Chapter 1

Introduction

This study analyses the geographical pattern of all-cause and cause-specific mortality from the national vital registration system in Thailand for the years 1999-2001. Appropriate statistical graphs and models were developed to investigate the mortality pattern by gender and age group.

1.1 Background

Basic Mortality Measurement and Uses of Mortality data

Prince of Songkla University Pattani Campus

Mortality is one of the important indicators for measuring population health. The main data source for national mortality is death certificates for countries with well established death registration system. The aggregated data from registered deaths are used to calculate mortality rates that can be manipulated in various ways to show general and specific health indicators and trends. The commonly used varieties of mortality rates are: crude; age-standardized; cause-specific; infant and perinatal; maternal; and the standardized mortality ratio. Every kind of mortality rate has its uses and limitations.

The *crude death rate* is calculated by dividing the number of deaths that occur in a population during a given year or period by the average number of person-years lived by the population during that period. The crude death rate does not take account of the age distribution of the population. *Age-specific death rates* are used to adjust for differences in age distributions between populations. The age-specific death rate is computed by dividing the number of deaths in specific age group by the average number of person-years in the same age group over a particular period.

The *age-standardized mortality rate* is the expected rate calculated under the age distribution of a standard population. This adjustment is used when populations in the study have different age distributions.

*Cause-specific mortality rate*s are used in particular studies on specific disease or conditions, such as HIV/AIDS, cancer, stroke, injuries, for comparing the problem in different populations, regions, and time periods.

Infant, perinatal, and maternal mortality rates are the important indicators for overall development of the country, as they are included in the Millennium Development Goals (MDGs) indicators. The *infant mortality rat*e is the probability of a child born in a specific period dying before reaching the age of one, if subject to age-specific mortality rates of that period (WHO, 2008).

The *standardized mortality ratio* (SMR) is the ratio of the number of deaths observed in a specified population to the number that would be expected if that population had the same mortality rate as a standard population. The SMR is a very useful statistic, often used to compare mortality in two or more groups, such as the sub-national study. It can be used to identify geographic areas in the country with higher or lower mortality than the expected value.

Proportional mortality is a simple and potentially useful way of portraying the burden of a specific disease within a population.

Mortality levels and trends provide important information on the many serious diseases and injuries that affect a nation. Studies of the trends in mortality and related

Prince of Songkla University Pattani Campus

statistics can help to explain how the health status of the population is changing and assist in evaluating the health system.

The life table provides overall assessment of country's mortality, and the age-specific death rates are used for life expectancy calculation. An increase in the death rate of a specific disease will be an early indication of a problem, whereas a decrease rate may help confirm that the intervention programs for known problems are effective. In addition, it has been shown that some groups in the population have markedly higher death rates from some causes of death, or overall, and this can guide planning as well as providing information about equity in a society and its health system.

National vital registration system and vital statistics

The main data sources for mortality statistics is vital registration system. Thailand's vital registration system has been implemented since 1917. According to the civil registration law, every death must be registered within 24 hours of being witnessed.

Before 1996, there were three parts of the death certificate, labeled as "Tor Ror 4", and submitted to different person. The first part was given to the informer. The second part was sent to the Bureau of Registration Administrator, Ministry of Interior, for reporting the overall mortality statistics, while the third part was sent to the Ministry of Public Health for providing the report on age-specific and cause-specific mortality.

The computerized system for civil registration was started in 1995. The death certificate was divided into two parts. The first part was kept by the informer for the funeral process. The second part was submitted to the Bureau of Registration Administrator, Ministry of Interior by electronic data from the district office where the computer network was available, and by hard copy for the district office not ready

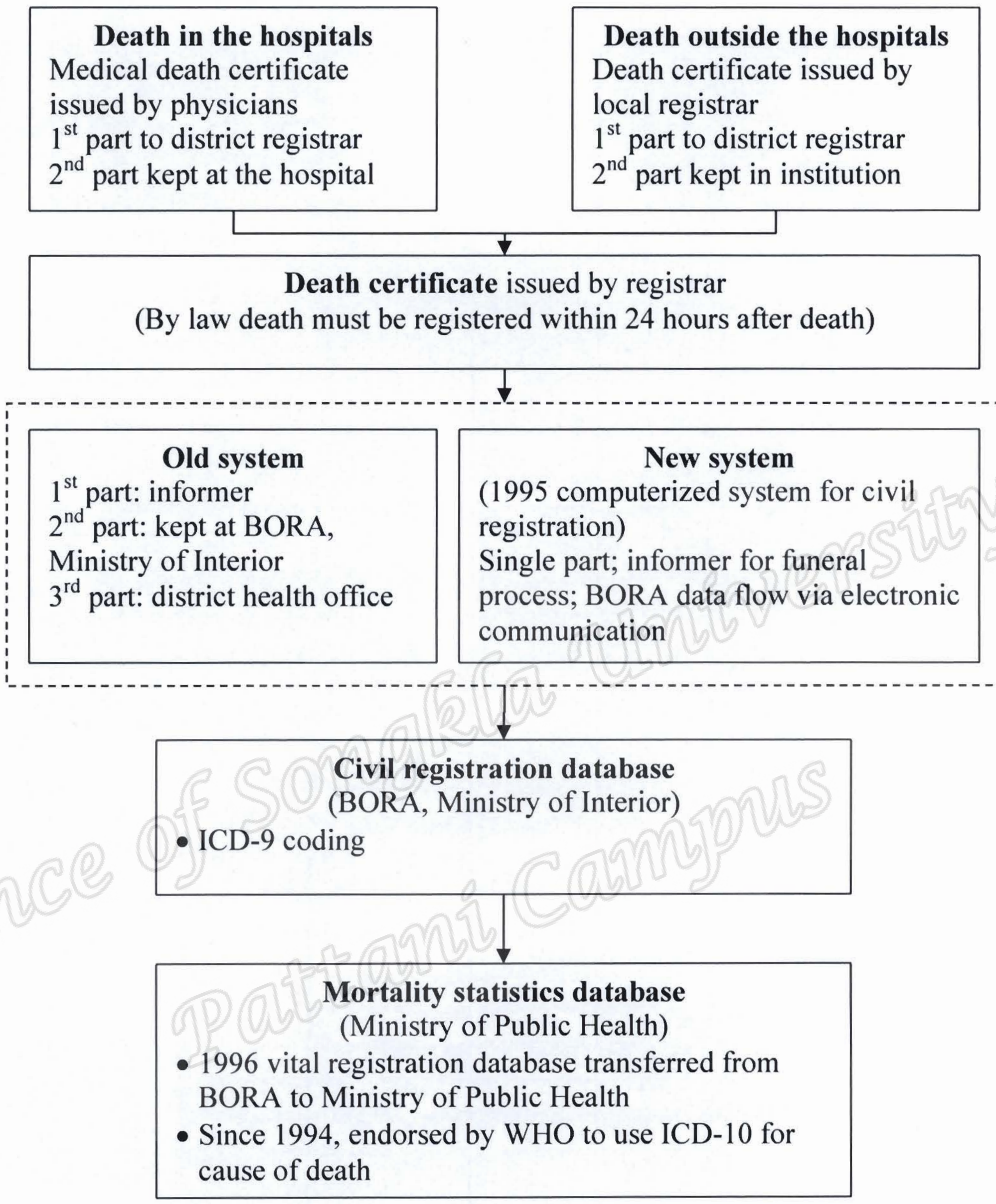
Prince of Songkla University Pattani Campus

for the computer online system. All registered records were routinely transferred from the Bureau of Registration Administrator (BORA), Ministry of Interior to Ministry of Public Health since 1996. These records were coded as cause-of-death using the tenth International Classification of Diseases (ICD-10) by the Bureau of Policy and Strategy, Ministry of Public Health. Finally, the public health statistics report is provided annually. Figure 1.1 summarizes the data flow of death registration system in Thailand.

Different datasets from the vital registration system have been used for different purposes. Age-specific mortality rates have been used for life table calculation (Bundhamcharoen et al, 2002; The Thai Working Group on Burden of Disease and Injury, 2007; Institute for Population and Social Research, 2010). The age-specific deaths by causes for males and females have been used for estimation of fetal burden (Years of Life Lost--YLL) in the national burden of diseases and injury study (Bundhamcharoen et al, 2002; The Thai Working Group on Burden of Disease and Injury, 2007).

Prince of Songkla University
Pattani Campus

The proportions of deaths from specific causes to overall deaths are used to rank the cause of the problem in order to monitor and introduce the disease control and prevention programs. These percentages of cause-specific deaths are found in many publications including the national public health statistics reports (Ministry of Public Health, 1990-2006), burden of disease and injury reports (Bundhamcharoen et al, 2002; The Thai Working Group on Burden of Disease and Injury, 2007).



Source: Public Health Statistics A.D. 2003 (Ministry of Public Health, 2004)

Figure 1.1 Data flow of death registration system in Thailand

Several studies have been concerned with the quality of mortality data from the registration system in Thailand (see, for example, Prasartkul and Vapattanawong, 2006; Rukumnuaykit, 2006; Tangcharoensathien et al, 2006; Mathers et al, 2005).

Prince of Songkla University Pattani Campus

1.2 Literature Review

Mortality models

One of the most popular mortality models is the Lee-Carter (LC) model, proposed by Lee and Carter (1992). Many extensions of the LC model have been proposed (see, for example, Lee and Miller, 2001; Booth et al, 2002; Hyndman and Ullah, 2007; De Jong and Tickle, 2006). It has been applied to populations in many countries, for example Australia (Booth et al, 2002) and the seven most economically developed countries (G7) (Tulkapurkar et al, 2000).

Because the number of deaths is a non-negative integer valued random variable, Poisson regression models have been used to analyse mortality data. Lovett et al (1986) applied the Poisson regression model to analyze deaths from ischaemic heart disease among young adults in the county boroughs of England and Wales during 1969-1973, and they concluded that when the number of deaths is small there are both theoretical and practical advantages in using Poisson regression to analyse mortality data. Frome et al (1990) analyzed the mortality of 28,008 white male employees who had worked in Oak Rige, Tennessee, during World War II using Poisson regression methods to evaluate the influence of duration of employment, facility of employment, socioeconomic status, birth year, period of follow-up, and radiation exposure on cause-specific mortality. Brouhns et al (2002) analyzed Belgian mortality data using a generalized linear model, substituting the Poisson random variation for the number of deaths by an additive error term on the logarithm of mortality rates. Delwarde et al (2006) used a Poisson log-bilinear projection model for mortality data in the G5 countries (France, Germany, Japan, UK and US).

Prince of Songkla University Pattani Campus

The predicted European age standardized mortality rates (EASMRs) and numbers of deaths for the period 2001–2015 have been estimated by O'Lorcain and Comber (2004) using Poisson regression models of Irish lung cancer mortality data for the years 1954–2000.

Lim and Choonpradub (2007) applied Poisson and negative binomial lagged observation-driven regression models to investigate the regional and temporal patterns of death reported from HIV/AIDS and other infectious diseases 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. They found that the hospital mortality rates started to increase sharply in 2003 - 2004. The 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 age 40 and over started in 2003-2004, particularly among persons reported as dying from septicemia.

Prince of Songkla University
Pattani Campus

Regional variations of mortality

Studies on the regional variations in mortality give insight on how mortality differs across a country and worldwide. Some studies investigate all-cause mortality for the whole population, while some studies focus on specific-cause mortality, such as cardiovascular diseases, cancers, traffic accidents, suicide, and homicide.

Langford and Bentham (1996) attempted to establish the magnitude of regional differences in mortality rates in England and Wales using the techniques of multi-level modeling. Standardized mortality rates (SMRs) for males and females under 65 for 1989–1991 in local authority districts are grouped into categories using the

ACORN classification scheme. The Townsend Index is included as a measure of social deprivation. Using a cross-classified multi-level model, it is shown that region accounts for approximately four times more variation in SMRs than is explained by the ACORN classification.

Linear regression was used by Kindig et al (2002) to examine the factors associated with age-adjusted death rates in 366 metropolitan and non-metropolitan areas of the United States for 1990–92. They found that analysis explained 71% of this variance. Factors with the strongest independent positive association were ethnicity (African-American), less than a high school education, high Medicare expenditures, and location in western or southern regions. Factors with the strongest independent negative associations were employment in agriculture and forestry, ethnicity (Hispanic) and per capita income.

Fulton et al (1978) analyzed the registered deaths from ischaemic heart disease and stroke of middle-aged (age group: 35-44, 45-54, 55-64 years) British men and women during 1969-1973, and used the 1971 census as the source of population data. A linear logistic regression models showed significant differences between the regions. They concluded that mortality from ischaemic heart disease and cerebrovascular disease was highest in the north and west of Britain.

The variation in the year of onset of ischemic heart disease mortality decline among 39 regions in Netherland was studied by Mackenbach et al (1989) using loglinear regression method. A quadratic regression model fitted the observed numbers of male deaths in each region in 1950-84, whereas this model proved inadequate to describe female mortality.

Prince of Songkla University Pattani Campus

Filate et al (2003) studied cardiovascular disease and ischemic heart disease (IHD) age-standardized mortality rates in Canada during 1995-1997. Linear regression analyses and analyses of variance were employed to identify relationships between these health region characteristics and CVD and IHD mortality rates. They found the significant regional variations in age-standardized CVD and IHD mortality were noted both at the provincial/territorial level and the health region level.

Muller-Nordhorn et al (2008) analyzed the regional variation in cardiovascular mortality within Europe from data provided by Eurostat and the National Statistical Offices of the respective countries. Age-standardized mortality rates were calculated for ischaemic heart disease (IHD) and cerebrovascular disease (CVD). For age-standardization, the European standard population was used. Rates were calculated both on a national and on a regional level. There was a clear north–east to south–west gradient in mortality from IHD. With regard to CVD, a 'green' circle of reduced mortality in the centre of Western Europe including countries such as France and the northern regions of Italy and Spain. Countries with higher mortality rates, such as the Central and East European countries as well as some Mediterranean countries including Greece, Portugal, and certain regions in Southern Spain and Italy, surround this circle.

Nandram et al (2000) purposed precise and informative displays of geographic variation of age-specific chronic obstructive pulmonary disease (COPD) mortality rates for white males in United States. Bayesian hierarchical models used in their study were able to discern patterns in the data even in the presence of many zero counts.

Prince of Songkla University Pattani Campus

In Thailand, studies have investigated regional variations of overall and cause-specific mortality. The crude death rates from 1964-1965 to 1995-1996 by regions in Thailand using the results from the Survey of Population Change were presented in the study by Rukumnuaykit (2006). The northern and north-eastern regions experienced the highest death rates while the southern region recorded lower levels. The high death rates in these regions much improvement during the period 1964-1965 to 1995-1996, decreased by almost half of the original levels. In addition, a study by Lopez et al (1993) indicated that there were no significant differences in the proportions of ill-defined causes of death across regions in Thailand.

Faramnuayphol et al (2008) presented age-specific mortality rates and cause-specific and all-cause standardized mortality ratios at the district level using the national vital registration data in 2000. They found clustering of cause-specific SMR in a single region for liver cancer (in the upper northeast region) and chronic obstructive pulmonary disease (in the upper north region).

Prince of Songkla University Pattani Campus

Lotrakul (2005) examined the characteristics of suicide in the North of Thailand during 1998-2002 using the registered deaths from the Bureau of Policy and Strategy, Ministry of Public Health. The suicide rate in the North for both sexes was the highest among all regions of Thailand. Suicides were most prevalent in the upper northern region where high suicide rates occurred in Chiang-Mai, Lampoon, Phayao, Chiang-Rai and Phrae provinces.

An extended study by Lotrakul (2006) investigated suicide in Thailand during the 1998–2003 period found that the suicide mortality rates were highest in the northern region, followed by the central, south, and north-east regions. Suicide was most prevalent in the upper northern region where HIV infection might be related to the high prevalence.

de Mateo and Regidor (1996) compared the conventional technique, direct standardization method, and Poisson regression for estimating a standardized mortality rate. They concluded that a Poisson regression can be use as the alternative stratified analysis when the objective is to compare standardized mortality rates in relation to one or two variables.

The standardized (adjusted) mortality rates were used to compare geographical differences in mortality across the country. The two common techniques for calculating the standardized incidence/mortality rates are the direct and indirect methods. The direct method uses the population distribution while the indirect method uses specific rates to calculate the expected deaths and compare to the observed deaths.

Liu et al (2006) found that the direct standardization method provide inaccurate estimated rates and had very large standard errors for small-population states. In addition, the direct method cannot be used for the state with the empty categories. They concluded that the Poisson regression model can overcame the disadvantages of the direct standardization method for calculating state-level adjusted incident rates, especially for small states.

Prince of Songkla University Pattani Campus

1.3 Rationale and objectives

Information from population-based mortality statistics is used for the development of public health intervention programs and health care resource allocations. In Thailand, many studies on mortality have used descriptive statistics, whereas only a few statistical models have been used by specific groups of researchers. Appropriate statistical models and corresponding graphical methods need to be developed to study mortality data and to produce statistically valid summaries for decision makers.

The objectives of the present study are:

1. To improve the statistical models used for investigating the levels and patterns of overall mortality in Thailand.
2. To develop statistical models for analyzing the levels and patterns of cause-specific mortality in Thailand.
3. To develop appropriate graphical methods for displaying observed and fitted mortality patterns.

1.4 Roadmap of the present study

This thesis is organized as follows: Chapter 2 describes the data source, data management and analysis methods used in our study. Chapter 3 contains the graphical and statistical results from the analysis of Thai mortality data. Finally, the conclusions and discussion are addressed in Chapter 4.

Prince of Songkla University Pattani Campus