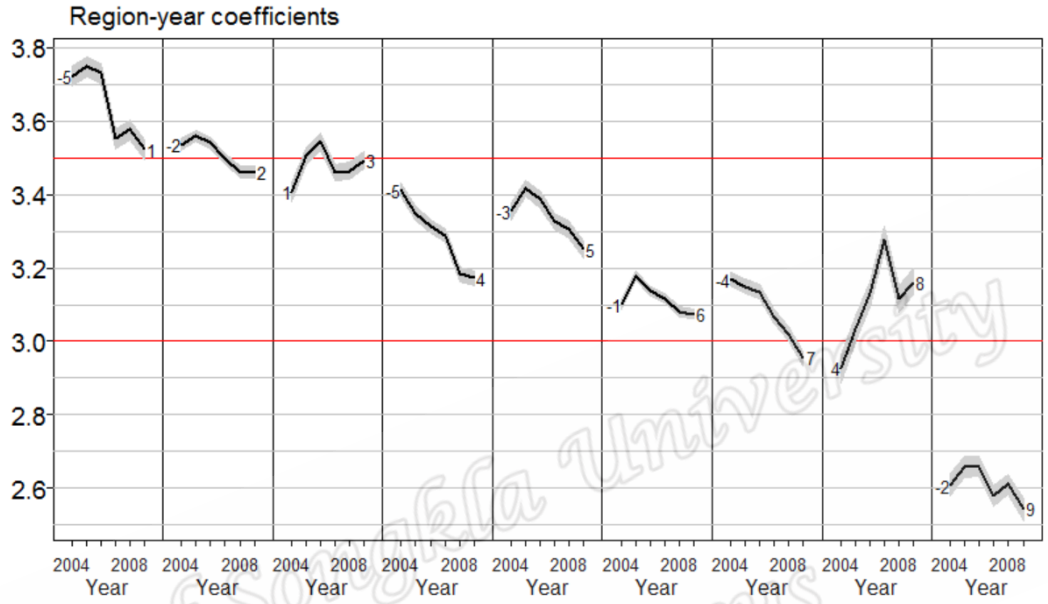

Figure 3.9 Poisson coefficients and regression coefficient of nine region-year groups from 2004 to 2009

For nine region-year groups of transport accident mortality rates years 2004 to 2009, list of provinces and the mean estimated transport accident mortality rates of each group are shown in Table 3.16 and Table 3.17.

Table 3.16 Name of province for each group by region in Thailand

Groups	Region	Provinces
1. High and fast going down (5 provinces)	Central	Ayutthaya, Nakhon Nayok, Saraburi, Sing Buri
	North	Kamphaeng Phet
	Northeast	-
	South	-

Table 3.16 (cont.)

Groups	Region	Provinces
2.High and slow going down (11 provinces)	Central	Chachoengsao, Kanchanaburi, Lopburi, Prachinburi, Rayong, Sa Kaeo, Suphan Buri
	North	Phetchabun, Phichit, Uttaradit
	Northeast	Nakhon Ratchasima
	South	-
3.High and slow going up (8 provinces)	Central	Chai Nat, Ang Thong, Chanthaburi, Trat
	North	Nakhon Sawan, Phisanulok, Uthai Thani
	Northeast	-
	South	Krabi
4.Medium and fast going down (7 provinces)	Central	-
	North	Chiang Mai, Lamphun, Sukhothai
	Northeast	Chaiyaphum, KhonKaen
	South	Phuket, Songkhla
5. Medium and slow going down (5 provinces)	Central	Chonburi, Nakhon Pathom, Pathum Thani
	North	Chiang Rai
	Northeast	Loei
	South	-
6. Low and flat (25 provinces)	Central	Nonthaburi, Prachuap Khiri Khan, Samut Prakan, Samut Sakhon, Samut Songkhram
	North	Lampang, Nan, Phayao, Phrae, Tak
	Northeast	Amnat Charoen, Buriram, Maha Sarakham, Mukdahan, Nakhon Phanom, Roi Et, Sakon Nakhon, Si Sa Ket, Ubon Ratchathani, Yasothon
	South	Chumphon, Phattalung, Ranong, Satun, Surat Thani
7. Low and fast going down (10 provinces)	Central	Phetchaburi, Ratchaburi
	North	Mae Hong Son

Table 3.16 (cont.)

Groups	Region	Provinces
	Northeast	Kalasin, Nong Bua Lam Phu, NongKhai, Surin, Udon Thani
	South	Nakhon Si Thammarat, PhangNga
8. Low and fast going up (4 provinces)	Central	-
	North	-
	Northeast	-
	South	Narathiwat, Pattani, Trang, Yala
9. Low and slow going down (1 province)	Central	Bangkok
	North	-
	Northeast	-
	South	-

Table 3.17 Transport accident mortality rates for each group years 2004 to 2009

Groups	Estimated population (6 years)	Transport accident deaths	Estimated mortality rate (per 100,000)
1. High and fast going down	15,381,603	8,134	52.9
2. High and slow going down	57,212,892	26,270	45.9
3. High and slow going up	24,433,319	10,885	44.6
4. Medium and fast going down	44,131,233	16,168	36.6
5. Medium and slow going down	28,428,705	11,048	38.9
6. Low and flat	115,601,984	35,559	30.8
7. Low and fast going down	53,453,475	16,059	30.0
8. Low and fast going up	15,125,073	4,580	30.3
9. Low and slow going down	40,866,868	7,400	18.1
Total	394,635,152	136,103	34.5

The plots of deviance residuals versus normal quantiles from the Poisson regression model with 16 gender-age group and nine region-year group are shown in Figure 3.10. The model fitted reasonably well.

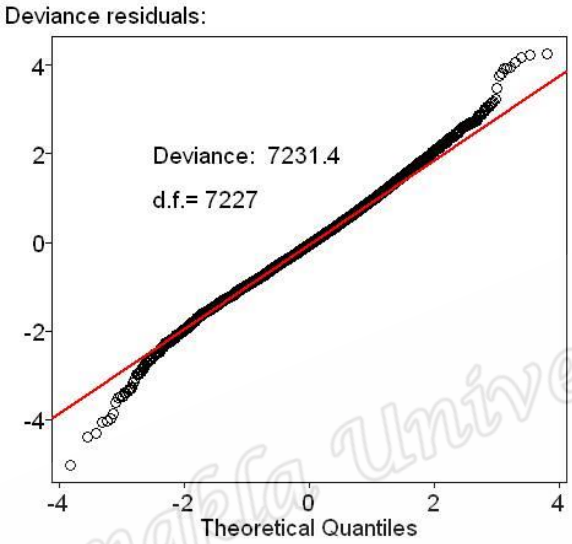

Figure 3.10 Residuals plot of transport accident deaths for all ages in nine region-year groups, 2004 to 2009