Estimating the Age-specific Mortality Rates for Female Population of 54 World's Most Populous Countries

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Thesis Title Estimating the Age-specific Mortality Rates for Female Population of 54 World's Most Populous Countries

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I hereby certify that this work has not been accepted in substance for any degree, and is not being currently submitted in candidature for any degree.

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ชื่อวิทยานิพนธ์ การประมาณอัตราการตายเฉพาะอายุของเพศหญิงใน 54 ประเทศของโลกที่มีประชากรสูงสุด

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บทคัดย่อ

หากไม่นำอัตราการย้ายถิ่นมาพิจารณา โครงสร้างประชากรในประเทศจะถูกควบคุมโดยอัตราการเกิดและอัตราตาย ด้วยการใช้แนวคิดนี้ การศึกษาในครั้งนี้ จึงใช้วิธีการคำนวณอัตราการออกไป (Departure rate) เพื่อประมาณอัตราการตายของเพศหญิงจากข้อมูลประชากร สำหรับการศึกษานี้ ใช้ข้อมูลจากเว็บไซด์สำนักสำรวจสำมะโนประชากรของสหรัฐอเมริกา (US census bureau) ที่ให้ฟรีจากเว็บไซต์ดังกล่าว เพื่อประมาณการตายจำเพาะอายุของประชากรเพศหญิงใน 54 ประเทศของโลกที่มีประชากรสูงสุด วิธีการนี้ ในลำดับแรกทำการประมาณอัตราการตายสำหรับประเทศที่มีอัตราการอพยพย้ายถิ่นออกน้อย จากนั้นนำอัตราการตายที่คำนวณได้นี้ไปประยุกต์ใช้กับประเทศที่มีอัตราตายเหมือนกัน ณ อายุที่สูงขึ้น ที่เหตุผลเพียงพอที่จะสมมติได้ว่าไม่มีการอพยพย้ายถิ่นในกลุ่มอายุนี้ ผลการศึกษาพบว่า ประเทศที่กำลังพัฒนาส่วนใหญ่มีอัตราการตายของทารกเพศหญิงในระดับที่สูง เช่นเดียวกับในเพศหญิงสูงอายุ แต่ประเทศที่พัฒนาแล้ว อัตราการตายจากการประมาณของเพศหญิง พบค่อนข้างสูงในกลุ่มหญิงวัยกลางคน แต่อัตราการตายต่ำกว่าทารก แบบจำลองทั้งสามแบบที่ใช้ในการพิจารณาการเบี่ยงเบนของอัตราตายนี้ พบว่าการประมาณการตายในเพศหญิงขึ้นอยู่กับความถูกต้องของข้อมูลประชากร ซึ่งนำไปสู่การประมาณการตายของเพศหญิง และการได้มาซึ่งตัวแบบ สรุปสุดท้าย วิธีการที่ใช้ในการศึกษานี้ มีข้อพิสูจน์ได้ว่าเป็นวิธีการที่ง่าย มีประสิทธิภาพ และมีความเหมาะสมในการนำมาประมาณการตาย โดยเฉพาะในประเทศที่มีการอพยพย้ายถิ่นต่ำ อย่างไรก็ตาม สำหรับประเทศที่มีการอพยพย้ายถิ่นสูง อิทธิพลของการอพยพย้ายถิ่นดังกล่าวจำเป็นต้องกรองออกด้วยการใช้ตัวแบบของอัตราการออกไป

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ABSTRACT

If net migration is negligible, the structure of the population of the country is regulated by the births and deaths rate. Using this common demographic concept, in our study, we adopted the departure rate method to estimate the female mortality from population data. For this study, we used the data from US census bureau which are freely available from the website of the US Census Bureau to estimate age-specific mortality rates for female populations in 54 of the world's most populous countries. The method involves first estimating mortality rates for those countries with negligible net age-specific emigration then applying these rates to countries with matching mortality at older ages where it is reasonable to assume that migration is negligible. The result showed that most of the developing countries had a higher female infant mortality as well as the older age of the female, but in the developed countries, the female mortality rate was estimated relatively higher in the middle age of female but lower in infant. All the three models of the deviations were found for the estimation of female mortality based on the accurate population data, which lead to the estimation of female mortality and derived the model. Finally method used in this study is proven to be easy, efficient and

appropriate in estimating mortality rates, especially for low net migration countries. However, the effect of migration must be filtered out by using the models of departure rates for high migration countries.

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List of the Abbreviations

ASMR	Age Specific Mortality rate
AIDS	Acquired Immune Deficiency Syndrome
GGB	General Growth Balance
HIV	Human Immune Virus
IDB	International Data Base
UK	United Kingdom
UN	United Nation
UNAIDS	United Nation for HIV/AIDS
UNFPA	United Nation for Population Found
UNICEF	United Nation for Child Education
USA	United State of America
WHO	World Health Organization

Chapter 1

Introduction

1.1 Background and rational

A distorting pattern of morbidity and death by place, time and cause are defined as mortality (WHO, 2015). It is a key indicator for the country to assess the health of the population (WHO, 2014). This population structure of the country has historically regulated by mortality (Berin *et al.,* 1989). Reducing mortality has been a major goal of population health by considerable investment in public health and medical technology system (Bangha *et al.*, 2013). These efforts help to dramatically declined in mortality and extending the longevity of human since last four decade (UN, 2015). Therefore, most of the developing countries were facing the enormous population growth due to the declining of mortality and increasing of fertility rate (Bangha *et al.*, 2013). This declining mortality was particularly more evident in the child and maternal mortality rates, which have been recorded since the 1960s (Liu *et al.,* 2015; WHO, 2015a). However, in the 21st century, female mortality still remains high in most of the African and Asian countries because of the poor behavior and socioeconomic status (Johri *et al.,* 2014; Bangha *et al.,* 2013). These factors have been associated with the mortality and the magnitude of the people's life (Gardner *et al.,* 2004). Throughout the world, a healthy lifestyle of children will give them improvement for their longevity (Currie *et al.,* 2015). Regarding children longevity, there have been uneven variations of mortality across the female children from developing to developed countries. Female children from the least developing countries have 15 times higher chances of not reaching their first fifth birthday compared to those from the developed countries

(Gostin *et al.,* 2013). Even if they live until their childbearing age, there are more than 100 times probability of death during labor (You *et al.,* 2011). Numerous studies have shown that female children from developing countries have 26 years shorter life expectancy than children from developed countries (You *et al.,* 2011; Gostin *et al.,* 2013).

Biologically, female children have a longer life span than male children and have more life advantages than males as well (Chaudhuri, 2015). Not only the biological difference in the longevity and mortality rate of both females and males across the different countries, it is also regulated by behavioral, and environmental factors (Stevens *et al.,* 2013). Nevertheless, the level of female infant mortality and adult mortality rates is high due to the unequal distribution of the fundamental human right services (Brinda *et al.,* 2015; Wisser *et al.,* 2014). Globally, millions of female have been dying due to inferior cares, son preferences, infectious diseases, and non-communicable diseases (Das *et al.,* 2003; Anderson *et al.,* 2010). In developed countries, cardiovascular, metabolic disorder conditions, neurological disease and endometrial carcinoma are the leading causes of death among the females during the postmenopausal period (Lindemann *et al.,* 2015; Pritchard *et al.,* 2013; Paul *et al.,* 2005). However, poor nutrition, maternal complication, breast cancer, cervical cancer, HIV/AIDS, malaria, injuries, and violence were largely contributed to female mortality in developing and least developing countries (Banda *et al.,* 2015; Huang *et al.,* 2016; Verma *et al.,* 2016).

Hence, gaining knowledge of female mortality can be beneficial in improving health policy, and thus improving the survival and extending the longevity of life for females. Furthermore, female mortality plays an important role for the demographic analysis, which helps to estimate and project the population, because females are more related to fertility than males (Upadhyay *et al.,* 2014). The results of the analysis can contribute to better handling of population growth, aging population, estimate and projection of population for any nation, where an age-specific characteristic of mortality is provided. Age-specific mortality is one of the important characteristics of mortality rate. Which can be simply calculated from the total number of deaths for specific age group in a specific geographic area and divided by the total number of population of the same age group and geographic area (Brown, 2003).

Previously, many researchers and international organizations estimated the age-specific mortality rate using different models and techniques from censuses, vital registrations, data and household surveys (Sharrow *et al.*, 2012; Luy *et al.*, 2012; Doctor *et al.*, 2012). Nevertheless, it was found that most of the developing countries and even some developed countries have been facing the lack of complete vital registration data and some demographic data (Luy *et al.*, 2012; Ahmed and Hill, 2011), important factors for calculating the age-specific mortality. To handle this issue, the census-based method was used for estimating the adult mortality from the stable population (Preston and Bennett, 1980), forward projection technique and modified growth balance equation (Bennett and Horiuchi, 1981; Preston *et al.,* 1980). The General Growth Balance (GGB) method, first used by Brass (1975), was applied for estimating the adult mortality with the fundamental assumption of the population experiencing the negligible migration during the inter-censal period (Bangha *et al.,* 2013). These different studies proved that age-specific mortality rate can be determined using only population data from census without death registrations, provided that the age distribution of a population is stable and determined by the mortality. Even though the census-based method can be implemented for determining the mortality rate, more than half of all countries in the world do not have their own census with high quality and acceptable data (Raftery *et al.*, 2013; US Census Bureau, 2016).

The nature of human mortality is the same throughout the world, but it becomes different for each country because of the discrepancies in economic development, resulting from the industrial revolution and sanitary progress. (Meslé and Vallin, 2010). Additionally, mortality patterns of the countries heavily depend on the mixture of other socioeconomic factors such as income and educational level. These differences of mortality rates were confirmed by the study comparing inequalities in morbidity and mortality between different countries in Western Europe (Mackenbach *et al.*, 1997). The effect of different mortality leads to inequalities of life expectancy at birth among countries, ranging from 34 years in Sierra Leone to 81.9 years in Japan (WHO, 2004).

From the aforementioned reasons, it can be seen that the estimation of common age-specific mortality rates for females from the groups of countries can help the development of understanding the mortality patterns for each included countries. However, there is a burden to gather complete information regarding vital registration from each country. US Census Bureau (2016) provides the accurate reliable population data by both census and projection for many countries. These data can be useful in population studies for many countries, and they are freely available to download from the website. Unfortunately, the database does not include the age-specific mortality data (US Census Bureau, 2016). Therefore, this study aimed to develop a simple and straightforward technique to use available dataset from US Census Bureau to estimate a model of female age-specific mortality rates for the countries and use them to explain the patterns of mortality for the countries of interest.

1.2 Objectives

The objectives of this studies are:

I. To estimate age-specific mortality rates for female population from population data.

II. To examining the age-specific female mortality patterns for 54 countries.

1.3 Scope of the study

This study focused for 54 countries' female mortality estimation and examining the patterns any individual age group. The outcome of the study is departure rate and determinants are age of females, year and countries. Retrospective data were collected from 1990 to 2015. The mortalities were estimated by using the departure rate method. Additionally, we investigated the distribution and trends of mortality among both developed and developing.

1.4 Literature reviews

Throughout the world, numerous study has been conducted to assess the mortality estimation using the different tools, technique and methods.

1.4.1 Estimation of mortality using population data

If the population experience the negligible migration, then the age- specific mortality rate and the intercensal survivorship is estimation by using the simple fact from two consecutive census that person now aged x who survives mortality will be aged $x+t$ in t year time. However, this method required the census data with malting no assumptions of age specific mortality, which provide the clear estimation of mortality in specific time period. In contrast, this method is more complicated for the high migration especially in the adult age of population. Because, this migration affect the mortality, mostly happen in the productive age of population. Therefore, Preston and Hill (1980), used the population data to estimate the completeness of mortality rate from the Korean females in the period of 1970-1975s. For this estimation, they used the approximately stable population data, and the results showed that, using the population data gave approximation estimation of Korean female's age-specific mortality rate from stable population. Another application for estimation of age specific mortality rate is reasonably based on the absence of vital registration systems. Hence, Bangha (2013) conducted a study in Cameroon based on General Growth Balance Method (GGB) and found that consistent result with overall mortality of adult was higher prior to emerging HIV/AIDS. Similar study conducted by the Doctor *et al.* (2012) with using the same technique for estimation of mortality in Malawi in the period of 1977 to 1987. However, in the method, they used the two different steps. First, interpolate to estimate at the four corners and in second step, they applies an arithmetic formula to the four corner values to estimate the mortality rates. The results from the study revealed the reduction of mortality was nearly fall for all age groups between 1977 and 1987 for males, while in the cases of females, the reduction rate was only for age groups 15–19 and 40–44 years. Also this differential may be related to maternal mortality in the childbearing age groups. Different to this finding, the 1987–1998 intercensal period showed that mortality increased at a higher rate in the age of 20 and above for males than females. However, the increase of mortality for females was much higher for the 1987–98 intercensal period than 1977–87s. Another study by Brass (1971), who develop the methods of growth balance equation for estimating the completeness of the mortality from these data, found that 59% of the mortality was estimated, whereas, Preston estimated 62% of morality in Sweden population (Preston *et al.*, 1980).

1.4.2 Estimation of mortality from direct and indirect technique

Estimation of the mortality from population data was derived by using the model life table. This model life table is a table shown the relationship between the levels of mortality with age groups and provided the complete information about the effect of age-specific mortality rate in any population (Wilmoth *et al.*, 2012). Which is commonly used for the estimating the mortality by describing the age-specific patterns of mortality of any population based on the empirical evidence. For the application of this model is consider for a certain assumption regarding the mortality pattern of population (Adlakha *et al.*, 1972). Furthermore, to construct this model, it used the graphical and two statistical procedures for age-specific patterns of mortality of each individual life table (Clark *et al.*, 2011). However, depending on availability of data, various researchers has been using the direct or indirect technique to estimate the mortality by age and sex in developing and developed countries. In developed countries, most of the studies used the direct techniques to estimate the mortality. Because, this technique obtains the complete birth and death data from vital statistics. However, in developing countries, the registration of birth rate is not complete due to the lack of functioning of the government, therefore, most of the researchers used the indirect technique to estimate the mortality rate (Preston *et al.*, 1984). Hill *et al.* (2000) applied the indirect techniques to estimate the mortality and the results revealed that this indirect technique provided the accurate and consistent information regarding the mortality by age and sex. Another study conducted by Bennett *et al.* (1981) in Argentina during the 1960s to 1970s by using the same technique and the result of the study agreed to a study conducted by Hill *et al*. (2000). The similar results were found in South Africa, where, this study used the both direct and indirect techniques to estimate the mortality (Bradshaw *et al.*, 2004). Using the same approaches in the less developing countries, Timaeus *et al.* (1991) found that both technique gave a similar estimation of mortality rate.

1.4.3 Estimation of maternal mortality

Maternal mortality remains a major public health concern among women in reproductive age group and it differs between the developed and developing countries (Betrán *et al.,* 2005). Meanwhile, maternal factors like low education, higher age, smoking, alcoholism and nutritional status are predictors for the maternal mortality in developing countries. Moreover, lack of antenatal checkup as well as postpartum hemorrhage is also the leading cause of the maternal mortality in developing countries (Brown *et al.*, 2013). However, numerous studies have focused on the global estimation of maternal mortality (Betrán *et al.,* 2005; Brown *et al.,* 2013).

Hill *et al.* (2007), conducted the study to estimate the global maternal mortality from 1990 to 2005 and found that 535,900 per 100,000 live births were estimated during that period. A study conducted by Alkema *et al*. (2016) found that the estimated maternal mortality declined by 44% from 1990 to 2015. Similarly, Nobuko *et al.* (2012) also conducted the study to estimate the global maternal mortality and found that 4 % was estimated to decline in Asian countries, less than 2% in sub-Saharan Africa, and under 1% in developed countries. Nevertheless, many studies were conducted in the developing countries (Sub-Saharan African, Southeast Asia) to estimate the maternal mortality rate, and found that Sub-Sharan, India, and Afghanistan faced the highest maternal mortality rate. It was estimated that, annually more than 50% of maternal mortality rate was occurring in these countries (Araya *et al.*, 2012). A study conducted in Ethiopia found that the high maternal mortality rate was estimated at 1995 with about 1,814 per 100,000 live births and 672 per 100,000 live births in 2011 (Berhan *et al.*, 2014). Another study was conducted in Afghanistan to estimate the maternal mortality and results showed that in 2010 maternal mortality was 327 per 100,000 live births (Rasooly *et al.*, 2014). Similarly, a study conducted in Nepal found that the estimated maternal mortality rate was 229 per 100,000 live births in 2011 (Bhandari *et al.*, 2014).

1.4.4 Estimation of mortality by using the model life tables

Currently, there has been different models of life tables used for the estimation of the mortality by age and sex (Lopez *et al*, 2000). However, a study was conducted in china by using the three model life table methods, namely Murray, Wilmoth and Clark models. The result of this study found that female mortality estimation had higher errors than the male, also the urban population also had more errors than the rural population. Therefore, the study concluded that this model life table system cannot accurately reflect the Chinese mortality rate (Hu *et al*, 2014). A study conducted by Wilmoth *et al*. (2012) estimated mortality from developing countries and the results showed that Demeny and United Nation (UN) model life table methods provided the complete and transparency estimation of the age specific mortality of the population.

1.5 Road map of this thesis

This thesis consists of the four chapters. This thesis organize the chapter, which are described in follow:

Chapter 1 comes under the background and the rational for the study, objectives, scope of the study and literature reviews. Chapter 2 is consists of methodology and statistical method for analyzed the data. Chapter 3 contains of the analysis and results. Finally, chapter 4 is the discussion conclusion and recommendation of the study.

Chapter 2

Methodology

This chapter is described the overall method for the study. The first part of this method covered the data source, data structure, data management and study areas, whereas second part consists of about statistical method.

2.1 Data Source

The data on female populations in 54 countries, from 1990 to 2015, were selected retrieved from the US Census Bureau (2016). High-quality acceptable data for applying demographic analysis and calculating the demographic indices were available from the source. However, only the world's most populous countries were selected here, and these 54 countries were chosen to equally represent Asia, Africa, and Western countries, with 18 countries for each region.

2.2 Data Structure

It is necessary to understand the variables of the data of this study. In this sub-group, we managed the data by using the different terms. In the data structure, data were structurally managed and classified into five sub-groups, namely Zone, Type, Age, CID, Cnam, and Year. Furthermore, these sub-headings also categorized by their nature. For example, Zone, it was divided into the four section namely, Af, As, Am, Eu. On extend of migration, Type also divided into three sub-groups of A, B and C, which indicated as the least moderate and high immigrant countries, respectively. The dataset consists the records of 89 age groups of the female population. These age groups are kept as a single year of age ranged from 0 to 84 years, after that, we categorized the age into 5 years of age interval up to 100 years. Cnam was managed as country name, where 54 countries were selected for the years 1990 to 2015 from the US Census Bureau website.

Table 1: Example of the data structure

CID	Zone	Type	Age	Cnam	Fem 90	Fem91	F00	.	Fem15
1	Af	A	0	Algeria	8092331	6787361	6864900	.	967341
2	As	A	1	Burma	8358208	8358208	9409379	.	102839
3	As	B	3	China	6787361	1930102	1966105	.	219237
4	Af	B	4	Egypt	7133026	8386326	211355	.	239812
5	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	Eu	B	.	Poland	.	.	.	.	.
.	Am	C		UK	7876342	9876342	1506342	.	18076342
54	Am	C	100+	USA	9876342	1287642	1544287	.	1987365

Where, Zone was divided into the four sub-group based on origin of countries and on extend of immigration Type was also classified in three group, which are given in below:

Fem90	Female population in 1990
Fem91	Female population in 1991
Fem00	Female population in 2000
Fem15	Female population in 2015
Cnam	Country name
CID	Country identity code
A	Least immigrants countries
Af	African countries
Am	America countries
As	Asian countries
B	Moderate immigrants countries
C	High immigrants countries
Eu	European countries

2.3 Study Areas

Table 2 shows the study areas. The areas in this study consists of 54 countries based on the most populous countries. In 54 countries, all countries were symmetrically divided into three regions namely, Africa, Asia and West countries and these three region equally bears the 18 countries.

Table 2: Selected countries for study

Zones			
Asia	**Africa**	**America**	**Europe**
Bangladesh	Algeria	Argentina	Australia
Burma	Angelo	Brazil	France
China	Burkina Faso	Canada	German
Japan	Cameroon	Columbia	Italy
Indonesia	Congo(K)	Mexico	Poland
India	Ethiopia	Peru	Romania
Iran	Egypt	USA	Russia
Malaysia	Ghana	Venezuela	Spain
Nepal	Ivory- Coast		Turkey
Pakistan	Kenya		UK
Philippines	Madagascar		
Sri-Lanka	Mozambique		
South-Korea	Morocco		
North-Korea	Nigeria		
Taiwan	South- Africa		
Thailand	Sudan		
Vietnam	Tanzania		
Uzbekistan	Uganda		

2.4 Variables

In this study, the outcome is departure rate of female population. Meanwhile, determinants are countries, age and years.

2.5 Approach to analysis plan

2.5.1 Data management and analysis approach

In this study data management and analysis comprised of the five steps. Figure 1 shows the data management. In this sub-section, first, we downloaded the raw data of female population from the US Census Bureau website and compiled than copy to these data into a spreadsheet. After this, data were managed and further classified based on the variable. For this study, age ranged from 0 to 100 years, where age from 0 to 84 years was shown individual age-group. After 84 to 100 years, we grouped the year by five-year interval up to 100 years. Countries were classified into zones, namely Af, Am, As, Eu, where Af= Africa, As=Asia, Eu=Europe, Am=America and other. Base on the extent of immigration, we categorized the countries into three groups, namely, A, B, C, which denoted as the least, moderate and higher immigration countries. Graphical procedure were used to examine the age-specific mortality rate. Statistical methods were used to estimate the age-specific mortality rate of females.

In fact, till this date, there is no complete availability of the mortality data in developing and even some developed countries (Hill *et al.*, 2009). It is due to no readily available resources to establish the routine vital registration and to conduct census regularly in developing countries. Similarly, in some of the developed countries, the resources are only allocated to the urban areas of the countries leaving the non-urban areas. Thus, unlike the non-urban areas of some developed countries with low-quality data (Luy *et al*., 2012). However, to compensate these lack of unavailability of mortality data, we used a simple method for estimation of mortality by using the population data, which are shown in Figure 1.

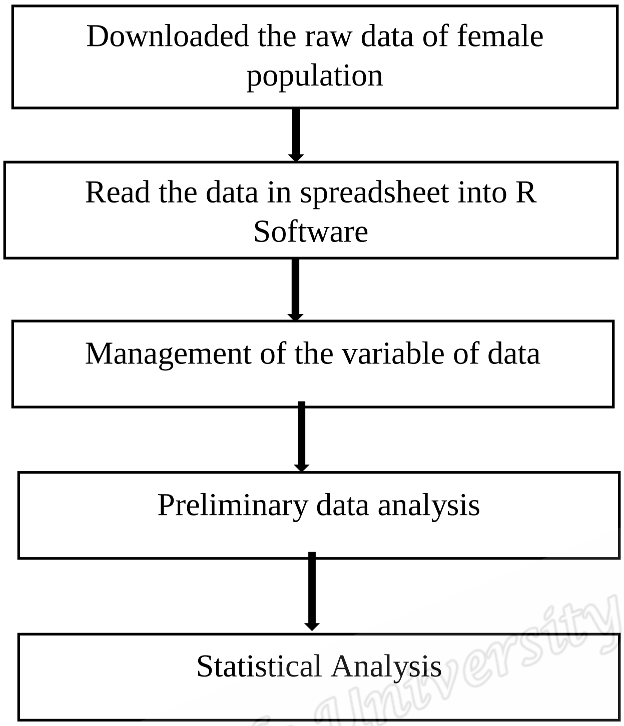

Figure1: Diagram of data management

2.5.2 Graphical procedure

First, we calculated the departure rate of all 54 countries and plotted the graphs to see the patterns of departure rates. After that, rearranged the countries into three patterns, namely good, wobbly and bad, which were based on migration. However, this method was considered with the population data with some assumptions of migration, which provides the clear estimation of mortality in specific time periods, if the age-specific population experience low migration. In contrast, this method is more complex for the high migration population, especially in the productive ages of females. Therefore, we categorized countries into three patterns. In the good patterns, all of the countries were reasonably assumed to that low migration countries. So, these countries were set for the sample of the estimation of age-specific mortality rate. From these baseline samples, median or model were developed and which helps to filter the migration.

In wobbly and bad patterns, departure rate in the productive age was due to the migration. It is believed that the immigration at the infant and old age the migration might not supposed migrants. So, in the wobbly and bad patterns, departure rate as the mortality rate was estimated in the infants and older age of females, especially at old age of females.

2.5.3 Statistical analysis

Previously, Coale and Demeny (1966) used age-specific population data to develop their classical model life tables for 192 countries, which were basically grouped according to geographical regions of the countries. The countries within one geographical region usually shared the same life table model. Nevertheless, there could be exceptions where a country from another region was included in the life table model out of its region: for example, Taiwan and Japan are in the West model (Coale and Demeny, 1966). Therefore, the concept of grouping population trends for countries by their regions and similarities was adopted in this study. This study was aimed to estimate the models for the mortality rates of each group of countries. However, the mortality rates were not calculated directly, but rather extracted from the departure rates. For this study, the departure rate was a combination of mainly mortality and migration. Firstly, this method began with the calculation of departure rate by using the simple method based on the population data of a single calendar year and a single age of the females. To estimate the age-specific departure rates for a female population, we used the following equation

$$\text{Departure rate} = 1 - \frac{N(x+1, t+1)}{N(x, t)}$$

Where, the function N(x, t) is the number of persons aged x in year t and N(x+1, t+1) is the number of persons age x+1in year t+1.

Subsequently, the estimated departure rates for each country were calculated by minimizing the values for all years. It was found that including the data from all years from 1990 to 2015 gave the results that required smoothing, and the better results were obtained by selecting fewer years. Therefore, only data for 1991, 1992, 1995, 1996, 2000, 2001, 2005, 2006 and 2008-2015 were consequently selected. The calculated departure rates were then plotted using a cubic root scale to make the variance homogeneity assumption more plausible. As the age ranges we used single ages from 0 to 85 years, and the departure rates for all countries were grouped by patterns, based on the level of fluctuations in the plots. To create a baseline, countries with the least fluctuating patterns were selected and then divided into sub-groups by similarity of the departure patterns.

For countries with only slightly deviating departure rates it was reasonable to assume that migration was negligible. In each sub-group, taking the median of departure rates provided a filtering mechanism to diminish the migration, and therefore represented the baseline for the departure rates in the sub-group. This baseline was considered the model of mortality rate for each sub-group because of the cancellation of migration parts from the departure. These medians or the model of mortality rates were then used to apply with the departure rates from other levels of fluctuation, to form further sub-groups in each level. A country with the departure rate at old ages matching the pattern of any particular model of mortality rate was then added into a corresponding sub-group, because it was reasonable to assume that migration at older ages were negligible. In each further sub-group, the difference between the departure rates and the model of mortality rate indicated migration, either immigration or emigration for each age level. When the departure rates for all 54 countries were classified into groups according to the medians or the mortality rates, it could be observed that the patterns of mortality rates could systematically identify the model of mortality rates for each group.

2.5.4 Operational definition:

2.5.4.1 Departure rate

The rate of people leave the place either by death or migration is called departure rate. The departure rate is examine by using the pattern of deviation. If the patterns are negative deviation then it implies that the departure is due to immigration while if the patterns are positive then the rate must be due to mortality and some emigration.

Furthermore, it is normally calculated from total number of current year population minus last year population for the specific age group in a specific geographic area and divided by the total number of current population of the same age group and geographic area. Normally, it is multiplied by 100,000 in tabulations.

2.5.4.2 Pattern

A pattern is an approach to describing a design for examining female mortality based on the extent of migration. Therefore, in this study, we subsequently created the three patterns, namely good, wobbly and bad pattern to examining the age-specific mortality rate for female.

2.5.4.2.1 Good pattern

It is a tactic to describe the smoothest pattern of female departure rates with sharing the low net migration countries. In this pattern, most of the countries shows the positive deviating departure rates where it is reasonable to assume that net migration is negligible. In this case, departure rate of good pattern can examined the departure as the mortality rate for the female population.

2.5.4.2.2 Wobbly pattern

Wobbly is the terms, which designate the pattern of female departure rates possibly due to the intermediate net migration rate with the ranged from 0 to - 2000 per 100,000 live births female population. In this group of pattern, the countries shows both negative as well as positive deviating departure rates. If the departure rate is moderately negative deviating then the departure rate is assumed is due to the immigration, while if the deviation is positive then it would be mortality and also may be emigration.

2.5.4.2.3 Bad pattern

It is the pattern, which covered the unpleasant trends of female departure rates ranged from 0 to - 10,000 per 100,000 live births of the female population due to the high immigration rate mostly in productive age of the female, especially from the low and middle-income countries. In this pattern, all of the countries in the latter group shows erratic fluctuations of female's departure which is termed as the bad pattern.

2.5.4.3 Median of departure rate

It is an average calculation of female departure rates from low migration countries as baseline countries, which simplified the real female departure rate as mortality rates in particular model. These medians of mortality rates were then used to apply with the departure rates from other levels of fluctuation, to form further sub-groups in each level. For the each level of sub-group, we created the three model, Africa, Asia and West model, to identify the departure as mortality rate for each sub-group by the cancellation of migration parts from the departure. In sub-groups of Africa model, where the mortality remained higher in lower age to the older age of the female population. In Asia, the patterns of female mortality were higher than the west but lower than Africa model in all age of females, whereas, in West, the trends of female mortality remains lower in all age groups of females.

2.5.4.4 Most populous countries

The terms populous comes from the Latin words, which is denoted as the people in specific geographic areas. So, if the group of people shared the highest number population due to the high birth rate, high immigration rate, low death and emigration rate of particular areas or countries based on the population density which is called populous country. These population density is normally estimated by 116 people per square kilometer of a particular country (European Union, 2016).

Chapter 3

Results

This chapter concerns the main objective relating to the estimation of the age- specific mortality rate for female population and shown the results from analysis from calculating the departure rate method.

Figure 2 to 4 shows the age specific female departure rate from 54 countries. These Figure, Y axis denotes the number of departures per 100,000 live births and the X axis is the age in year of female population. In this result, we plotted the graph based on the geographical origin and also based on the similar pattern of departure. We created the different patterns of departure rate and made groups namely, good, wobbly and bad patterns of groups. In the good group, all the countries showed the least deviation patterns of departure rate, and these least deviation indicated the low migration countries. Whereas, in the wobbly and bad patterns of groups, these deviation were noted moderately and severely with negative patterns in the productive ages of female population. These fluctuation patterns of departure rate indicates the high migration during the working age of females. However, after the productive age, these high/low deviation of departure rate were stopped for all the countries. After the age of 60 years our method provide the approximation estimation of departure rates as a mortality rate.

Nonetheless, the departure rates could be separated into three groups, as we mention in above. Among these separated group, a good pattern group of the countries shows the smoothest patterns of female departure rates, which were considered the group of the lowest migrating countries. The countries in this group were further divided into three sub-groups based on the patterns of the departure rate plots. Furthermore, Figure 2 to 4 shows the pattern of departure rates of females for age 0 to 100 years for all three sub-groups with the departure rates in a logarithm scale. To simplify the reference to different age groups the ages below 1 year, 1 to15 years, 16-59 years and over 59 years were defined as infant, adolescence or young age, productive age and old age, respectively.

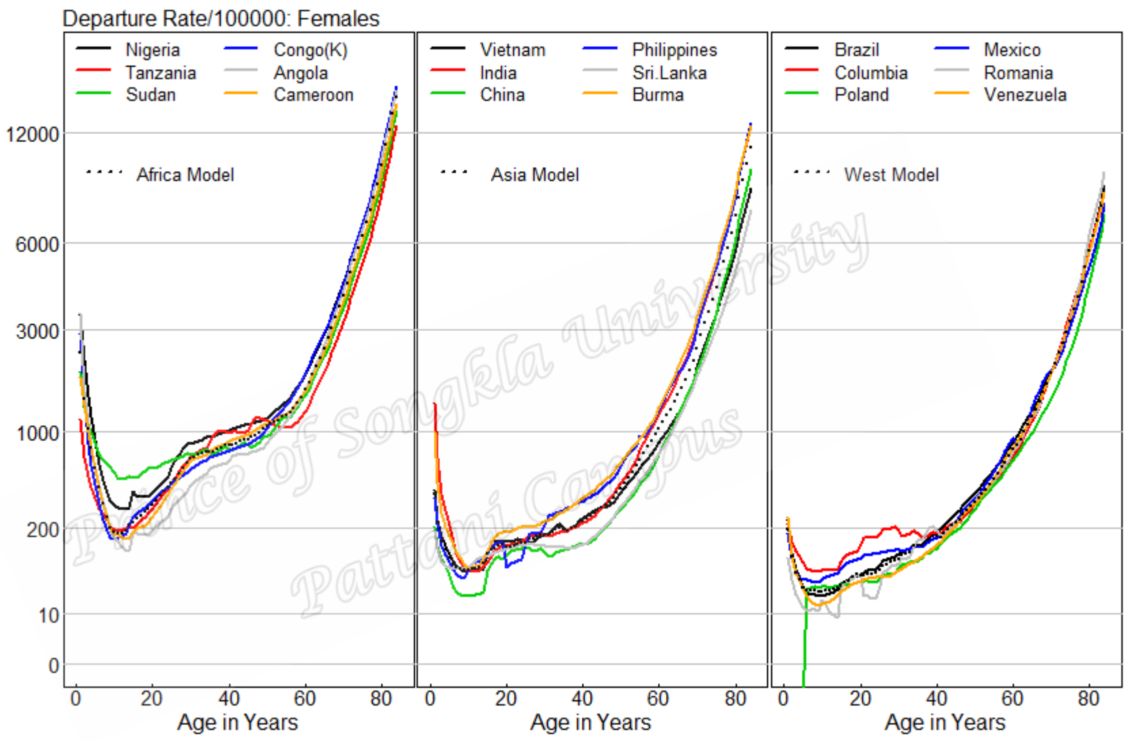

Figure 2: Female departure rate with good pattern

Figure 2 shows the good pattern of departure rates for the age 0 to 100 years and this group was further classified into three sub-group consisting of 18 countries. In this sub-group all the countries have similar patterns of departure at only in infant and old age. However, in the productive age, the departure rate shows the some wide variation of departure rates among these countries. In Sudan, the departure rate is the highest (5,000 per 100,000 live births at 20 years of age) and Angola had the lowest during the productive age of females.

The graph in the middle of Figure 2 consists of Burma, China, India, the Philippines, Sri Lanka and Vietnam. In this plot, the graph shows variation of the departure rates among the six Asian countries mostly in the adolescence, productive and old age. India revealed the highest departure rate (1400 per 100,000 live births at infant age) and China had the lowest departure rate (200 per 100,000 live births at infant age), but, Philippines had the highest departure rate (11,900 per 100,000 live births at old age) and Sri Lanka had the lowest departure rate (around 8,700 per 100,000 live births at old age). However, in the adolescence and productive ages, the departure rate showed some positive fluctuation among the countries, where Burma had the highest and china had the lowest departure rates and rest of other countries had similar patterns of departure rates. Furthermore, the right panel of Figure 2 comprises the countries Brazil, Columbia, Mexico, Poland, Romania and Venezuela with the least departure rates at young and old ages. In this sub-group, Poland showed a steep negative departure at 10 years of age and Columbia showed the highest departure between 10 to 40 years of age. Romania had the highest departure (10,000 per 100,000 live births at old age) and Poland showed the lowest departure (around 8,400 per 100,000 live births at old age). Afterwards, a median for each sub-group was created and then named Africa model, Asia model and West model, respectively, according to the common locations of the countries for each sub-group. The medians for all three sub-groups are shown in Figure 2 in dotted line. The shape of the median in each group indicated the common pattern among countries in the group. For Africa model, the departure rate started at a high level before dropping significantly from infant to the ages of 10 years. It then started to go up sharply until 35 years before the slope was less steep afterwards. The slope changed again at the age of 60 years when the departure rate went up more rapidly again. For Asia model, the departure rate started at lower level than the previous model and dropped with a hook shape from infant to 20 years of age. The rate then had a gentle slope with small oscillation from 20 to 40 years and the departure went up exponentially afterwards. In West model, the departure rate began at the lowest point among the three models before dipping until the age of 10 years. After that, the rate moved up with an exponential scale toward the end. Additionally, there was little fluctuation between 20 and 50 years of age in this model.

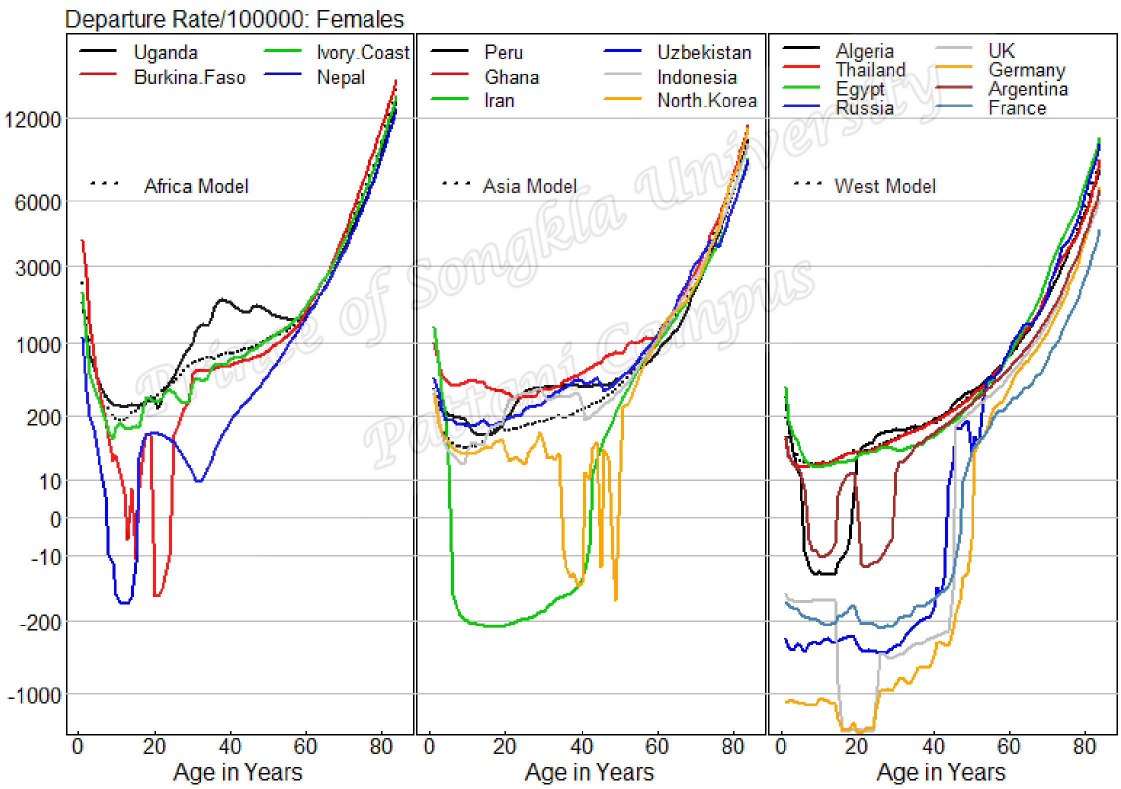

Figure 3: Female departure rate with wobbly pattern

The wobbly pattern in Figure 3 also consists of 18 countries. All the sub-group of figure 3 were separated by three model of Africa model, Asia model and West model, respectively. These models were achieved from the good pattern of departure rates, which were used to differentiate these countries by matching them with the departure rates. The left panel of Figure 3 represents Africa model, with four countries consisting of Burkina Faso, Ivory Coast, Uganda and Nepal. All these countries had almost similar patterns of departure rates at the infant and old age, while in the productive age of females the departure rate revealed moderate fluctuating patterns. Only Burkina Faso and Nepal displayed negative departure rates, mainly around the ages of 15 and 25 years. The countries in this sub-group shared virtually the same level of departure rates at old age. The departure rates of Burkina Faso and Uganda were the highest at infant and ages of around 40 years, respectively. Nepal showed opposite departure rates from Uganda around middle-age years with the lowest rates among all four countries. Moreover, in this sub-group, Burkina Faso had the highest departure rate (4,500 per 100,000 live births at infant) and old age (around 15,000 per 100,000 live births), whereas Nepal had the lowest rates (1100 per 100,000 live births at infant age) and in old age it's (around 12,900 per 100,000 live births). In contrast, Burkina Faso had the highest departure rates (4,500 per 100,000 live births at infant) and also in old age (around 15,000 per 100,000 live births).

The middle figure consists of Asia model, which also includes Indonesia, Iran, North Korea, Uzbekistan, Ghana and Peru. In this model the estimated female departure rates are often unsymmetrical mostly in young and productive ages, but in old age it seems quite similar patterns. It revealed that only Iran and North Korea had negative departure rates, mainly found around the ages of 15 to 40 and 40 to 60 years, respectively. In contrast, Ghana, Peru, Uzbekistan and Indonesia were found positive fluctuation patterns of departure rates at the ages of 15 to 59 years. In this plot, Iran showed the highest rate (1,200 per 100,000 live births at infant)and North Korea had the lowest rate (400 per 100,000 live births at infant), but, Ghana represented the highest departure rate(11,000 per 100,000 live births at old age) and Uzbekistan was the country with the lowest depart rate (9,000 per 100,000 live births). The right panel of figure 3 consists of eight countries based on West model, containing Germany, France, Russia, United Kingdom (UK), Algeria, Argentina, Egypt and Thailand. In this sub-group, all countries had negative departure rates except for Egypt and Thailand. For other countries, Germany, France, Russia, UK had a similar fluctuation with negative patterns of departure rates, while Algeria and Argentina had also found to show negative departure rates with mild fluctuations from 0 to 65 years of ages, respectively. These all negative fluctuation patterns were mostly noted in adolescence to productive age of female. After the age of 60 years, all the countries shows exponential patterns of departure rate. However, in this sub-group, all the countries shows the wide variation of departure rate, where Algeria were estimated with the highest rate(10,000 per 100,000 live births at old age) and France with the lowest rate (5000 per 100,000 live births at old age).

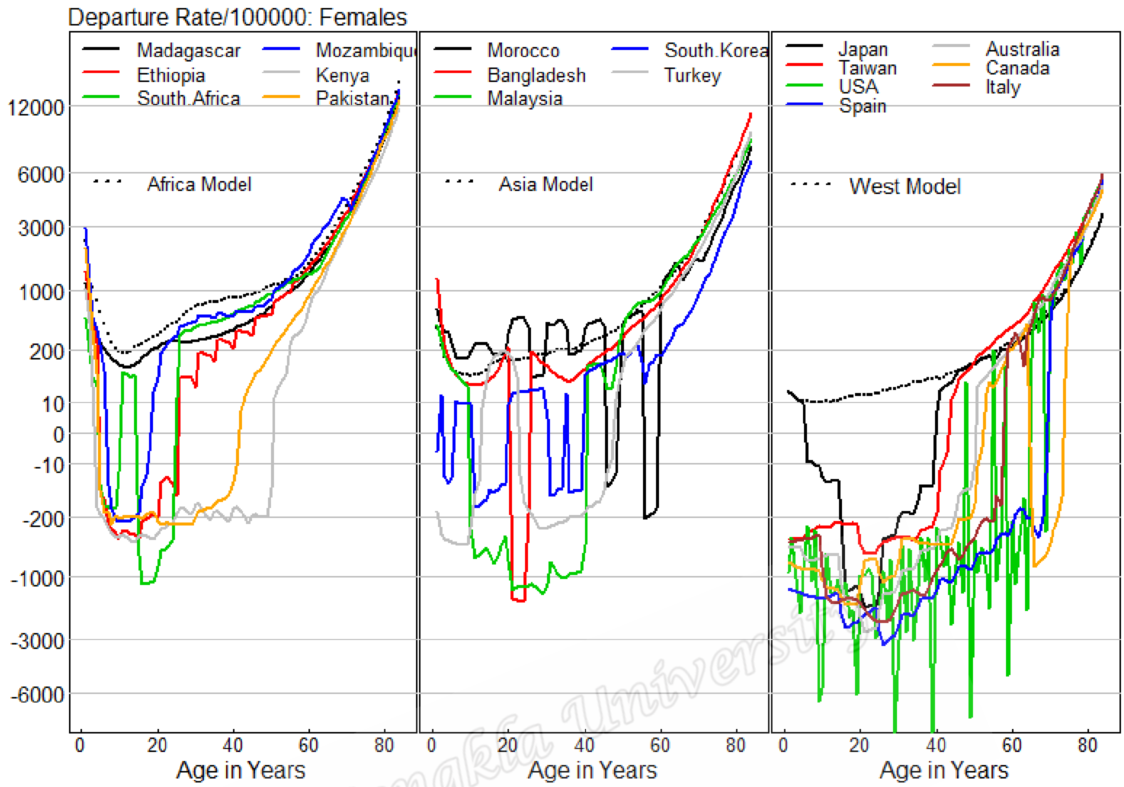

Figure 4: Female departure rate with bad pattern

For the bad pattern in Figure 4, there were also consists of 18 countries with severe fluctuation of departure rates. Following the previous process, we further classified these countries into sub-groups. Subsequently, we found there were three sub-groups as all three models could match all these countries as well. However, in the left of the figure is an Africa model, it consisted of six countries including Ethiopia, Kenya, Madagascar, Mozambique, South Africa and Pakistan. Asia model matched five countries, consisting of Bangladesh, Malaysia, South-Korea, Turkey and Morocco, while West model fitted with seven countries - Canada, Italy, Spain, United State of America (USA), Australia, Japan and Taiwan, respectively. For this group, all countries showed erratic fluctuations of female departure rates with negative deviation mostly. In the left panel of Figure 4, six countries including Ethiopia, Kenya, Madagascar, Mozambique, Pakistan and South Africa were included in Africa model. In this sub-group, Pakistan and Kenya revealed the “U” shape of female negative departure rates at productive age, whilst Ethiopia, Mozambique and South Africa also displayed the steep up and down with negative patterns of departure rates. Meanwhile, at the infant age and after the age of 60 years, all the countries in this sub-group showed the similar patterns of departure rates. In the middle of the figure 4, Asia model was matched with five countries, consisting of Bangladesh, Malaysia, Morocco, South-Korea and Turkey. In South Korea, Malaysia, Turkey and Bangladesh, the steep up and down negative fluctuation patterns of departure rates during adolescence to productive age were found, but Morocco showed the opposite pattern of departure rates. After the age of 60 years, all the countries followed the similar patterns of departure rates with some variations. In this model, Bangladesh shows the highest departure rate (11,000 per 100,000 live births at old age) and South Korea had the lowest rate (7500 per 100,000 live births at old age).

In the right panel of Figure 4, West model is fitted with six countries comprising Australia, Canada, Italy, Spain, Taiwan and United States of America. As a result, all countries showed erratic fluctuations of female’s departure rates with negative deviation. Within this fluctuation, USA had huge fluctuation of female departure rates from 0 to 65 years, while Japan had the lowest fluctuation. Besides, Australia, Canada, Taiwan, Japan and Spain showed the similar patterns with negative departure rates of female population following the “*j*” shape. In this sub-group, after the age of 65 years, all countries also had equal patterns of departure rates, and Taiwan had the highest rate (5,800 per 100,000 live births at old age), while Japan had the lowest rate (4000 per 100,000 live births at old age).

Chapter 4

Discussion and Conclusion

This chapter consists of the summary of overall findings, discussion, limitation and recommendation.

4.1 Summary of the findings

Finding from this study indicate that, mortality were heavily concentrated in the African women, where African were estimated the higher mortality rather than the Asia and West countries, respectively. By the figure, in an average, infant mortality rate was estimated around 4,200 per 100,000 live births but 13,000 per 100,000 live births in old ages of female mortality in Africa. In the Asia, averagely, infant mortality rate was 800 per 100,000 live births and 10,000 per 100,000 in old female mortality. While in the west, an average infant mortality was estimated around 300 per 100,000 live births and 14,400 in the older age of female. However, these all finding were estimated by using the simple departure rate method. In this method, we consider both the departure as migration and the mortality. If the countries experiencing the stable population, then the estimated number of female was departure reasonably assumed due to the mortality. However, this method employed the median, which filter out the migration and is collectively estimate the mortality of female in three different region, namely Africa, Asia and West.

4.2 Discussion

Our study provides an estimation of the female mortality based on the latest population data by using departure rate method. The mortality rates of these 54 world's most populous countries were divided into three categories - Africa model, Asia model and West model. Even though the names originated from the geographical locations in the groups that created the models, it was not exclusive to only countries within the same region with regards to the name. For example, Pakistan, Morocco, and Algeria were included in Africa model, Asia model and West model, respectively. Therefore, these models depend on the respective patterns of the departure rates rather than the locations.

From aforementioned results, it was shown that the departure rates for all 54 countries were systematically classified into groups using the patterns of the medians or models. The patterns of the models could be considered the estimation of the mortality rate. This is due to the nature of human beings to possess the common characteristics of death. Even though being from the different countries, humans share the virtually similar pattern of mortality, higher at infant and at old age while lower during adolescence and productive ages, for a normal situation. The major difference between departure rates among countries is mostly from human movements or migrations and probably special situations, for example, an outbreak of disease. The use of medians as common models for mortality rates was confirmed by the findings that indicated a consistency in the results. It was shown that the countries in the same model shared distinguish properties compared to countries of other models. In Africa model, a higher mortality rate was found in infant, adult and older females compared to those in Asia and West models. In Asia model, the estimated mortality rate was quite lower than those Africa model, but higher than West model. These findings are quite consistent with the Hill *et al.* (2012), where Africa had higher number of the death of children, while Asian/Pacific and Western had the lowest rates. In Africa, 1 out of 12 children dies before reaching their fifth birthday, while 1 death was found among 19 children in Southeast Asia. Furthermore, the proportion of child death, 1 out of 147 children, in developed countries was considerably less (UNICEF, 2015a; Hill *et al.*, 2012). Also, other studies found that countries in Africa and Southeast Asia contributed to the highest mortality rate among adults and old-aged females compared to other regions. This is due to higher prevalence of HIV/AIDS, poverty, malnutrition, maternal complications, violence against women, power and decision-making in African and Asian countries (UN, 2015; UNICEF, 2015a; UNICEF, 2015b; UNAIDS, 2013). In contrast, the levels of mortality in western countries have been incredibly declining in all ages of the female population. This is possibly due to the considerable improvement in public health policies and economic developments. The same situation of female mortality in the world is well documented in the other studies, where it is evident that females are found to be less benefiting from fundamental service compared to their male counterparts. Hence, females are forced to be dying for their entire life mostly from low and middle-income countries (Alkema *et al.*, 2016; UN, 2013; UNAIDS, 2013; Hill *et al.*, 2007; Sawyer, 2012; Stevens *et al.*, 2013; UNFPA, 2014; WHO, 2015b). A joint study by the WHO (2014) and UNICEF (2015) revealed that females are dying due to lack of basic health care, poor and inadequate education, poor nutrition and violence in developing countries of Sub-Saharan and Southeast Asia while another study from WHO (2015) also reported that, high female mortality rate for the same regions (Bulletin of the WHO, 2014; WHO, 2015b). Therefore, it can be implied that the mortality rate is dependent on the country's level of socio-economic and cultural development.

This study provides an instructive way to estimate departure rate based on patterns of population of many countries. The patterns were classified into three categories - good, wobbly and bad. The good pattern showed the smoothness of departure rate, while the wobbly pattern showed some deviation of departure rate among the productive age of female, whereas the bad pattern showed severe fluctuations of departure rates throughout the ages ranging from 0 to 65 years. These patterns also offered a detailed justification to estimate mortality as described before. If the departure rate is positive, it is reasonable to assume that the net age-specific migration is negligible. In such a case, the pattern of departure in the females directly reflects the estimated mortality rate. This is because infants and older people are not supposed to migrate, by the nature and other specific issues such as physical challenges and policy (Angel, 2003; WHO, 2016). Therefore, the changing number of population in these age groups is not affected by migration but rather death.

In the good pattern, all of the countries have revealed positive fluctuations in the departure rates, in which it is reasonable to assume that migration is negligible. Therefore, these countries provide the estimation of female departure as the mortality rates. In the wobbly and the bad patterns, most countries indicated irregular negative fluctuations of departure rates. If the departure rates are negatives, then the trends of departure reflect the immigration. This mostly happens at younger ages of females in high and even some middle-income countries due to more people migrating into these countries. Therefore, UK, USA, Canada, Australia, Germany, France, Italy, Russia, Spain, Turkey, Taiwan, Algeria, Kenya, South Africa, Bangladesh, Iran, Malaysia, Pakistan and South Korea can be considered the host countries for the immigrants from other countries at the productive ages of females. This finding is consistent with other literatures. UN (2015) showed that more than 48% of females were migrating in western countries, and some of immigrants went to African and Asian countries. This is possibly because these countries have a good income, literacy and well facilitated medical care services. Therefore, these countries have hosted a large number of immigrations including the legal and illegal entrances and refugees (UN, 2015a; UN, 2015). In contrast, this trend of migration stops at old ages of female population. One explanation can be found in Angel (2003) indicating that at the higher age the immigrants face higher distress with few saving and lower rates of health insurance coverage.

In low and most middle-income countries, the fluctuation of departure was found to be at low level. It is again reasonable to assume that these countries have a negligible immigration. If the immigration is negligible, then it is justifiable that the departure rate vastly depends on morality rates and possibly emigration in some cases. Despite of this, Morocco showed the exactly opposite fluctuation of departure with a repeatedly bumping pattern of departure at the productive age. It is possibly due to both emigration and also mortality. This finding is supported by the United Nations Population Fund (UNFPA) and World Data Atlas, showing that, during the period of 1990-2015, a large number of emigrants from Morocco were flowing as labors or refugees, and transiting to different destinations. In addition, around 18.43 per 100 females adult also died due to maternal, child health complication and others in Morocco (Demographic profile of Africa, 2016; World Data Atlas 2016).

Although the method used in this study is aimed to provide the estimation of female mortality rates for developing and developed countries from the departure rates, its full utilization can probably be applied to the least developing and developing where the migration is relatively low. In high income countries, where the immigration is fairly high except for old age, this approach cannot explain all the departure rates as the mortality rates in the young and productive ages of female population. Another restriction of this study is that the accuracy of this estimation can be disputed because it relies mainly on the accuracy of the source of the data. While US Census Bureau has provided a great deal of reliable projected population data, there are many factors and turning points that could affect population projection, and in turn the estimated departure and mortality rates. Additionally, the further study, which includes more countries into the estimation, might help capturing more patterns and expanding on characteristics of departure and mortality rates.

In summary, the age-specific mortality rates were estimated from the population data by using the simple departure rate method. This departure rate method can be employed to reveal the mortality rate if the countries experience the low net migration countries. For high migration countries, the effect of migration must be filtered out by using median departure rate before estimation of the mortality rates. By this evident, it was found that the higher female mortality were seen in the African countries rather than in Asian and West countries in all age group of females population.

4.3 Conclusion

We estimate the age-specific mortality rate from the population data by using the simple departure rate method. This departure rate method worked on the mortality if the countries were experience the low net migration countries. For high migration countries, the effect of migration must be filtered out by using median departure rate before estimation of mortality. By this evident, we estimate and found the higher female mortality were in the African countries rather than to Asia and West in all age group of females population.

4.4 Implication of the study

This study highlight the estimation of mortality of female from the population data for 54 countries by using the simple straightforward method of departure rate. The information from this paper can be facilitating to the population forecasting and the also in the demographic analysis, which ultimately focused on the issue of supply and demand of resources in the particular countries.

4.4 Recommendation of the study

In this study, we only used the female population data for 54 countries. We employed a simple method for estimation of female departure rate. This departure will implies the mortality more evidently where there is low migration. Furthermore, we recommend for the further studies need to explore the other methods and techniques for estimation of mortality by using both population data and also the vital registration. These two type of data may help to provide more accuracy for the study.

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Appendix

ISI REGIONAL STATISTICS CONFERENCE

BANK INDONESIA

Certificate of Participation

This is to certify that

Nirmal Gautam

has participated in the ISI RSC 2017
held from 22 - 24 March 2017 in Bali, Indonesia

Yati Kurniati
Local Organizing Committee

ISI REGIONAL STATISTICS CONFERENCE

isi

International Statistical Institute
Regional Statistics Conference
Bali, 20 - 24 March 2017

BANK INDONESIA

Certificate of Paper Presentation

This is to certify that the contributed paper entitled

Trends of age-specific mortality rates for female populations in 54 of the world's most populous countries

by

Nirmal Gautam*; Apiradee Lim; Attachai Ueranantasun; Metta Kuning

was presented in the Contributed Paper Session of the ISI Regional Statistics Conference 2017 held in Bali, Indonesia, from 20 - 24 March 2017

Yati Kurniati
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