1. INTRODUCTION

1.1 *A life table is a useful tool for presenting the mortality situation of a population. A life table is prepared from age-specific mortality rates or probability of deaths (q_x) and the results used to measure mortality, survival ratio and life expectancy.*

1.2 *Life expectancy is the average number of years a person is expected to live at the beginning of a certain age, assuming the mortality rate of a certain age is the same throughout his or her lifetime. Life expectancy at birth reflects mortality. It is independent of the population's age structure and is not influenced by extraneous factors such as the selection of a standard population, changes in birth rates and other demographic phenomena.*

1.3 *Life tables are used by demographers, public health workers and actuaries in the studies of fertility, mortality, migration, longevity, population growth, population projections, length of working life and length of married life*[1].

1.4 *This report also provides life tables by major ethnic group at Malaysia level based on the classification used during Population and Housing Census of Malaysia 2020 (MyCensus 2020). The classifications used are:*

Citizens

a. *Bumiputera consists of Malay and Other Bumiputera*
b. *Chinese*
c. *Indians*
d. *Others*

Non-citizens

1.5 *The statistics of life expectancy for 2020 to 2023 have been revised based on the MyCensus 2020 meanwhile the statistics of life expectancy for 2010 to 2019 are based on the Population and Housing Census of Malaysia 2010 (Census 2010) and will be revised later.*

[1] *H.S Shryock and J.S. Siegel (1976)*

2. CONCEPTS

2.1 *Abridged life table is a table that shows the probability that a person at a certain age (5-year age interval) will die before reaching his or her next birthday. A life table is prepared from age-specific mortality rates or probability of deaths (q_x) and the results used to measure mortality, survival ratio and life expectancy.*

2.2 *Life expectancy is the average remaining age (years) for a person is expected to live at the beginning of a certain age if the age-specific death rates of the given period continued throughout his or her lifetime.*

2.3 *Survivors are the number of survivors at the beginning of a certain age.*

3. METHODOLOGY

3.1 *The life tables are generated from Coale-Demeny (West) model based on the average final number of mid-year for three year. This approach was adopted to minimise random annual fluctuations in the number of vital events. The use of triennial deaths implies that there will always be a time lag of one or two years for life tables of a year to be made available. Thus, to cater for the needs of the user, the Brass Logit model was used to generate the estimate of life tables.*

3.2 *The abridged life tables 2021 (final) are generated using the Coale-Demeny (West) model based on the average final number of mid-year deaths by single age, ethnic group, sex and state for 2020, 2021 and 2022.*

3.2.1 *Mid-year data on deaths for 2020 refers to the deaths recorded in the second half-yearly of 2019 from July to December 2019 and the first half-yearly of 2020 deaths from January to June 2020 by single age, ethnic group, sex and state.*

3.2.2 *Mid-year data on deaths for 2021 refers to the deaths recorded in the second half-yearly of 2020 from July to December 2020 and the first half-yearly of 2021 deaths from January to June 2021 by single age, ethnic group, sex and state.*

3.2.3 *Mid-year data on deaths for 2022 refers to the deaths recorded in the second half-yearly of 2021 from July to December 2021 and the first half-yearly of 2022 deaths from January to June 2022 by single age, ethnic group, sex and state.*

3.2.4 The input of the population used to generate the abridged life tables is the mid-year population estimates for 2021 based on the MyCensus 2020 by single age, ethnic group, sex and state.

3.3 The abridged life tables 2022 (preliminary) are generated using the Coale-Demeny (West) model based on the average final number of mid-year deaths by single age, ethnic group, sex and state for 2021, 2022 and 2023 (estimates).

3.3.1 Mid-year data on deaths for 2021 refers to the deaths recorded in the second half-yearly of 2020 from July to December 2020 and the first half-yearly of 2021 deaths from January to June 2021 by single age, ethnic group, sex and state.

3.3.2 Mid-year data on deaths for 2022 refers to the deaths recorded in the second half-yearly of 2021 from July to December 2021 and the first half-yearly of 2022 deaths from January to June 2022 by single age, ethnic group, sex and state.

3.3.3 Mid-year death estimates for 2023 refer to the deaths recorded in the second half-yearly of 2022 from July to December 2022 and the first half-yearly of 2023 deaths from January to June 2023 by single age, ethnic group, sex and state. The 2023 estimate deaths based on 10-year death time series data using the time series modeler-exponential smoothing models.

3.3.4 The input of the population used to generate the abridged life tables is the mid-year population estimates for 2022 based on the MyCensus 2020 by single age, ethnic group, sex and state.

3.4 The abridged life tables 2023 (estimates) are generated using the Brass Logit model based on the mid-year death estimates and mid-year population estimates for the current year.

3.4.1 Mid-year death estimates for 2023 refer to the deaths recorded in the second half-yearly of 2022 from July to December 2022 and the first half-yearly of 2023 deaths from January to June 2023 by single age, ethnic group, sex and state.

3.4.2 The input of the population used to generate the abridged life tables is the mid-year population estimates for 2023 based on the MyCensus 2020 by single age, ethnic group, sex and state.

3.5 The calculation of life tables requires a set of input values of either the age-specific mortality rates of the population, ${}_nM_x$ *or the* ${}_nq_x$ *values, that is,* *probabilities of dying between exact ages x and $x+n$, where n equals to 5-year age intervals except for the first two age groups below 1 year and 1-4 years.*

3.6 *For estimating ${}_1q_0$ and ${}_4q_1$ from ${}_1M_0$ and ${}_4M_1$ and ${}_1L_0$ (where ${}_1L_0$ refers to the number of person-years lived between age 0 and 1) and ${}_4L_1$ from ${}_1q_0$ and ${}_4q_1$, death separation factors which are required from the Coale-Demeny model life tables*[2].

3.7 *The data input is in the form of 17 values of ${}_nM_x$ or ${}_nq_x$. If there are more than 17 values, only data up to ${}_5q_{75}$ were taken. If there are less than 17 values, that is, data up to an age group below the age of 75 years, extrapolation up to the age of 75 years is done automatically.*

3.8 *The extrapolation is done by assuming that the ${}_5q_x$ values have exponential functions. The ratio of the two highest values of ${}_nq_x$ in the data input is constant for estimation, up to the age of 75 years. For example, the ratio of a from the data given is computed as:*

$$a = \frac{{}_5q_{x+5}}{{}_5q_x}$$

where:

${}_5q_{x+5}$ *The highest value of the given set in which x is less than 70*

a *Constant value*

Therefore, the estimate of ${}_5q_{x+10}$ is:

$${}_5q_{x+10} = a \,.\, {}_5q_{x+5}$$

This relationship is used in estimation up to ${}_5q_{75}$.

3.9 *The age-specific mortality rates, ${}_nM_x$ of the population calculated as follows:*

$${}_nM_x = \frac{{}_nD_x}{{}_nP_x}$$

[2] *A. Coale and P. Demeny* (1966)

where:

$_nD_x$ Number of deaths between ages x and $x + n$

$_nP_x$ Number of populations between ages x and $x + n$

3.10 The Brass Logit system is based on a two-parameter transformation of a standard life table and allows infinite variations in the patterns of mortality at any given level. A relationship model was used to compare the levels and patterns of mortality between triennial year life table and single year life table which was used as a standard. It assumes that different mortality schedules can be linearly related to each other by a transformation of their respective survivorship values into logits, that is, the number of survivors at age x are converted to logits for both the single year-based life table and triennial year-based life table. This is based on the following relationship:

Logit Y = α + β logit S

Logit Y Refers to the logit transformation of l_x values from the life table of triennial average deaths

Logit S Refers to the logit transformation of l_x values from the life table of single year deaths

α Refers to the level of mortality

β Refers to the pattern of mortality

4. COMPUTATION OF LIFE TABLE FUNCTIONS

4.1 If $_nM_x$ values are used as inputs, the $_nq_x$ values are computed as:

$$_nq_x = \frac{(n.\ _nM_x)}{(1 + (n - \ _nk_x).\ _nM_x)}$$

where:

$_nq_x$ Probability of dying between exact age x and exact age $x + n$

$_nM_x$ Age-specific mortality rates for ages x and $x + n$

n Age group interval (1, 4 and 5)

$_{n}k_{x}$ *Death separation factor for ages x and $x+n$*

The death separation factors for ages below 1 year and 1-4 years can be provided as the input or the Coale-Demeny death separation factors can be used.

The separation factor for all higher age groups is assumed to be 2.5.

4.2 *Survivors (the number of survivors) at each exact age x, l_x is:*

$$\frac{l_{x+n}}{l_x} = 1 - {}_{n}q_{x}$$ *with a radix of 100,000 births, that is, at exact age 0, l_0*

4.3 *The number of deaths between exact ages x and $x+n$, $_{n}d_{x}$ is:*

$$_{n}d_{x} = l_x - l_{x+n}$$

4.4 *The number of person-years lived (survivors) between exact ages x and $x+n$, $_{n}L_{x}$ is calculated as:*

$$_{1}L_{0} = {}_{1}k_{0} \,.\, l_0 + (1 - ({}_{1}k_{0}))l_1$$

$$_{4}L_{1} = {}_{4}k_{1} \,.\, l_1 + (4 - ({}_{4}k_{1}))l_5$$

$$_{5}L_{x} = 2.5(l_x + l_{x+5}) \qquad x = 5, 10, \ldots 75$$

where:

$_{1}k_{0}$ *Death separation factors for ages below 1 year*

Male : $_{1}k_{0} = 0.0425 + 2.875\ {}_{1}q_{0}$

Female : $_{1}k_{0} = 0.05 + 3.0\ {}_{1}q_{0}$

$_{4}k_{1}$ *Death separation factors for aged 1-4 years*

Male : $_{4}k_{1} = 1.653 – 3.013\ {}_{1}q_{0}$

Female : $_{4}k_{1} = 1.524 – 1.625\ {}_{1}q_{0}$

All the death separation factors used are as suggested in Coale-Demeny model life tables.

The open-ended age group, L_{80+} is calculated as:

$L_{80+} = 3.725\ (l_{80}) + 0.0000625\ (l_{80})^2$

4.5 *The central mortality rate between age x and age $x+n$, ${}_nm_x$ is:*

$$_nm_x = \frac{_nd_x}{_nL_x}$$

4.6 *The total number of person-years lived after exact age x, T_x is:*

$$T_x = \sum_{y=x}^{y=w} L_y$$

where:

$\sum_{y=x}^{y=w} L_y$ *Sum of the L_x for ages x and over to the end of the life table*

w *The oldest age in the life table*

4.7 *The survival ratio, ${}_nS_x$ is:*

$$_nS_x = \frac{_nL_{x+5}}{_nL_x}$$

where:

Proportion of surviving from birth to ages 0-4 years is:

$$S_0 = \frac{_5L_0}{5(l_0)}$$

Proportion of surviving from ages 0-4 years to 5-9 years is:

$$S_1 = \frac{_5L_5}{_5L_0}$$

Proportion of surviving from ages x to $x+5$ is:

$$_5S_x = \frac{_5L_{x+5}}{_5L_x}$$

Proportion of surviving from ages 75-80 years and over is:

$$S_{75+} = \frac{L_{80+}}{L_{75+}}$$

4.8 *Life expectancy at the age x, e_x is:*

$$e_x = \frac{T_x}{l_x}$$

5. LIFE TABLE DEFINITIONS

x and $x+n$ — *The period of life between two exact ages x and $x+n$.*

For example, age group of the age of '65-70' means the 5-year interval between the 65th and 70th birthdays.

${}_nq_x$ — *The probability of dying between age x and age $x+n$, the proportion of persons in the cohort that alive at the beginning of age interval x who will die before reaching the end of that age interval $x+n$.*

For example, refer to the Table 2.1, the probability that a person of exact the age of 65th will die before reaching his 70th birthday, ${}_5q_{65}$ is 0.13449, that is, out of every 100,000 persons alive and exactly 65 years old, 13,449 will die before reaching their 70th birthday.

l_x — *Survivors at each exact age x, that is, the number of persons living at the beginning of an age interval x out of a total of births assumed to be 100,000 persons.*

For example, refer to the Table 2.1, out of 100,000 newborn male babies, 73,094 persons would survive to exact the age of 65th years.

${}_nd_x$ — *The number of deaths between exact age x and exact age $x+n$, that is, the number of persons who would die within the indicated age interval x to $x+n$ out of the total number of births assumed in the table.*

For example, refer to the Table 2.1 there would be 9,830 deaths for male between exact the ages of 65 years and 70 years to the initial cohort of 100,000 newborn male babies.

${}_nm_x$ — *Central mortality rate between exact age x and exact age $x+n$.*

For example, refer to the Table 2.1, the central mortality rate for male between the age of 65 years and the age of 70 years is 9,830 / 340,894 that is, 0.02884.

$_nL_x$ *The number of person-years lived (survivors) between exact age x and exact age $x+n$ by the cohort 100,000 births assumed.*

For example, refer to the Table 2.1, the 100,000 newborn male babies would live 340,894 person-years between exact the ages of 65 years and 70 years. Out of 73,094 person who reach the age of 65 years, the 63,264 persons who survive to the age of 70 years would live 5 years each, that is, 316,320 person-years (63,264 x 5 = 316,320 person-years) and 9,289 persons who die would each live varying periods of time less than 5 years, averaging about 2.5 years, that is, 24,575 person-years (9,830 x 2.5 = 24,575).

$_nS_x$ *The proportion of survivors from age group x to $x+n$ to another age group $x+5$ to $x+5+n$.*

For example, refer to the Table 2.1 the proportion of survivors for male from the age group of 65-69 to the age group of 70-74 is 285,321 / 340,894 that is 0.83698.

T_x *The total number of person-years to be lived after the beginning of exact age x by the cohort of 100,000 births assumed.*

For example, refer to the Table 2.1, the 100,000 of newborn male babies would live 1,053,041 person-years after their 65th birthday.

e_x *Life expectancy is the average remaining age (years) for a person is expected to live (survives) at the beginning of a certain age x if the age-specific death rates of the given period continued throughout his/ her lifetime.*

For example, refer to the Table 2.1, males who reaches his 65th birthday is expected to live 14.4 years more.

6. NOTE AND SYMBOLS

p	Preliminary
e	Estimates
W.P.	Wilayah Persekutuan
-	Nil/ blank