



# **COMPLETE LIFE TABLES OF ISRAEL**

**1997-2001**

**1998-2002**

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Total population - Males



Total population - Females



Jews and others - Males



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Jews - Males



Jews - Females



Arab population - Males



Arab population - Females

### COMPLETE LIFE TABLES OF ISRAEL - 1998-2002



Total population - Males



Total population - Females



Jews and others - Males



Jews and others - Females



Jews - Males



Jews - Females



Arab population - Males



Arab population - Females

## INTRODUCTION

This publication presents complete life tables for 1997-2001 and 1998-2002. The tables present data by single years of age, for males and females separately, for the entire population, for Jews and Others, for Jews, and for the Arab population.

The Central Bureau of Statistics produces two series of life tables - complete and abridged<sup>1</sup>. The abridged life tables (by five-year age groups) are produced annually, and complete life tables (single years of age) are produced for five-year periods (moving averages). Because different methods are used to calculate the two types of tables (see below), values of life expectancy in the complete life tables may differ from those in the abridged tables.

### MAIN FINDINGS

Life expectancy at birth in 1998-2002 was 80.8 years for females and 76.7 years for males. For Jews and Others life expectancy was 81.2 years for females and 77.0 years for males, for the Jewish population 81.2 for females and 77.2 for males, and among the Arab population 77.8 for females and 74.3 for males.

Assuming that current mortality patterns remain unchanged, then half of the females born between 1998 and 2002 can expect to live more than 83 years, and half of the males born in the same period can expect to live more than 80 years. 22.6% of the females and 14.6% of the males born between 1998 and 2002 can expect to live at least 90 years. Females aged 65 in this period can expect to live an additional 19.0 years on average, and those aged 80 can expect to live another 8.4 years on average. Males aged 65 can expect to live 16.9 more years on average, and those aged 80 can expect to live another 7.6 years on average.

The World Health Report 2003<sup>2</sup> computed life expectancies based on estimated life tables for all countries in 2002. In comparison to other industrialized countries the life expectancy of Israeli males (77.3 years) ranks relatively high (in 6<sup>th</sup> position), just below that of Australia (77.9 years), Sweden (78.0 years) and Japan (78.4 years). However, the ranking of Israeli females is lower, Israel ranks 16<sup>th</sup>, with a life expectancy of 81.4 years. Japan, France and Switzerland are at the top of the ranking, with life expectancies of 85.3 years, 83.5 and 83.3 years respectively. Germany, Belgium and New Zealand rank close to Israel.

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<sup>1</sup> See *Statistical Abstract of Israel*, Central Bureau of Statistics.

<sup>2</sup> World Health Organization, *The World Health Report 2003: Reducing Risks, Promoting Healthy Life*, Geneva, 2003.

## METHODS OF COMPUTATION

There are two types of life tables: "cohort" life tables and "period " or "current" life tables. In cohort life tables, the mortality of a particular birth cohort is observed until all individuals in that cohort die. For example, the annual mortality probabilities of persons born in 1894 could be tracked until 1993 and their mortality pattern could be obtained at every age, from birth to age 100. With this data a life table can be compiled for the whole cohort, assuming that by 1994 all of them had died.

To produce such a life table, mortality data should be assembled over a long period of time. This is practical only in "closed" populations (with no migration) which, in the case of Israel, is far from the case. Moreover, the value of a generational table is mainly historical, since it reflects mortality patterns of individuals born long ago and who lived under different conditions from those prevailing at the time the table is calculated.

Since calculating cohort life tables is impractical and because it is desirable to describe current mortality conditions, period life tables are compiled. Unlike a cohort life table, a period life table reflects the mortality conditions of a hypothetical cohort born in a given year, assuming that the mortality patterns prevalent in the given year will persist throughout its life. For example, the life table for 1990 assumes that the survivors of the generation born in 1990 will be exposed at every age from 0 to 100 to mortality rates for these ages in 1990, i.e., mortality rates are assumed to be static. The life tables presented here are complete period life tables.

Mortality rates in Israel, as in all countries, are subject to random variations (statistical error) and to a variety of non-statistical errors, such as those that arise from errors in reported year of birth or age at death. Due to both kinds of error, calculated mortality rates may differ from the "true" mortality rate, which would have been obtained if it were possible to overcome statistical and reporting errors. Statistical error is more significant the smaller the population group involved, with single years of age or short periods of time, which may lead to irregular empirical data. In order to overcome this problem it is customary to use a "smoothing" technique of some kind.

An "abridged" life table, based as it is on wide age groups and not on single years of age, is less exposed to random variations. The problems are more severe when calculating a "complete" life table bases on single years of age. Complete life tables in Israel for 1986 onwards were computed using the MORTPAK<sup>1</sup> software package, which was provided by the United Nations. The software calculates complete life tables by estimating a Heligman-Pollard (H-P) mortality model<sup>2</sup>, by the least-squares method. In recent years it became obvious that this program did not produce reasonable results for the Israeli data. The fit between the model and the empirical data was not statistically significant. It was found that the H-P model raised life expectancy at birth for all population groups (at least by 0.2 years)

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<sup>1</sup> United Nations, *MORTPAK: The United Nations' Software Package for Mortality Measurement*, 1988.

<sup>2</sup> Heligman L. and Pollard J.H., "The Age Pattern of Mortality", *Journal of the Institute of Actuaries*, no. 107, pp. 49-75, 1980.

as compared to the abridged life table. The curve of the model strays beyond the boundaries of the confidence interval of the empirical probabilities of death ( $q_x$ ). Moreover, although the parameters of the H-P model can be estimated, the statistical properties (standard deviation and significance) of the parameter estimates cannot be calculated, and thus the overall statistical significance of the model is not known. And finally, this smoothing procedure does not take account of distinct features of the Israeli data: at certain ages the smoothing procedure greatly reduces the probability of death (for example, the ages of compulsory military service) and at other ages it increases it (in particular at older ages).

For these reasons a new method of smoothing was developed by means of a two-stage polynomial function<sup>1</sup>. The model is based on the Local Maximum Likelihood method<sup>2</sup> and as well as on a technique for estimating change points<sup>3</sup>.

This method has four advantages:

- The differences between life expectancies before and after smoothing are not statistically significant.
- Statistical parameters of the model can be estimated, such as variance, confidence intervals, and statistical significance.
- The model smoothes the age-specific probabilities of death ( $q_x$ ) while taking account of the distinct features of the Israeli data.
- The method is easy and convenient to use.

In the new method life expectancy is calculated in four stages:

Stage A.: calculation of the  $q_x$  values based on single year of age mortality rates ( $m_x$ ) for each population group and each sex, on average for the five year period (1997-2001 or 1998-2002).

Stage B.: Testing the hypothesis that there is a change point in the model. If the hypothesis is not rejected we move on to stage C.

Stage C.: Smoothing the  $q_x$  values by estimating two models of the  $q_x$  function, one for the younger ages (up to the change point) and one for the older ages (after the change point).

Stage D.: Calculation of all the parameters of the life table based on the model  $q_x$  values.

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<sup>1</sup> Vexler A., Flaks N. and Paltiel A., "A Model For Calculating Complete Life Tables in Israel", 2004 (Central Bureau of Statistics, unpublished, Hebrew only).

<sup>2</sup> Fan J., Farnen M. and Gijbels I., "Local Maximum Likelihood Estimation and Inference", *J.R. Statist. Soc.*, B. no. 60, pp. 591-608, 1998.

<sup>3</sup> Koul H.L., Lianfen Q. and Surgailis D., "Asymptotics of M-estimators in Two-phase Linear Regression Models", *Stochastic Processes and Their Applications*, no. 103, pp. 123-154, 2003.

## COMPONENTS OF THE LIFE TABLE

The life table is based on age and sex-specific mortality rates, and consists of the following functions:

$m_x$ : average mortality rates at age  $x$ , i.e., the number dying at age  $x$  divided by the average population at age  $x$ . The  $m_x$  values for computing the life table for 1997-2001 are based on average mortality rates for 1997-2001 and the  $m_x$  values for computing the life table for 1998-2002 are based on average mortality rates for 1998-2002.

$q_x$ : the probability of dying between age  $x$  and age  $x+1$ . The column presents the proportion dying between age  $x$  and age  $x+1$  of those who lived until age  $x$ . The  $q_x$  values for ages of one year or more are derived from  $m_x$  values as follows:

$$q_x = \frac{m_x}{1 + \frac{1}{2}m_x}$$

$l_x$ : the number of survivors at exact age  $x$  out of 100,000 infants born (radix of the table =  $l_0 = 100,000$ ). The  $l_x$  values are based on the  $q_x$  values, on which basis the number of survivors since age  $x-1$  is calculated.

$$l_x = l_{x-1} (1 - q_{x-1})$$

$L_x$ : the number of person-years lived by the cohort that reached exact age  $x$ , between age  $x$  and age  $x+1$ .

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

The values of  $L_0$  (the number of person-years lived by the cohort between birth and its first birthday) and  $L_{100+}$  (the number of person years lived by the cohort from age 100 until the last one has died) are calculated differently for two reasons:

$L_0$  is affected by the non-linear distribution of deaths in the first year of life.

$L_{100+}$  requires an estimate of the number of years that will be lived until the last member of the cohort has died. Thus:

$$L_0 = 0.3 l_0 + 0.7 l_1$$

$$L_{100+} = 1000 (l_{100} / m_{100+})$$

$T_x$ : the total number of person-years lived by the survivors to age  $x$  after reaching age  $x$ ;  $T_x$  is the sum of  $L_x$  for all ages after  $x$ .

$e_x^o$ : the life expectancy at age  $x$ . This is the average number of years a person may expect to live after age  $x$ , assuming that he survived to age  $x$ , and assuming that mortality rates are unchanging.

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

The complete life tables presented here show the  $l_x$ ,  $q_x$  and  $e_x^o$  functions. The values are calculated up to age 100.