Expanding Abridge Life Table by Using Heligman Pollard Method: Malaysian Experience 2010-2013

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Abstract

Mortality rate is the measurement of the number of death in certain population and it is scaled to the size of the population per unit time. The study of mortality rate is meant to find ways to extend the survival of an individual to reduce the mortality rate. Mortality rate is also one of the important elements in determining the premium in insurance pricing. In Malaysia, Census department will take the responsibility to determine the total number of population and the data will be presented in the form of five years age group called Abridged Life Table. This paper used the Abridged data and to obtain the rate for each age, Heligmann Polard Method was applied to expand the Abridged Life table into a complete table.

Keywords: Mortality Rate, Abridged Life Table, Heligmann Pollard Method

1. Introduction

Mortality is derived from the word mortal, of which more is a Latin word means death or a fatal outcome. It is the condition from being in a state of alive to a state of death. Every living things including human will face mortality whether they are at the younger or older age. Mortality rate is the measurement of death in some population and it is scaled to the size of the population per unit time (Benjamin and Pollard, 1970). Usually, the mortality rate will be expressed in a unit of death of 1,000 persons per year. For instance, mortality rates of 5.0 in a population of 10,000 persons mean 50 deaths per year in that entire population. Thus, the mortality rate is the ratio of the total number of population per unit of time, based on 1,000 persons per year.

Previous research on mortality rates were used to find ways to extend the survival of an individual, thus the mortality rate in the current population could be reduced (United Nations, 1984). Mortality rate is used as an indicator to estimate the life expectancy in a society. Lower mortality rate will indicate that a society has a good survival rate and higher mortality rate will indicate otherwise.

If the mortality rate has declined over the years, then it is a good sign as it shows the survival of an individual has been extended. The pattern of mortality rate usually will decline over time because the society is experiencing an improvement in health and longer life expectancy. This leads to an increase on life expectancy that is currently experienced globally.

1.1 Mortality Rates in Malaysia

In 1999, Malaysia experienced a sudden increase in mortality rate compared to previous years. According to Disease Information (1999), it is believed that the reason for the mortality rate to experience a rapid increase because of the major disease outbreak that happened in 1999 was known as Japanese Encephalitis. This disease came from Culex mosquitoes that breed in the dirty water from the pig farm. The first case of this disease was found in Perak and later spread to other states such as Negeri Sembilan (Department of Public Health, Ministry of Health, Malaysia, 1999). Based on the mortality rates, it indicates that people at their advanced age have a lower chance to survive in 1999 and due to this, Malaysia has experienced in declined of health and shorter life expectancy caused by the major disease outbreak.

In Malaysia, the Census department will take the responsibility to determine the total number of population, death and birth rate of the country. Population Census is done once in five years' time and the data will be represented in the form of five years age group. It is called Abridged Life Table. The main reason for the mortality rate data presented in the abridged form is because of the age phenomenon heaping in data registration. Therefore, only mortality data in abridged form are available although a complete mortality table is normally needed especially by the insurance companies.

It is important to construct single age mortality rate as this rate shows an estimate number of death at each particular age. In an actuarial field, mortality rate is one of the important elements in determining the price of the premium for individuals. A complete mortality life table is needed in order to calculate the premium pricing, profit testing, claim and reserve. Therefore, the main objective of this study is to expand the Abridged Life Table into a complete mortality table to be used by the insurance company to calculate the premium pricing, profit testing, claim and reserve based on the exact age of the person in order to estimate the cost accurately. Insurance companies would normally construct a complete life table based on the insurance's experience. It may slightly differ from the tables constructed by the Department of Statistics. This is because the mortality tables constructed from the Department of Statistics is based on the population of a specified country. Therefore, this study, will only focus on the current Abridged Life Table that is available from year 2010 to 2013 from the Department of Statistics Malaysia 2014.

2. Construction of Complete Life Table

To obtain the rate for each age, interpolation can be applied to expand the Abridged Life Table into a complete table. Interpolation method had been extensively used for constructing the complete life table as suggested in King (1914). It is stated that the interpolation method that are still being used provides good estimation for the adult mortality but less accurate for the childhood ages (Elandt-Johnson, 1980). However, this method is limited to those ages 75 and below.

There are other methods that can be used to construct a complete life table. Heligman Pollard Model is one of many ways that is being considered to compute the mortality rate for both male and female. Several application of Heligman Pollard Model had been used in some countries such as in Sweden by Hartmann (1987). Hartmann concluded that Heligman Pollard model is the best existing demographic model of mortality at all ages and is an efficient means of generating life table's model. Other than Hartmann, Kostaki (1991) also discussed about this model and concluded that, this model provides quite a satisfactory representation of the age pattern of mortality. This model provided a new way to expand a life table through direct estimation of the complete set of probabilities of dying from the abridge form. Although there are a few other methods in expanding the Abridged Life Table, the most commonly used for computing the mortality rate for both gender male and female are Exponential Smoothing Method and Heligman Pollard Model.

2.1 Construction of Heligmann Pollard Method

Mainly, this paper focuses on the calculation and expanding of mortality rates for male and female population from year 2010 to 2013 by using the Heligman Pollard method. This method will only be applied to the Malaysian male and female population at advanced ages which are 55 to 80 years old. The mathematical function for Heligman Pollard method is:

$$\frac{q_x}{p_x} = A^{(x+B)^C} + D\{exp\{-E[\ln x/F]^2\}\} + GH^x \;; \quad q_x = mortality\, rate\ at\ age\ x$$

There are seven parameters in this equation which are A, B, C, D, E, F, G and H. This model contain three terms, each representing different component of mortality. The first term is a rapidly decreasing exponential function and reflects the fall in mortality at the infant and early childhood ages, which are at ages less than 10 years. This component of mortality has three parameters which are A, B, and C. The second term (the parameters are D, E and F) describes about the mortality age from ages 10 to 40, which the accident "hump" appears. Those parameters measure the location, width and height of this accident "hump". And the third term is a Gompertz exponential function and this term reflects the rise in mortality at the adult ages, which ages are greater than 40 years old. The parameters for this term are G and H. Since this study analyses the mortality rates for person aged 55 to 80 years, the first and second term of Heligmann Pollard method is insignificant. Therefore, it can be simplified as:

$$q_x = \frac{GH^x}{GH^x+1}$$

The values of G and H are referred to the value of parameters that will be estimated by using simple linear regression analysis.

2.2 Estimating Parameters of G and H Using Simple Linear Regression Analysis

The parameter for G and H will be estimated by using the simple linear regression. The parameter for G and H are estimated by using the equations below:

$$q_x = 1000\frac{GH^x}{GH^x+1}$$

$$\frac{q_x(GH^x+1)}{1000} = GH^x$$

$$\frac{\frac{q_x}{1000}}{\left(1-\frac{q_x}{1000}\right)} = GH^x$$

$$ln\frac{q_x}{1-q_x} = \ln G + x\ ln\ H$$

3. Results of the Mortality Rates by Using Heligmann Pollard Method

The value of the mortality rate is based on the estimated parameters, G and H that have been calculated by using the simple linear regression analysis. The value of the parameters of G and H will be used to compute the mortality rate from year 2010 to 2013 which can be referred in Table 1. The result of the mortality rate in years 2010 to 2013 computed using the Heligmann Pollard method are later shown in Table 2.

Table 1: The Value of Parameter G and H Estimated by Using Simple Linear Regression Analysis, 2010 to 2013

	Male			Female	
Year	G	H	Year	G	H
2010	3.6025	1.1127911	2010	1.3734	1.118054
2011	3.67137	1.1120409	2011	1.4693	1.116524
2012	3.81289	1.1110813	2012	1.4845	1.115919
2013	3.86482	1.1127148	2013	1.5206	1.117697

Table 2: Mortality Rates obtained Using Heligmann Pollard Method, 2010 to 2013

	q_x in 2010		q_x in 2011		q_x in 2012		q_x in 2013	
	Male	Female	Male	Female	Male	Female	Male	Female
55	0.0582538	0.0329249	0.057091	0.0349173	0.0565339	0.0321571	0.0559644	0.0317498
56	0.0637124	0.0367695	0.0624421	0.0387486	0.0617775	0.0358228	0.0610254	0.0353422
57	0.0696448	0.0410439	0.0682586	0.0429816	0.0674725	0.0398891	0.0665118	0.0393246
58	0.0760846	0.0457916	0.0745738	0.0476541	0.07366514	0.0443958	0.0724534	0.0437354
59	0.0830667	0.0510592	0.0814221	0.0528065	0.0803474	0.0493854	0.078881	0.0486159
60	0.0906267	0.0568967	0.088839	0.0584817	0.0875945	0.0549037	0.0858259	0.0540102
61	0.0988006	0.063357	0.0968603	0.0647253	0.0954275	0.0609989	0.0933204	0.0599654
62	0.1076245	0.0704961	0.105522	0.0715847	0.1038812	0.0677224	0.1013967	0.066531
63	0.117134	0.0783722	0.1148597	0.0791095	0.1129903	0.0751276	0.1100871	0.0737591
64	0.1273638	0.0870459	0.1249083	0.087351	0.1227887	0.0832702	0.1194234	0.0817037
65	0.1383471	0.0965789	0.1357013	0.0963612	0.133309	0.0922074	0.1294362	0.0904205
66	0.1501146	0.1070335	0.1472699	0.1061926	0.1445822	0.1019971	0.140155	0.099966
67	0.1626939	0.1184715	0.1596425	0.1168973	0.1566364	0.1126971	0.1516068	0.1103969
68	0.176109	0.1309525	0.172844	0.128526	0.1694964	0.1243641	0.1638161	0.121769
69	0.1903788	0.1445328	0.1868943	0.1411266	0.183183	0.1370524	0.1768037	0.1341358
70	0.2055164	0.1592633	0.2018081	0.1547432	0.1977116	0.1508123	0.1905863	0.1475477
71	0.2215282	0.1751877	0.2175935	0.1694144	0.2130918	0.1656884	0.2051755	0.1620496
72	0.2384132	0.1923401	0.2342513	0.1851719	0.2293266	0.1817178	0.2205771	0.1776797
73	0.2561617	0.2107428	0.251774	0.2020385	0.2464109	0.1989283	0.2367905	0.1944676
74	0.2747548	0.2304039	0.270145	0.2200266	0.2643314	0.2173359	0.2538075	0.2124318
75	0.2941637	0.2513152	0.2893381	0.2391362	0.2830656	0.2369429	0.2716123	0.2315785
76	0.3143495	0.27345	0.3093169	0.2593537	0.3025815	0.2577364	0.2901803	0.2518989
77	0.3352624	0.2967616	0.3300346	0.2806499	0.3228371	0.2796857	0.3094784	0.273368
78	0.3568426	0.3211821	0.3514338	0.3029795	0.3437802	0.3027419	0.3294642	0.2959431
79	0.3790198	0.3466216	0.3734472	0.3262799	0.3653489	0.3268364	0.3500863	0.3195626
80	0.4017144	0.3729689	0.3959975	0.3504713	0.3874718	0.3518808	0.3712844	0.3441457

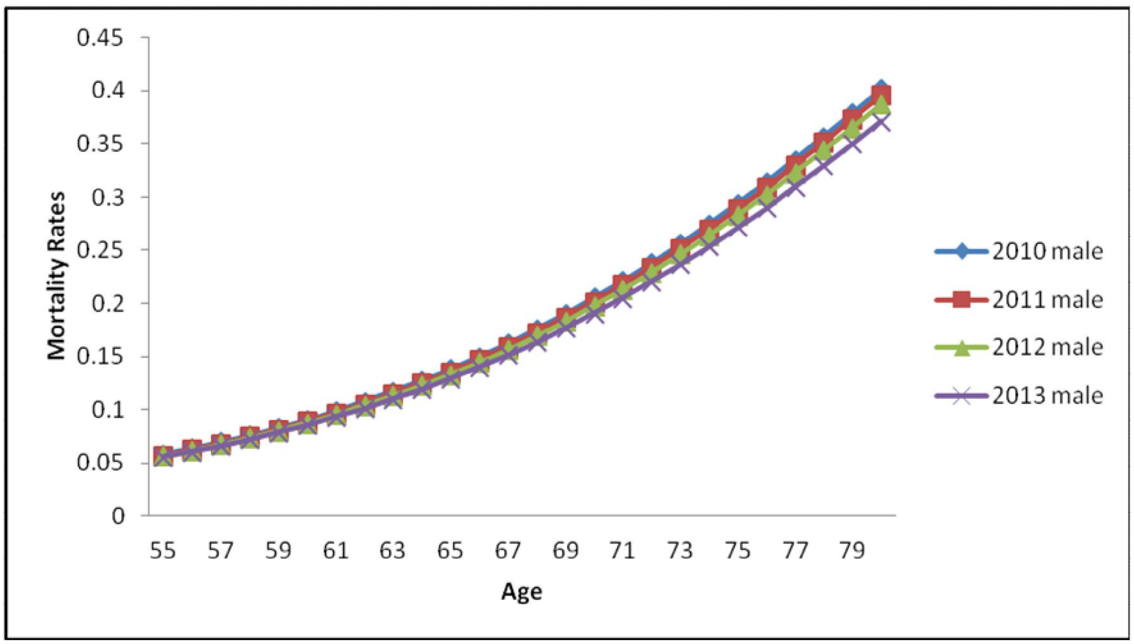
4. Results and Discussion

The construction of the complete mortality table using Heligmann Pollard method has shown similar pattern of mortality rates compared with the actual rates of mortality for both gender, male and female. The result from year 2010 to 2013 show similar trend compared to the actual value. The results also show that the mortality rate of male is higher than female, given the same age. Apart from that, the law of increasing mortality is also applied; the mortality rate tends to increase as age increases. Therefore, it can be concluded that the Heligmann Pollard method has no significant difference from the actual value.

4.1 Estimated Mortality Rate by Using Heligmann Pollard for Male and Female

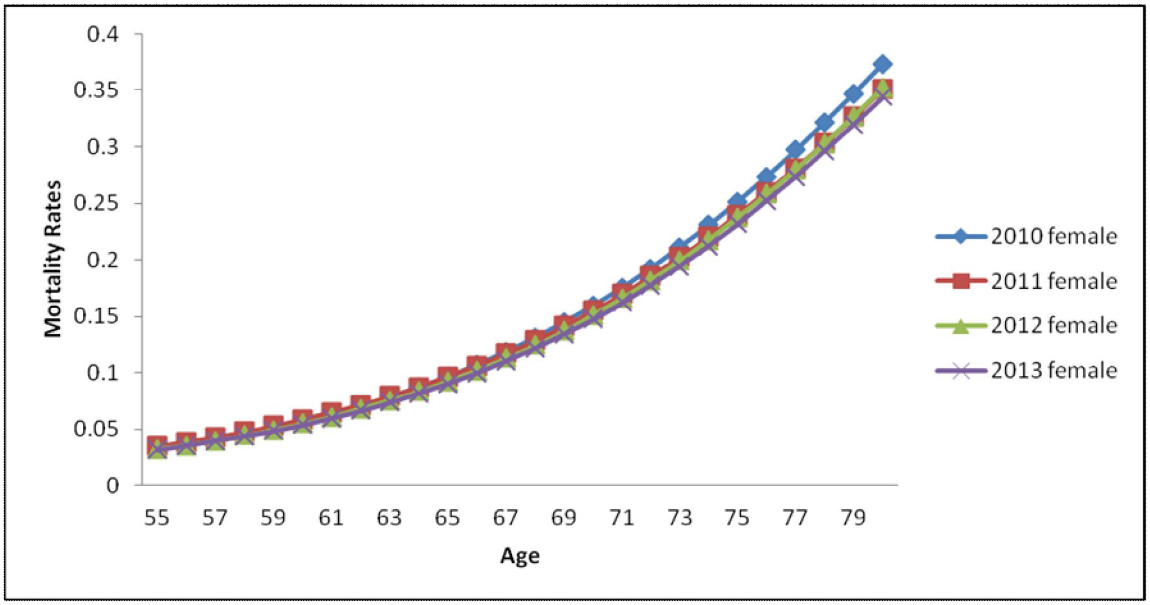
The estimated mortality rate that has been calculated by using Heligmann Pollard Method is compared from year 2010 to 2013. Figure 1 and Figure 2 shows the patterns of the estimated rate of mortality rate for male and female, respectively from years 2010 to 2013. Based on Figure 1, mortality rate in year 2010 shows the highest mortality rate compared to other years. This figure also shows that the mortality rate decreased from year 2010 to 2013 by 0.057569 that is approximately 14.33 percent. During this 4 years period, the mortality rate shows the lowest rate in 2013. This shows that the people at the advanced age have a greater chance to survive in 2013 since Malaysia has experienced an improved of health and longer life expectancy. The indicators of ageing include an increased in median age of the population, longer life expectancy and also the proportion of dependency ratio of elderly people compared to the proportion of youth dependency. Since there was no serious disease or unexpected catastrophes during the period, the value of the mortality does not show any sudden rise in mortality rates.

Figure 1: Mortality Rate for Male Using Heligmann Pollard



Similar pattern can be seen for female mortality rates. During that period from 2010 until 2013, it shows a declining pattern. The mortality rate decrease from year to year and in year 2013, the mortality rate shows the lowest rate. Both figures also show the mortality rate among males was consistently higher than females for every age group. This is consistent with the current situation where the life expectancy of males is lower than females. From another point of view, these results also shows that people should start focusing on saving for old age as they are expected to live longer that leads to higher expenses.

Figure 2: Mortality Rate for Female Using Heligmann Pollard



5. Conclusion

From this research the estimated mortality rate by using the Heligmann Pollard shows a similar trend with the actual value. Thus, this shows that Heligmann Pollard method is a good method to expand the life table. This method is believed to be the most efficient means of generating life table model since it is proved that there are no significant differences from the actual values (Ibrahim, 2008). This paper also manages to transform an Abridged Life Table from the form of five years age group to a complete table. Therefore, it is easier for insurance companies to make use of the mortality rates at the exact age rather than in an abridged form. Apart from showing that the mortality rate decreases over the years, this also explains that Malaysian population has experienced an increase in health over the years.

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