Office for National Statistics

Guide to calculating national life tables

Explanation of the methodology used to create the national life tables.

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1 . What is a national life table?

A life table is a demographic tool used to analyse death rates and calculate life expectancies at various ages. We calculate life tables separately for males and females because of their different mortality patterns.

We publish national life tables annually in September for the UK, Great Britain, England and Wales combined and the UK countries separately. These provide the official country-level estimates of life expectancy for the UK and UK countries. They cover a consecutive three-year period to help reduce the effect of annual fluctuations in the number of deaths caused by seasonal events such as winter flu. The current series goes back as far as 1980 to 1982.

The national life tables give period life expectancies. A period life expectancy is defined as:

"The average number of additional years a person can be expected to live for if he or she experiences the age-specific mortality rates of the given area and time period for the rest of his or her life."

Our period and cohort life expectancy explained article explains in more detail what a period life expectancy is and how this differs from cohort life expectancy.

The national life tables are published by single year of age (known as complete life tables) from age 0 years up to age 100 years. Although people do live beyond age 100 years, life expectancies at these oldest ages are highly uncertain and so we do not publish them.

As well as national life tables, we also publish different types of life table. You can read about the different types of life table and life expectancy we produce in our life expectancy explainer article.

2 . How to use the national life tables

In the national life tables we publish five components:

m_x

Definition - This is known as the central rate of mortality. That is the average number of deaths each year at age x last birthday in the relevant three-year period, divided by the average population at that age over the same period.

Example - mx for age 70 years in 2015 to 2017 would be the average number of deaths at age 70 years across 2015, 2016 and 2017, divided by the average number of people aged 70 years across 2015, 2016 and 2017.

q_x

Definition - This is the mortality rate between age x and (x +1). That is, the probability that a person aged x exactly will die before reaching age (x +1).

Example - qx for age 70 years in 2015 to 2017 would be the probability that a person aged 70 years exactly in 2015, 2016 or 2017 will die before reaching age 71 years.

l$_x$

Definition - This is the number of males or females surviving to exact age x of 100,000 live births who are assumed to be subject throughout their lives to the mortality rates experienced in the specified three-year period.

Example - lx for age 70 years in 2015 to 2017 would be the number of males or females out of 100,000 live births in 2015 to 2017 expected to survive to age 70 years calculated using the age specific mortality rates applicable for 2015 to 2017.

d$_x$

Definition - This is the number of males or females dying between exact age x and (x +1) described similarly to lx, that is, $d_x = l_x - l_{x+1}$.

Example - dx for age 70 years in 2015 to 2017 would be the number of males or females out of 100,000 live births in 2015 to 2017 expected to die between age 70 and age 71 years.

e$_x$

Definition - This is the average period life expectancy at exact age x, which is the average number of further years that those aged x exactly will live based on the mortality rates experienced in the specified three-year period.

Example - ex for age 70 years in 2015 to 2017 would be the average number of further years that a person aged 70 years exactly in 2015, 2016 or 2017 could expect to live if they experienced the age-specific mortality rates of the given area for 2015 to 2017 for the rest of their life.

There are two further components that we do not publish in our national life tables but which are used in the calculation.

L_x: This is the number of person years lived between age x and (x+1).

T_x: This is the number of person years lived from age x to the oldest age.

3 . How to calculate national life tables

A life table is a hypothetical calculation, the national life tables are based on mid-year population estimates and calendar year death registrations for a period of three consecutive years. The calculation of infant mortality also requires births data for the year before the three-year period.

How we calculate the national life tables

Step 1: The life table starts with 100,000 simultaneous births (l_0).

Step 2: The life table population is then calculated by multiplying 100,000 (l_0) by the mortality rate between age 0 and 1 years (q_0) to give the number of deaths at age 0 years (d_0).

Step 3: The number of deaths between age 0 and 1 years (d_0) is then subtracted from 100,000 (l_0) to give the number of people surviving to age 1 year(l_1).

Similarly, the number of people surviving to age 2 years (l_2) can be calculated by starting with the population surviving to age 1 year (l_1). This is then multiplied by the mortality rate between age 1 and 2 years (q_1) to give the number of deaths at age 1 year (d_1). This is then subtracted from the population surviving to age 1 year (l_1) to give the number of people surviving to age 2 years (l_2).

This continues through the life table until we close the national life tables at age 110 years. This means that after age 110 years, we assume the number of survivors is zero and the life table finishes.

Generally, the number dying between exact age x and x+1 is the mortality rate between age x and age x+1 multiplied by the number surviving to exact age x, which can be written as follows:

$$d_x = q_x * l_x$$

The number of survivors to age x+1 is the number surviving to exact age x minus the deaths between exact age x and x+1, which can be written as follows:

$$l_{x+1} = l_x - d_x$$

Calculating q_x

To calculate the mortality rate between age x and x+1 (q_x), the central mortality rate (m_x) must first be calculated. m_x is calculated by dividing the total number of deaths over the three-year period by the total mid-year population over the three-year period. This can be calculated using the following equation:

$$m_x = \text{total calendar year deaths/mid-year population}$$

For ages above 1 year, q_x can then be calculated using the following formula:

$$q_x = 2* m_x / (2 + m_x)$$

Below age 1 year, there is a different process for calculating infant mortality (q_0). Infant deaths at less than four weeks, one to two months, three to five months, six to eight months and nine to 11 months are summed separately for males and females over the three years T, T+1 and T+2. The "at risk" population (also known as exposures to risk, or ETR) is then derived for each group from the monthly birth figures, separately for males and females, as follows (where B_{XxxT} = births in month Xxx of calendar year T):

Four weeks:

$$\frac{^{B} Dec(T-1)}{2} + \sum_{i=Jan\,T}^{i=Nov\,(T+2)} B_i + \frac{^{B} Dec(T+2)}{2}$$

One to two months:

$$\frac{\left(^{B} Oct\,(T-1) + {}^{B} Nov\,(T+2)\right)}{4} + \frac{3 * \left(^{B} Nov\,(T-1) + {}^{B} Oct\,(T+2)\right)}{4} + \sum_{i=Dec\,(T-1)}^{i=Sep\,(T+2)} B_i$$

Three to five months:

$$\frac{\left(^{B} Jul(T-1) + {}^{B} Sep\,(T+2)\right)}{6} + \frac{\left(^{B} Aug\,(T-1) + {}^{B} Aug\,(T+2)\right)}{2} + \frac{5 * \left(^{B} Sep\,(T-1) + {}^{B} July\,(T+2)\right)}{6} +$$

$$\sum_{i=Oct\,(T-1)}^{i=Jun\,(T+2)} B_i$$

Six to eight months:

$$\frac{\left(^{B} Apr\,(T-1) + {}^{B} Jun\,(T+2)\right)}{6} + \frac{\left(^{B} May\,(T-1) + {}^{B} May\,(T+2)\right)}{2} + \frac{5 * \left(^{B} Jun\,(T-1) + {}^{B} Apr\,(T+2)\right)}{6}$$

$$\sum_{i=Jul\,(T-1)}^{i=Mar\,(T+2)} B_i$$

Nine to 11 months:

$$\frac{\left(^{B} Jan\,(T-1) + {}^{B} Mar\,(T+2)\right)}{6} + \frac{\left(^{B} Feb\,(T-1) + {}^{B} Feb\,(T+2)\right)}{2} + \frac{5 * \left(^{B} Mar\,(T-1) + {}^{B} Jan\,(T+2)\right)}{6}$$

$$\sum_{i=Apr\,(T-1)}^{i=Dec\,(T+1)} B_i$$

Each of the total groups of deaths is then divided by the corresponding at risk population (deaths/ETR) calculated previously and the results summed to give q_0.

The m_0 shown in the life table is calculated from q_0 using the following formula:

$$M_0 = 2q_0 / (2 - q_0)$$

Calculating e_x

To calculate period life expectancy at exact age x, the number of person years lived at each individual age (L_x) needs to be calculated. For ages above 1 year, where deaths can be assumed to occur evenly over a year of age, this can be taken as follows:

$$L_x = (l_x + l_{x+1}) / 2$$

Below age 1 year, it is not realistic to assume deaths occur evenly over the year and L_0 is calculated using the following formula:

$$L_0 = a_0 l_0 + (1 - a_0) l_1$$

where a_0 is the average age of death of those dying within the first year of life.

To calculate a_0, first the sums of deaths divided by the appropriate at risk population (deaths/ETR) for each age group is multiplied by the corresponding assumed average age at death given in Table 1.

These are then summed and divided by the total deaths/ETR (the sum of all the age groups). Finally, this is divided by 12 to give a_0 in years.

Table 2: Assumed average age at death in months (a_0) for those dying within the first year of life

Age at death	Assumed average age at death (months)
less than 4 weeks	0.2
1 to 2 months	1.5
3 to 5 months	4
6 to 8 months	7
9 to 11 months	10

Source: Office for National Statistics

Notes:

1. Deaths under 4 weeks based on analysis of England and Wales data for deaths under one month.

Summing the L_x column from age x to the oldest age gives the total number of years lived (T_x) from age x. The period expectation of life at exact age x is given by dividing the number of years lived by the number at that age, that is:

$$E_x = T_x / l_x$$