Chapter 3

Details of the studies

In this thesis, two manuscripts were produced. The first manuscript, entitled "A Statistical Method for Forecasting Demographic Time Series Counts, with Application to HIV/AIDS and Other Infectious Disease Mortality in Southern Thailand" was published in Southeast Asian Journal of Tropical Medicine and Public Health volume 38, number 6 November 2007 page 1029-1040. The second manuscript, entitled "Methods for Analyzing Hospital Length of Stay with Application to Inpatients Dying in Southern Thailand" was accepted by Global Journal of Health Science and will be published in Volume 1 Number 1 April 2009. Each manuscript was written in a submission style set out in each journal's instructions to the author. The full manuscripts are shown in Appendix 1 and Appendix 2. In this chapter, abstract, rationale, results and further comments are mentioned briefly as the following.

3.1 Manuscript I

3.1.1 Abstract

This study investigated regional and temporal patterns of death from infectious diseases (including HIV/AIDS) reported in 14 provinces of southern Thailand over

the period 1999-2004, using data obtained from the Thailand Bureau of Policy and Strategy, Ministry of Public Health. Causes of deaths were identified using the International Classification of Diseases 10th revision (ICD-10), and mortality rates were then calculated using populations obtained from the 2000 population census. Poisson and negative binomial lag observation driven regression models for mortality rate were fitted to the data, separately for HIV/AIDS and other infectious diseases. Overall, the hospital mortality rates started to increase sharply in 2003 - 2004. The in-hospital mortality for HIV/AIDS showed peaks in urban districts and decreased from north to south, with mortality for males approximately double that of females.

For other infectious diseases, an upward trend in hospital mortality for those aged 40 and over started in 2003-2004, particularly among persons reported as dying from septicemia, while showing a slightly increasing trend for other infectious diseases.

3.1.2 Rationale

Infectious diseases accounted for a quarter to a third of all global deaths and their spread results from changes in human behaviour such as lifestyles and land use patterns, increased trade and travel, and inappropriate use of antibiotic drugs (National Intelligence Council, 2000). Infectious diseases can be transmitted from one person to other person by many routes, depending on the etiology of each disease. They can be transmitted by vector carrier, drinking, touching, breathing, or direct exposure to the sources of diseases. The endemic pattern of a disease possibly can be predicted from the pattern in which the disease happened previously. For example, a higher number of disease cases at the present may be due to a higher number of disease cases in the previous month, or in an earlier period. Also, areas close to each other may have similar incidence rates of diseases. Mortality from most infectious diseases shows a downward trend while mortality from HIV/AIDS shows an upward trend. Therefore, HIV/AIDS mortality must be analyzed separately from other infectious diseases. Even though the quality of mortality data in Thailand is still a problem, it is still useful to analyze such data by setting up the appropriate statistical methods and selecting diseases with a large number of cases. Thus, those aged 15 and over who died from HIV/AIDS and those aged 40 and over who died from other infectious diseases in hospital were selected for further statistical analysis. Investigating the regional and temporal pattern of disease can indicate the areas with problems and predict times of likely disease epidemic. This information is needed if problems are to be solved by the responsible authorities. The results from this study can be used for identifying problem areas and guiding intervention, for solving and preventing problems of high mortality from infectious diseases.

3.1.3 Results

Descriptive and comparative results which are not included in the manuscript are shown in this 'Results' section. This section starts with the overall characteristics of total deaths in Southern Thailand, separated mainly by place of death: whether deaths occurred in hospital or outside hospital. All of the data for infectious diseases was used in the descriptive statistics but because of the problem of unreliable cause of death data for those who died outside hospital, these cases were excluded from the inferential statistics modelling, with the exception that all HIV/AIDS deaths were included.

Total deaths for residents in Southern Thailand, from civil registration data, were 250,175. Among these 59,055 deaths occurred in hospitals. The percent of deaths in hospital gradually increased each year between 2000 and 2004, as shown in Table 3.1. The overall hospital proportion of deaths was 23.6%.

Table 3.1 Percentages of hospital deaths in Southern Thailand, by year

Year	Hospital		Total	% hospital death
	Inside	Outside		
1999	8,160	29,657	37,817	21.6
2000	7,607	33,504	41,111	18.5
2001	8,211	32,925	41,136	20.0
2002	9,266	32,848	42,114	22.0
2003	12,163	31,417	43,580	27.9
2004	13,648	30,769	44,417	30.7
Total	59,055	191,120	250,175	23.6

Apart from deaths from ‘other’ disease groups, the highest number or proportion of deaths was found in the ‘injuries’ group, followed by deaths from heart disease and then infectious diseases. The highest percent of hospital death was found in digestive disease group (47.9%). When considering only infectious disease groups, most deaths from HIV/AIDS occurred outside hospital while almost half of deaths from other infectious diseases occurred in hospital, as shown in Table 3.2.

Table 3.2 Percent of hospital death in each disease group

ICD-10 Code	Disease	Inside	Outside	total	% hospital death
I00-I99	Heart Disease	11,672	15,496	27,168	43.0
J00-J98	Respiratory	6,445	9,576	16,021	40.2
A00-B99	Infectious Disease	6,885	8,122	15,007	45.9
B20-B24	HIV/AIDS	2,392	5,154	7,546	31.7
C00-C97	Cancers	5,969	14,881	20,850	28.6
V01-Y35	Injuries	8,371	38,809	47,180	17.7
K00-K92	Digestive Disease	2,196	2,386	4,582	47.9
The rest	Other	15,125	96,696	111,821	13.5

The percentage of hospital deaths varied according to the provinces. The highest percentage occurred in Phuket, followed by Surat Thani and Pang-Nga. The lowest percent of hospital death was found in Narathiwat as shown in Table 3.3.

Table 3.3 Percent of hospital death in each province

province	Inside	Outside	Total	% hospital death
Nakorn Si Thamarat	10,463	34,597	45,060	23.2
Krabi	2,328	7,439	9,767	23.8
Pang-Nga	2,233	5,672	7,905	28.2
Phuket	3,261	4,853	8,114	40.2
Surat Thani	7,606	17,339	24,945	30.5
Ranong	1,411	3,142	4,553	31.0
Chumpon	4,250	11,080	15,330	27.7
Songkla	11,064	28,873	39,937	27.7
Satun	1,447	5,978	7,425	19.5
Trang	3,584	14,332	17,916	20.0
Phattalung	2,951	12,031	14,982	19.7
Pattani	3,139	17,338	20,477	15.3
Yala	2,767	9,083	11,850	23.4
Narathiwat	2,551	19,363	21,914	11.6

Hospital death rates per 1000 for each super-district and disease group are shown in Table 3.4. Higher rates of hospital death were found in urban areas, especially in Phuket and Hat Yai (super-districts 18 and 27). The lowest hospital death rate appeared in the three southernmost provinces of Pattani, Yala and Nathiwat (super-districts 31 - 36). Most of deaths from HIV/AIDS occurred outside hospital, with low death rates shown in Table 3.4, except for Phuket and Songkhla city (super-districts 18 and 26).

Table 3.4 Distribution of death rates per 1,000 by super-district for each disease group

Code	CVD	ID	RD	HIV	CA	INJ	DD	Other
1	1.8	1.1	1.2	0.3	1.1	1.1	0.4	1.9
2	1.9	1.3	1.4	0.4	1.2	1.6	0.3	2.3
3	1.9	1.2	0.9	0.5	1.0	1.0	0.3	2.0
4	1.2	0.8	1.0	0.2	0.7	1.3	0.4	1.8
5	1.8	1.1	1.2	0.5	1.4	1.7	0.5	2.8
6	1.5	0.9	1.1	0.5	1.1	1.2	0.4	2.1
7	1.2	0.8	1.1	0.3	0.7	1.3	0.4	1.8
8	2.0	0.9	1.0	0.7	1.2	1.3	0.4	2.1
9	1.7	0.9	0.9	0.3	0.8	0.9	0.2	2.1
10	1.2	0.7	0.6	0.1	0.5	0.7	0.1	1.2
11	1.5	0.8	0.9	0.3	0.7	0.8	0.2	1.7
12	1.2	0.9	0.7	0.2	0.6	1.0	0.1	1.5
13	1.9	1.2	0.9	0.3	0.9	1.2	0.2	2.6
14	1.4	1.0	0.8	0.3	0.7	0.8	0.2	1.8
15	1.2	0.7	0.6	0.2	0.5	0.9	0.2	1.3
16	1.4	0.9	0.7	0.2	0.5	1.4	0.3	1.7
17	1.2	0.7	0.9	0.2	0.7	1.1	0.2	1.8
18	2.4	1.2	1.0	1.3	1.5	1.4	0.5	3.8
19	1.2	0.8	0.7	0.1	0.4	1.0	0.2	1.3
20	1.7	1.0	0.8	0.2	0.7	1.0	0.3	2.4
21	1.0	0.6	0.5	0.1	0.4	0.7	0.2	1.1
22	1.6	0.6	0.9	0.3	0.7	1.1	0.3	1.7
23	0.9	0.5	0.5	0.2	0.4	1.0	0.2	1.1
24	1.7	0.8	0.7	0.3	0.8	1.1	0.3	1.9

Table 3.4 Cont.

Code	CVD	ID	RD	HIV	CA	INJ	DD	Other
25	1.3	0.7	0.7	0.3	0.6	1.3	0.3	1.4
26	2.2	1.3	1.1	1.0	1.5	1.2	0.4	2.9
27	2.3	1.6	1.1	0.4	1.3	1.6	0.6	2.8
28	1.5	0.7	0.5	0.2	0.7	1.1	0.3	1.4
29	1.4	0.9	0.9	0.2	0.7	1.0	0.3	1.7
30	1.0	0.7	0.5	0.2	0.4	1.1	0.2	1.6
31	1.2	0.7	0.7	0.2	0.7	0.8	0.2	2.3
32	0.6	0.6	0.4	0.1	0.2	0.6	0.1	1.1
33	1.0	0.7	0.5	0.2	0.5	0.7	0.2	1.7
34	1.3	0.8	0.7	0.1	0.7	0.7	0.2	1.9
35	1.5	0.9	0.9	0.1	0.6	0.8	0.3	2.0
36	0.8	0.3	0.3	0.0	0.2	0.4	0.1	1.2
37	1.1	0.4	0.5	0.1	0.4	0.6	0.1	1.4
38	0.7	0.3	0.3	0.1	0.2	0.5	0.1	1.2

CVD = Cardiovascular disease, ID = Infectious diseases, RD = Respiratory disease

HIV = HIV/AIDS, CA = Cancer, INJ = Injuries, DD = Digestive disease

Table 3.5 shows HIV/AIDS death rate per 100,000 patients aged 15 and over by gender and super-district. Most death rates from HIV/AIDS occurred outside hospital, especially for males. Males had much higher HIV/AIDS death rates than females. The highest death rate inside hospital was found in Phuket for male and in Trang South for females, while the highest death rate outside hospital was found in Nakhon Si Thammarat South Coast for males and in Songkhla West for females. The lowest death rate inside hospital was found in Narathiwat Coast for males and Surat Thani South for females, while the lowest death rate outside hospital was found in Pattani Central for males and in Ranong for females. The death rate inside hospital was higher than death rate outside hospital in Phang-nga, Phuket and Songkhla city for males and in Trang South and Pattani City-West for females.

Table 3.5 Distribution of HIV/AIDS death rate per 100,000, of patients age 15 and over, by gender and super-district

Code	Male death rate		Female death rate		Code	Male death rate		Female death rate	
	Inside	Outside	Inside	Outside		Inside	Outside	Inside	Outside
1	4.5	18.1	0.2	0.5	20	2.2	5.1	0.9	2.9
2	5.0	7.1	0.8	0.8	21	1.7	8.1	7.3	3.0
3	5.1	12.8	0.2	0.2	22	5.4	13.8	0.9	2.8
4	2.9	7.4	0.1	1.3	23	2.4	8.7	0.6	3.2
5	7.4	9.3	0.5	0.8	24	4.4	11.4	0.7	6.5
6	6.3	15.8	0.3	0.5	25	4.2	6.8	1.5	7.2
7	4.6	10.0	0.0	0.4	26	12.8	9.5	0.8	6.6
8	9.1	7.4	0.9	1.6	27	6.2	6.7	0.6	4.1
9	4.0	18.9	1.1	1.5	28	2.6	4.0	1.4	4.9
10	4.0	13.8	1.3	2.0	29	3.0	5.3	1.0	5.0
11	5.1	15.7	0.7	1.6	30	2.9	4.1	1.0	5.4
12	1.7	10.4	2.3	3.1	31	3.2	3.5	3.6	2.7
13	2.7	19.3	4.6	4.7	32	1.5	1.2	1.2	2.7
14	4.5	22.3	2.0	4.4	33	2.5	3.8	2.8	5.3
15	3.3	15.9	2.0	4.3	34	2.2	6.2	2.8	3.8
16	2.3	7.3	0.7	3.9	35	1.3	3.6	1.7	3.5
17	2.2	8.7	1.2	4.5	36	0.4	1.3	3.7	5.2
18	17.5	7.9	0.5	3.2	37	1.5	3.4	1.6	2.9
19	1.5	6.5	0.9	2.9	38	1.0	1.7	1.1	7.1

Death data from ‘other’ infectious diseases were analyzed, but only deaths in hospital were included. Patients aged 40 and over were considered. Results shown in Table 3.6 divide the death rate per 1000 from infectious diseases (excluding HIV/AIDS) into two groups: other infectious disease and septicemia. Death from septicemia was shown to have a high rate in all super-districts, with the highest rate in Hat Yai followed by Songkhla City, Nakhon Si Thammarat North Coast and Phuket (super-district 27, 26, 21 and 18).

Table 3.6 Distribution of infectious disease (excluding HIV/AIDS) hospital death rate per 1000 of patients aged 40 and over, by super-district

Code	Other ID		Septicemia		Code	Other ID		Septicemia	
	Count	Rate	Count	Rate		Count	Rate	Count	Rate
1	52	0.7	121	1.6	20	31	0.5	93	1.6
2	57	0.9	121	1.9	21	31	0.5	52	0.8
3	49	1.1	75	1.7	22	27	0.3	73	0.8
4	46	0.6	91	1.3	23	26	0.4	49	0.7
5	61	0.8	125	1.7	24	34	0.6	57	1.0
6	29	0.6	74	1.5	25	32	0.5	66	1.1
7	31	0.5	75	1.3	26	32	0.6	104	2.0
8	59	0.8	76	1.0	27	90	1.0	249	2.7
9	29	0.4	84	1.3	28	27	0.5	59	1.1
10	33	0.6	81	1.4	29	41	0.6	93	1.5
11	39	0.5	184	2.2	30	30	0.5	76	1.2
12	14	0.3	60	1.2	31	28	0.4	76	1.1
13	20	0.4	67	1.3	32	24	0.4	48	0.9
14	40	0.5	119	1.4	33	19	0.5	31	0.9
15	30	0.4	88	1.0	34	24	0.4	93	1.5
16	16	0.5	46	1.4	35	29	0.6	70	1.5
17	30	0.6	54	1.1	36	17	0.3	17	0.3
18	51	0.8	135	2.0	37	22	0.4	32	0.6
19	26	0.5	64	1.3	38	12	0.3	12	0.3

Death rates from above table can be shown as in Figure 3.1 in order to make it easier to understand the distribution of deaths according to disease group and super-district.

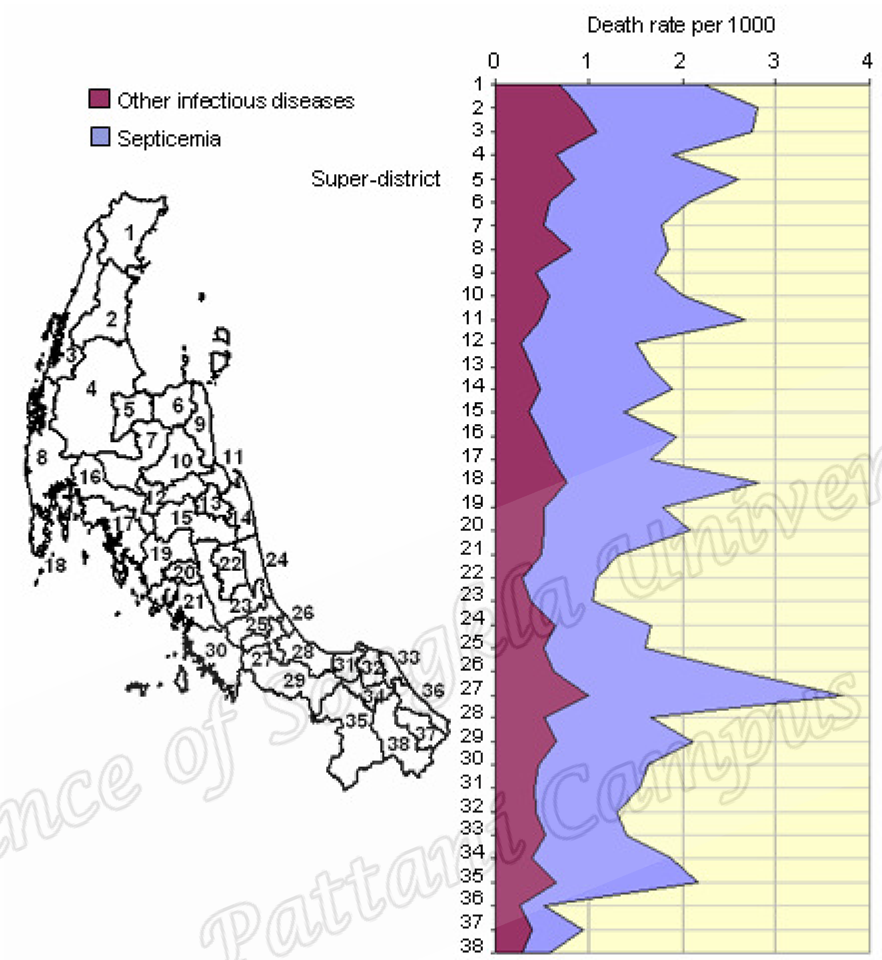

Figure 3.1 Distribution of death rates, by other infectious diseases group and super-district

In this analysis two models were used: one model for HIV/AIDs and another model for other infectious diseases. Those who died from HIV/AIDS aged 15 and over were included in the modeling. There were not many deaths from HIV/AIDS among persons aged less than 15. Two categories were formed by considering septicemia separately from other infectious diseases. The model for other infectious disease included persons who died in hospital and aged 40 and over, because there were not many deaths from septicemia for those aged under 40 and the recording of infectious disease as cause of death was unreliable outside hospital.

Table 3.7 Regression coefficients and standard errors for super-district effects based on the negative binomial GLM fitted to HIV/AIDS mortality in Southern Thailand

Factors	Coefficient	SE	Factors	Coefficient	SE
Constant	-0.85	0.97	29	-0.60	0.13
Super-district			30	-0.68	0.13
1	0.00		31	-0.72	0.13
2	-0.38	0.14	32	-1.47	0.22
3	-0.05	0.21	33	-0.82	0.35
4	-0.43	0.11	34	-0.76	0.14
5	-0.19	0.10	35	-0.96	0.23
6	-0.03	0.18	36	-1.83	0.22
7	-0.35	0.13	37	-0.91	0.16
8	-0.14	0.11	38	-1.36	0.28
9	-0.08	0.13	Season		
10	-0.17	0.18	Jan – Feb	0.00	
11	-0.12	0.10	Mar - Apr	0.02	0.05
12	-0.33	0.21	May - Jun	0.08	0.05
13	-0.01	0.21	Jul - Aug	-0.03	0.05
14	-0.01	0.10	Sep - Oct	-0.06	0.05
15	-0.13	0.11	Nov - Dec	-0.18	0.05
16	-0.46	0.31	Sex		
17	-0.51	0.16	Male	0.00	
18	0.16	0.10	Female	-0.58	0.32
19	-0.52	0.19	Hospital		
20	-0.60	0.17	Outside	0.00	
21	-0.49	0.14	Inside	-0.11	0.04
22	-0.17	0.11	Autoregressive		
23	-0.39	0.11	Lag 1	0.15	0.01
24	-0.23	0.23	Lag 2	0.14	0.01
25	-0.27	0.14	Lag 3	0.09	0.01
26	0.05	0.18	OD Lag 1	0.49	0.43
27	-0.37	0.15	F-M Lag 1	0.01	0.40
28	-0.75	0.21	M-F Lag 1	0.10	0.35

The coefficients and confidence intervals from the negative binomial GLM fitted to HIV/AIDS for each district in Table 3.7 can be plotted as shown in Figure 3.2. The graph shows that death from HIV/AIDS decreased from north to south. The lowest death rate from HIV/AIDS appeared in Pattani, Yala and Narathiwat which were statistically significantly different from the baseline (Chumphon North, super-district 1).

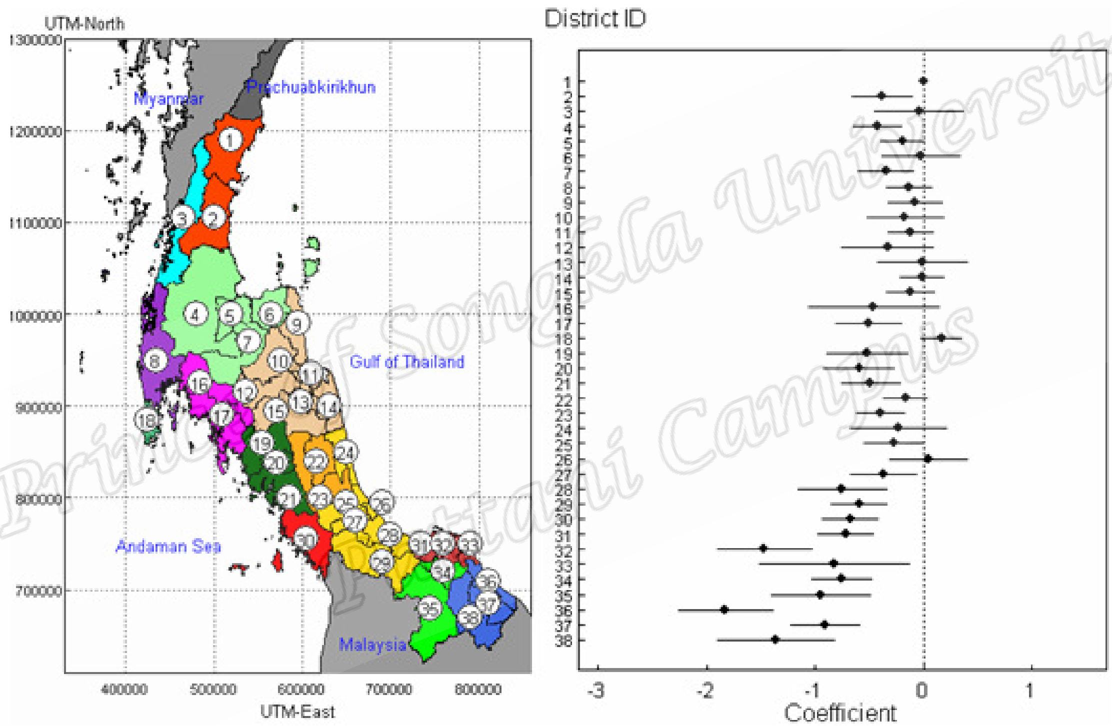

Figure 3.2 Plot of regression coefficient and confidence interval from negative binomial GLM fitted to HIV/AIDS mortality for each super-district

The observed and fitted values plot and residual plot from Figure 3.3 show that the model provided a reasonable fit.

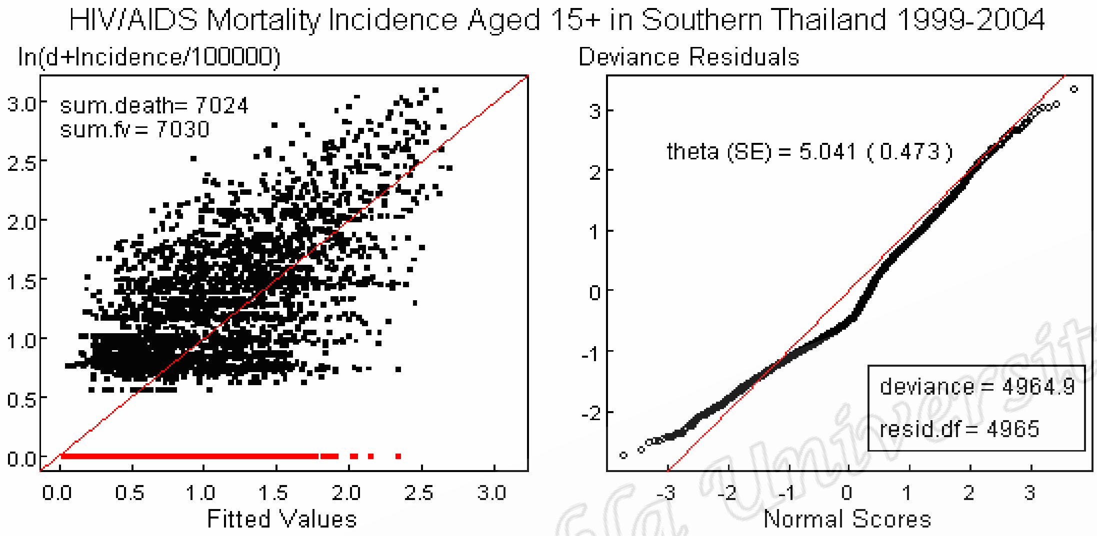

Figure 3.3 Observed and fitted plot (on left panel) and deviance residual plot (on right panel) from negative binomial GLM fitted to HIV/AIDS mortality

Table 3.8 Regression coefficients and standard errors for super-district effects in negative binomial GLM fitted to other infectious diseases mortality in Southern Thailand

Factors	Coefficient	SE	Factors	Coefficient	SE
Constant	-1.89	0.15	27	0.46	0.12
Super-district			28	-0.14	0.15
1	0.00		29	-0.02	0.14
2	0.25	0.13	30	-0.25	0.15
3	0.30	0.14	31	-0.29	0.15
4	-0.11	0.14	32	-0.38	0.16
5	0.16	0.13	33	-0.28	0.18
6	0.00	0.15	34	-0.07	0.14
7	-0.13	0.15	35	0.05	0.15
8	-0.08	0.14	36	-1.17	0.21
9	-0.24	0.15	37	-0.67	0.18
10	-0.05	0.15	38	-0.98	0.23
11	0.19	0.13	Infectious disease		
12	-0.27	0.16	Other ID	0.00	
13	-0.17	0.15	Septicemia	0.09	0.05
14	-0.13	0.14	Season		
15	-0.41	0.14	Jan-Feb	0.00	
16	0.01	0.17	Mar - Apr	-0.02	0.07
17	-0.13	0.16	May - Jun	-0.03	0.07
18	0.26	0.13	Jul - Aug	0.01	0.06
19	-0.09	0.15	Sep - Oct	-0.26	0.07
20	-0.02	0.14	Nov- Dec	-0.17	0.07
21	-0.37	0.16	Autoregressive		
22	-0.65	0.15	Lag 1	0.08	0.01
23	-0.54	0.16	Lag 2	0.01	0.01
24	-0.22	0.15	Lag 3	0.04	0.01
25	-0.25	0.15	OD Lag 1	0.81	0.05
26	0.19	0.14			

The coefficients and confidence interval from negative binomial GLM fitted to other infectious diseases for each district in Table 3.8 can be plotted as shown in Figure 3.4. The graph shows that deaths from other infectious disease decreased from north to south. The lowest death rate from other infectious diseases appeared in Pattani, Yala and Narathiwat which were statistically significantly different from the baseline.

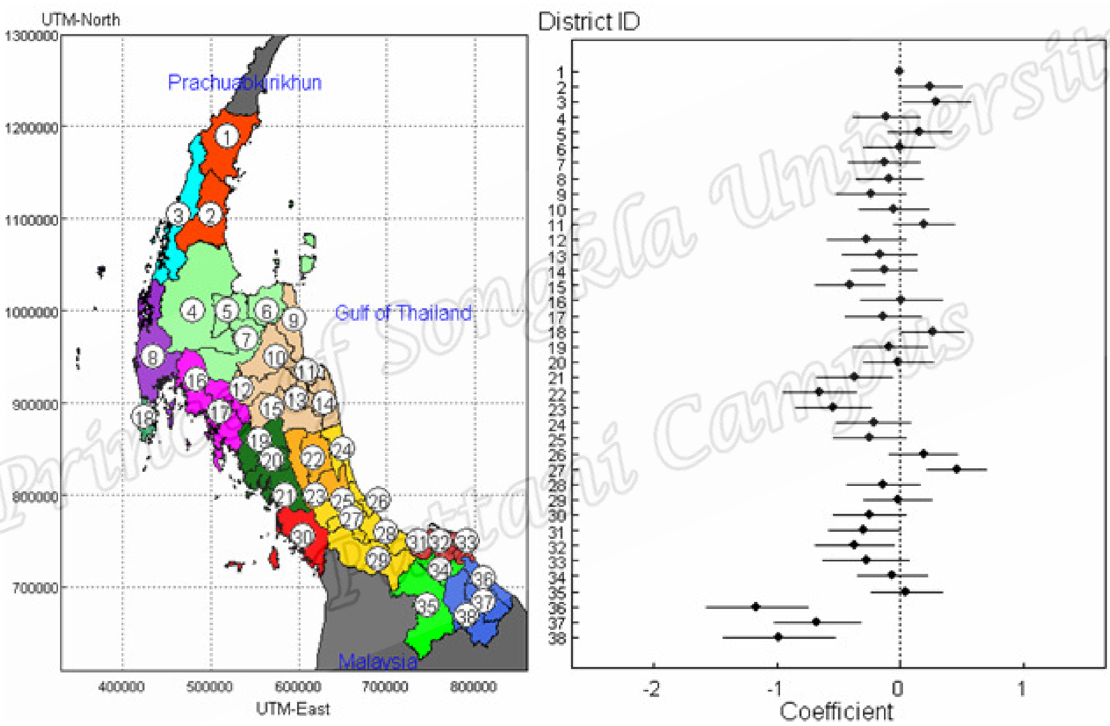

Figure 3.4 Plot of regression coefficient and confidence interval from negative binomial GLM fitted to other infectious disease mortality for each super-district

The observed and fitted values plot, and residual plot, from Figure 3.5 show that the model provided a reasonable fit.

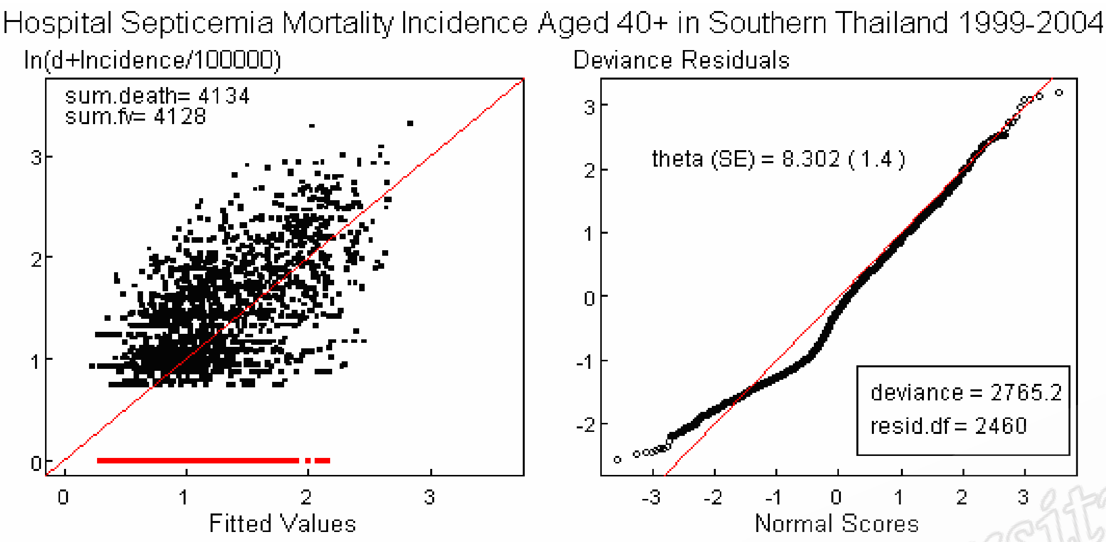

Figure 3.5 Observed and fitted plot (on left panel) and deviance residual plot (on right panel) from negative binomial GLM fitted to other infectious disease mortality

3.1.4 Further comments

In this study, autocorrelation terms were taken into account by adding three lag terms and spatial correlation (other district lag 1) into the negative binomial model. The GEE methodology, which was introduced by Liang and Zeger (1986), is one of the other models that we recommend to use for analyzing correlated outcome. Using this model the lag terms are not necessary to create and include into the model.

3.2 Manuscript II

3.2.1 Abstract

This study investigated length of stay (LOS) for patients who died in hospital in Southern Thailand, with respect to principal diagnosis and demographic, geographic and hospital size factors. Data of 40,498 mortality cases obtained from the Ministry of Public Health from 167 hospitals in 14 provinces of Southern Thailand between

October 2000 and September 2003, with information on age, gender, principal diagnosis, provinces and hospital size, were analyzed. Logistic and linear regressions with log-transformed LOS were used to analyze the data. Patients with injuries as principal diagnosis had shortest LOS, whereas cancer patients had the longest LOS. Older patients, particularly females, had higher LOS for all diagnoses. LOS increased with hospital size, except in the North and North West. Small hospitals in the South West region had the lowest LOS, whereas large hospitals in the North West had the highest. The highest proportion of bed days (11.2%) occurred for males aged less than 60 diagnosed with infectious diseases. Males aged less than 60 diagnosed with injuries and digestive diseases, and aged at least 60 diagnosed with COPD, and aged less than 60 diagnosed with infectious diseases, accounted for more than double those for female patients in the same disease groups. Both logistic regression with LOS at least 1 week as the outcome and linear regression on appropriately log transformed LOS gave consistent results.

3.2.2 Rationale

Length of hospital stay is the important indicator of hospital resources utilization and the cost of medical care. Different diseases result in differences in length of hospital stay. Length of hospital stay is also different according to patient's demographic characteristics, region and hospital size. Investigating the pattern of length of hospital stay for different diseases, patient demographic characteristics, regions and hospital sizes can identify the categories that are heavy users of hospital resources. There are many statistical methods for analyzing LOS. LOS always faces the problem that many cases of zero days stay occur with few extremely long LOS. The assumptions of linear model are violated by positively skewed LOS. Therefore, in this study we investigated the most appropriate methods for analyzing LOS and providing reasonable results.

3.2.3 Result

40,498 deaths occurred in hospitals in Southern Thailand during the period 2000-2003. The majority were males and those aged 60 and over accounted for 43.2%. Most of the deaths occurred in medium or large hospitals with size greater than 60 beds. Over the period 2000-2003 overall hospital death rates were fairly stable, though a little higher in the most recent year. Apart from other diseases group, the highest rate of death was from cardiovascular disease, followed by infectious diseases and then injuries. The region with the highest death rate was Nakhon Si Thammarat. Most deaths followed short LOS, less than 7 days.

Table 3.9 Descriptive results of all factors for in-patients who died in hospital

Variable	Code	Number	Percent
Gender	Male	24,621	60.8
	Female	15,877	39.2
Age group	0 – 29	9,910	24.5
	30 – 59	13,111	32.4
	60 - 74	9,927	24.5
	75+	7,550	18.6
Hospital bed size	≤ 60	2,677	6.6
	61 - 499	18,820	46.5
	500+	19,001	46.9
Fiscal year	2000	9,413	23.2
	2001	8,762	21.6
	2002	10,349	25.6
	2003	11,974	29.6

Table 3.9 Cont.

Variable	Code	Number	Percent
Principal diagnosis	Injuries	5,698	14.1
	Cardiovascular disease	8,462	20.9
	Septicemia	3,030	7.5
	Other infectious disease	6,261	15.5
	Digestive disease	2,186	5.4
	Chronic obstructive pulmonary disease	2,721	6.7
	Respiratory infection	2,375	5.9
	Cancer	3,163	7.8
	Other diseases	6,603	16.3
Region	North	4,051	10.0
	North West	5,591	13.8
	Surat Thani	5,512	13.6
	Nakhon Si Thammarat	7,151	17.7
	Central South	6,868	17.0
	South West	4,076	10.1
LOS	< 7 days	27,990	69.1
	7+ days	12,508	30.9

There were two models used for analyzing the data: logistic regression and linear model. For logistic regression, length of hospital stay was divided into two groups. They were LOS less than 7 days and LOS at least 7 days. The combination variable of principal diagnosis with gender and age group and the combination variable of hospital size and region were included into the model. For the linear regression model LOS was considered as a continuous outcome with natural log transformation adding 1 to zero days stay. The results of the logistic model and the linear model are shown in Table 3.10 and Table 3.11.

Table 3.10 Coefficients and standard errors from logistic regression

Disease	Sex	Age	Coef.	SE	Disease	Sex	Age	Coef.	SE
Constant			-1.74	0.06	RI	Male	<60	1.02	0.11
Injuries	Male	<60	0.00				60-74	1.50	0.11
		60-74	0.78	0.12			75+	1.94	0.11
		75+	1.10	0.15		Female	<60	1.25	0.12
	Female	<60	0.14	0.10			60-74	1.70	0.14
		60-74	0.78	0.15			75+	1.82	0.12
		75+	1.21	0.15	Cancer	Male	<60	1.66	0.09
CVD	Male	<60	0.23	0.08			60-74	1.95	0.09
		60-74	0.73	0.07			75+	1.96	0.12
		75+	0.91	0.08		Female	<60	1.97	0.10
	Female	<60	0.56	0.09			60-74	2.10	0.11
		60-74	0.76	0.08			75+	2.46	0.15
		75+	1.04	0.08	Other	Male	<60	0.96	0.07
SP	Male	<60	0.45	0.10			60-74	1.54	0.10
		60-74	1.01	0.12			75+	1.69	0.12
		75+	1.13	0.13		Female	<60	1.03	0.07
	Female	<60	0.39	0.11			60-74	1.57	0.10
		60-74	0.85	0.11			75+	1.96	0.11
		75+	1.14	0.12	Region	Hospital-size			
OID	Male	<60	1.17	0.06	North	S		-0.72	0.22
		60-74	1.35	0.13		M		-0.19	0.08
		75+	1.30	0.17		L		-0.21	0.05
	Female	<60	1.19	0.07	ST	S		-0.68	0.12
		60-74	1.29	0.17		M		-0.69	0.11
		75+	1.50	0.20		L		-0.20	0.04
DD	Male	<60	0.68	0.10	NW	S		0.20	0.16
		60-74	1.23	0.12		M		0.03	0.05
		75+	1.35	0.14		L		0.25	0.05
	Female	<60	1.39	0.14	Nakhon	S		-0.50	0.11
		60-74	1.45	0.14		M		-0.27	0.08
		75+	1.38	0.15		L		0.00	
COPD	Male	<60	0.85	0.12	SW	S		-1.02	0.15
		60-74	1.62	0.09		M		-0.22	0.05
		75+	1.60	0.09	Central	S		-0.53	0.10
	Female	<60	0.89	0.14		M		-0.05	0.05
		60-74	1.50	0.13		L		0.02	0.05
		75+	1.59	0.14	SE	S		-0.85	0.10
						M		-0.17	0.04

S = Small, M = Medium, L = Large

Table 3.11 Coefficients and standard errors from linear regression

Factors			Coef.	SE	Factors			Coef.	SE
Constant			0.70	0.03	RI	Male	<60	0.57	0.06
Injuries	Male	<60	0.00				60-74	0.91	0.07
		60-74	0.25	0.07			75+	1.31	0.07
		75+	0.59	0.09		Female	<60	0.74	0.07
	Female	<60	0.06	0.05			60-74	1.16	0.09
		60-74	0.37	0.09			75+	1.25	0.07
		75+	0.63	0.09	Cancer	Male	<60	1.08	0.05
CVD	Male	<60	0.11	0.04			60-74	1.30	0.05
		60-74	0.40	0.04			75+	1.37	0.08
		75+	0.53	0.05		Female	<60	1.31	0.06
	Female	<60	0.33	0.05			60-74	1.40	0.07
		60-74	0.48	0.04			75+	1.58	0.09
		75+	0.63	0.04	Other	Male	<60	0.51	0.04
SP	Male	<60	0.25	0.05			60-74	1.05	0.06
		60-74	0.53	0.07			75+	1.05	0.08
		75+	0.66	0.08		Female	<60	0.51	0.04
	Female	<60	0.20	0.06			60-74	1.04	0.06
		60-74	0.56	0.07			75+	1.29	0.07
		75+	0.73	0.07	Region	Hospital-size			
OID	Male	<60	0.73	0.03	North	S		-0.32	0.12
		60-74	0.88	0.08		M		-0.12	0.05
		75+	0.89	0.11		L		-0.24	0.03
	Female	<60	0.75	0.04	ST	S		-0.46	0.07
		60-74	0.79	0.11		M		-0.33	0.06
		75+	0.83	0.13		L		-0.14	0.03
DD	Male	<60	0.37	0.05	NW	S		0.02	0.10
		60-74	0.69	0.07		M		-0.04	0.03
		75+	0.88	0.09		L		0.15	0.03
	Female	<60	0.78	0.09	Nakhon	S		-0.29	0.07
		60-74	0.95	0.09		M		-0.19	0.05
		75+	1.00	0.10		L		0.00	
COPD	Male	<60	0.45	0.07	SW	S		-0.69	0.08
		60-74	1.00	0.05		M		-0.17	0.03
		75+	1.07	0.06	Central	S		-0.38	0.06
	Female	<60	0.45	0.08		M		-0.04	0.03
		60-74	0.94	0.08		L		0.00	0.03
		75+	1.11	0.09	SE	S		-0.56	0.06
						M		-0.12	0.02

3.2.4 Further comments

In this study zero day stays were assumed as not any duration spent in hospital but actually the patients did spend some time there. Therefore, treating zero days stay as zero does not represent the real situation. We recommend that the methods to impute data for zero day counts should be investigated in order to improve the residual plot of the model. Co-morbidity of diseases affects LOS for an individual. The inclusion of co-morbidity should be taken into account in future studies.