

**DOKUZ EYLÜL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED
SCIENCES**

**CONSTRUCTION OF MORTALITY TABLE FOR
PENSION SYSTEM AND TURKEY**

**by
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**August, 2012
İZMİR**

CONSTRUCTION OF MORTALITY TABLE FOR PENSION SYSTEM AND TURKEY

**A Thesis Submitted to the
Graduate School of Natural and Applied Sciences of Dokuz Eylül University
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**by
Hanife TAYLAN**

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İZMİR**

M.Sc THESIS EXAMINATION RESULT FORM

We have read the thesis entitled “**CONSTRUCTION OF MORTALITY TABLE FOR PENSION SYSTEM AND TURKEY**” completed by **HANİFE TAYLAN** under supervision of **ASSOC. PROF. DR. GÜÇKAN YAPAR** and we certify that in our opinion it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Science.


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CONSTRUCTION OF MORTALITY TABLE FOR PENSION SYSTEM AND TURKEY

ABSTRACT

In actuarial science and demography, a life table is a table which shows, for each age, what the probability is that a person of that age will die before his or her next birthday. Developed countries use a life table which reflects demographic structure of their countries. The purpose of this thesis is to construct a life table which is demonstrated demographic features of Turkey with changing database.

In application of this thesis, Turkey Abridged Period Life Tables are constructed by using population, deaths and births data which are published by TÜİK. The tables are obtained for general, female and male population in section 5.4. The forecasting of older ages pattern of mortality have been necessaried because of increasing older population. Thus, number of person lived have been estimated for older ages in section 5.4.1. In section 5.4.2, Abridged Period Life Tables have been finally formed for regions that are determined in level IBBS-1 by TÜİK. In section 5.3, The Exponential Smoothing Method is used for modeling death rates of urban and general population. The death rates of urban population are forecasted by using smoothed constant are compared the real deaths rates of general population. As a result of this analysis showed us, trend of urban and general death rates are different to each other.

In this thesis, Turkey Life Tables are constructed by using survival analysis. And the methodology of survival analysis is explained in section 2. Moreover, demographic approach is used for period life table analysis which is explained in section 3.

Keywords: Survival analysis, life/mortality table, period life table, exponential smoothing.

TÜRKİYE VE SOSYAL GÜVENLİK SİSTEMİ İÇİN YAŞAM TABLOSUNUN OLUŞTURULMASI

ÖZ

Yaşam tablosu aktüerya bilimi ve demografi alanında bir toplumda yaşayan insanların her bir yaş için ölüm ve yaşama olasılıklarının gösterildiği tablolardır. Gelişmiş ülkeler kendi demografik yapılarını yansıtan yaşam tablolarını kullanırlar. Bu çalışmanın amacı değişen veri kayıt sistemi ile birlikte ülkemizin demografik yapısını yansıtan yaşam tablolarının oluşturulmasıdır.

Bu tezin uygulamasında, Türkiye İstatistik Kurumundan (TÜİK) elde edilen ölüm, nüfus ve doğum verileri kullanılarak Türkiye Özetlenmiş Dönem Yaşam Tabloları elde edilmiştir. Tablolar uygulama bölümü 5.4'te Türkiye geneli, kadın ve erkek nüfus için oluşturulmuştur. Ülkemizde giderek artan yaşlı nüfusu, oluşturulan yaşam tablolarının ileriki yaşlar için tahminini gerekli kılmıştır. Bu yüzden 5.4.1'de yaşayan kişi sayısı yaşlı nüfus için tahmin edilmiştir. Son olarak bölüm 5.4.2'de TÜİK tarafından İBBS-1 düzeyinde tanımlanan bölgeler için Özetlenmiş Dönem Yaşam Tabloları oluşturulmuştur. Bölüm 5.3'te il-ilçe ve genel nüfusun ölüm oranlarının modellenmesi için üstel düzleştirme yöntemi kullanılmıştır. İl-ilçe nüfusunun ölüm oranları, düzleştirme sabitleri kullanılarak tahmin edilmiştir. Elde edilen tahmin değerleri genel nüfusun gerçek ölüm oranlarıyla karşılaştırılmıştır ve il-ilçe ve genel nüfusun ölüm oranlarının trendlerinin farklı olduğu görülmüştür.

Yaşam tablosu oluşturmak için yaşam sürelerinin modellenmesini sağlayan sağkalım analizi kullanılmıştır ve metodolojisi bölüm 2'de anlatılmıştır. Ayrıca bu çalışmada dönem yaşam tablosu analizi için geliştirilen demografik yaklaşımlar kullanılmış ve bölüm 3'te metodolojisi anlatılmıştır.

Anahtar Kelimeler: Sağkalım analizi, yaşam tablosu, dönem yaşam tablosu, üstel düzleştirme yöntemi.

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CHAPTER ONE

INTRODUCTION

Improvement for life conditions, developments in medical and technological conditions yields change of demographic structure in our country. These developments caused longevity and increase the rate of older population. Increase in older population creates many risk factors such that decrease in working population, longer pensions, rise in health expense, charge on younger population and rising in social problems. Besides these risk factors, lengthen life expectancy which is an important indicator of development and health shows that the prosperity of a country rises (Çiftçi, 2008). According to the study which is completed by the researchers at the department of gerontology of Mediterranean University in 2012 states that population is getting older in Turkey. Modeling pattern of mortality and forecasting future demographic structure have an important role in the management of social security, employment and renovation of health system for our country.

Analyzing some indicators related with life such as probability of deaths, number of survivors, number of deaths and survivals, life expectancy and so on can be obtained by constructing life table which demonstrates country's demographic structure. Unfortunately, studies in our country have not been progressed because of lack of reliable database. Since reliable and official data which is necessary for demographic researches was declared in 2009.

First attempt for construction of Turkey Life and Life Annuity tables using Preston Bennett method tended together with some academicians by Republic of Turkey, Prime Ministry, Under Secretariat of Treasury (Haymer, 2010). The last study in Turkey is constructed the complete period life table of 2009, and in this study, Heligman and Pollard method which is approach interpreted with different eight parameters is used by Smoothing method (Şirin, 2011).

Life tables are widely used in many areas. In particular, these tables are crucial in actuary and demography. The tables is used some areas such as product creation and

premium assurance calculation in insurance, calculation of health expenditure and social security obligations in pension system. In demography, life tables can be used to distinguish different risk factors for life expectancy, such as smoking status, occupation, socio-economic class and others. Moreover, as clinical and epidemiologic researches become more common, the life table analysis has been applied to patients with a given disease who have been followed for a period of time (Lee & Wang, 2003).

Survival analysis is the phrase used to describe the analysis of data in the form of times from a well-defined time origin until the occurrence of some particular event or end point. Life table is obtained by analyzing occurrence time until people die in a population. The survival analysis is used not only in examination of mortality but also in examination of measure process. Mentioned process is determined time from the beginning of any event to ending and it can be applied for living and nonliving units. The process is used in many areas such as; i) analyzing treatment time of a disaster and analyzing survival time of patient with cancer in medical area (Ferlay et al, 2006), ii) measure of unemployment times in economic area, iii) analyzing breakdown times for any tool in industry area, iv) analyzing marriage time for married couple in demography area (Preston et al, 2001), v) analyzing retirement times in pension system.

Modeling age pattern of mortality is a specific field in life table analysis. The search for a mathematical model of age variation in mortality risk is called mortality law. The development of a 'law of mortality', a mathematical expression for the graduation of the age pattern of mortality, has been of interest since the development of the first life tables by John Graunt (1662) and Edmund Halley (1693). Although Abraham De Moivre proposed a very simple law as early as 1725 the best known early contribution is probably that of Benjamin Gompertz (1825). The shape of mortality curve includes many parameters. "Law of geometric progression pervades" was first noticed by Gompertz (1825) and was also suggested representing the mortality risk for a certain age. Makeham (1860) considered to act of age and suggested adding a constant to Gompertz's model. For older ages the laws are

commonly used smooth data (Horiuchi and Coale, 1982). Suggestions' belonging to Gompertz and Makeham applied to younger ages tends to over predict mortality (Horiuchi and Coale, 1990).

The best-fitting are the functions including the age pattern of mortality in childhood, young adulthood and senescence. The Heligman Pollard model (Heligman & Pollard, 1980) also has eight parameters; each term takes positive values only at relevant ages, the whole function being estimated in one step. The parameters have meaningful interpretations. Others encountered difficulties, particularly in determining the best base period for projecting the parameters (Keyfitz, 1991) and (Pollard, 1987). McNown and Rogers (1989) modeled the eight parameters as univariate ARIMA processes.

The Heligman Pollard model represents senescent mortality using the Gompertz function; three variants were also proposed. This method is still used in United States population by National Center for Health Statistics. (Arias, 2010). Kostaki (1992) introduced a ninth parameter to improve the fit at young adult ages.

The Brass Relational Logit Model (1971) are used for forecasting at an older ages mortality. The relational model of mortality (Brass, 1971) linearly relates the logit transformations of observed and standard mortality. Forecasts based on this model include those by Golulapati, De Ravin, and Trickett (1984) for Australian male cohorts and Keyfitz (1991) for Canadian data.

McNown and Rogers (1989) was suggested projection methods of forecasting the hazard or mortality and was also used the functional form of Heligman Pollard (1980) to explain age behavior with time series model. McNown and Rogers (1992) forecast total mortality and five cause-specific mortalities by fixing six parameters and modeling only the level parameters by univariate ARIMA models.

Method of exponential smoothing is another approach for smoothing and forecasting mortality rates. Modeling future age-specific breast cancer mortality

using state-space exponential smoothing models as described by Hyndman et al (2002) and similarly by Erbas et al (2005). Exponential smoothing method is applied for forecasting age-related changes in breast cancer mortality among white and black US women (Yasmeen et al, 2010).

Life tables describe the mortality and survival experience of a population. These tables can be described different forms as period or cohort. Cohort life table explains the survival and mortality pattern for people who are all born in the same year or in the same period. Period life-tables are synthetic constructs that show what the mortality patterns of a hypothetical group of persons would be if they experienced the death rates observed in a population during a given period. In the United states, cohort and period life tables by age, sex and race are published from time to time by the National Center of Health Statistics (NCHS). Similar to Australian Life Tables (Cohort and Period life tables) are issued by Australian Bureau of Statistics (ABS). In United Kingdom period life tables are constructed by The Government Actuary, based on the mortality experience of general populations in England and Wales, known as English Life Tables, and in Scotland. At 2006, responsibility for the production of national life tables transferred to the Office for National Statistics (ONS). In New Zealand, similar period and cohort life tables are published by Statistics New Zealand (SNZ). These tables are constructed from registrations of births, deaths and population estimates.

Cohort life-tables have the advantage of conceptual simplicity, but the disadvantage of requiring data for, and referring to mortality risks over a very long time span. Since the upper limit of human life is about 100 years, a cohort life table can be constructed only for groups of persons born at least one hundred years ago. Even when such life-tables can be constructed and this is not possible for many countries of the world, including many developed countries they represent mortality experience over a very long period.

Period life tables are conceptually more complex, but have the advantage of providing mortality measures localized in time. It shows the change in expectation of

life at birth from one year to the next. Most life-tables available for human populations are, in fact, period life-tables. It is also possible to distinguish between period and cohort statistics in a more general way because life-table measures can be constructed on the basis of cohort experience over just a portion of the human life span. Period mortality statistics are those calculated on the basis of deaths observed during a given period and cohort statistics are those calculated on the basis of all deaths occurring to a particular group of persons followed over time.

In this thesis, the period life tables will be constructed by interpreting mortality experience of Turkey. The study consists of five chapters. In the first chapter, the introduction containing the areas of usage life table and the development of the life table analysis concepts which are the modeling mortality experience and the demographic approach are introduced. In the second chapter, the notations of the survival theory is explained in detail. In the third chapter, the notations of the Period Life Table is introduced and explained in detail by using demographic approach. In the fourth chapter, the exponential smoothing method is explained in detail. In the fifth chapter, the data of deaths are analyzed according to one parameter double exponential smoothing method and the period life tables are constructed by gender and region for Turkey. In the last chapter, the deductions gathered from the application are interpreted.

CHAPTER TWO

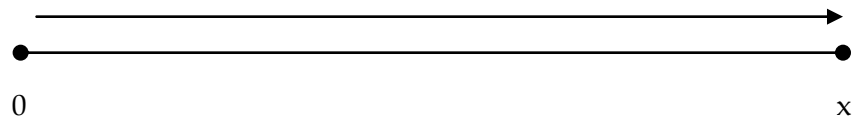
LIFE TABLE ANALYSIS

2.1 Survival Models

A survival model is a probabilistic model of a random variable that represents the time until the occurrence of an unpredictable event such as failure, deaths, response, relapse or divorce. For instance, we may wish to study the life expectancy of a newborn baby, the future working lifetime of a person until he/she retires or the lifetime of a machine until it fails. In both cases, we study how long the subject may be expected to survive. The focus of our study is the time until the specified event takes place which is known as waiting time or a random time until the specified event occur. Probabilities associated with these models play a central role in actuarial calculations such as life table. The life table method measures mortality and describes the survival patterns of a population. It has been used by actuaries, demographers, agencies and medical researchers in studies of survival, population growth, fertility, migration, length of married life and so on (Lee & Wang, 2003). In this part, we study the theory of survival models in mortality table functions.

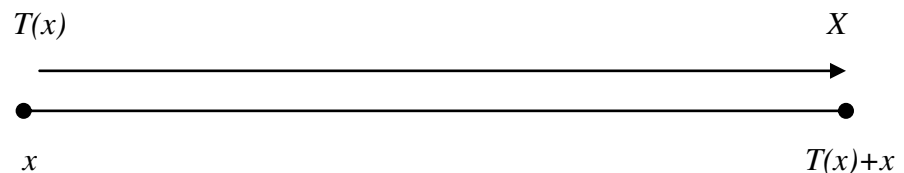
Random lifetime, complete future lifetime and curtate future lifetime are three basic variables, all of which are measured in years (Bowers et al, 1997):

- The random lifetime of a newborn life is denoted by X .



- The complete future lifetime at age x , given that a newborn has survived to age x , is denoted by $T(x)$.

$$T(x) = (X - x | X > x)$$



- The curtate future lifetime at age x , given that a newborn has survived to age x , is the complete number of years of future lifetime at age x and is denoted by $K(x)$.

$$K(x) = [T(x)]$$

It should be pointed out that in order to understand three concepts: X and T are assumed to be continuous random variables while K is a discrete random variable. K is a function of T and K is the integer part of T . In the same way T is a function of X . So these random variables are associated with each other. Life tables are pivot tables constructed for actuarial calculations and life insurance and definitely example for discrete survival models. When to construct a life table, choosing an initial age is chosen firstly and enough number of persons is assumed lives at that age. Number of persons at initial age is called radix number and this number is generally an integer value multiples of ten like 100,000, 1,000,000 or 10,000,000. When life table is constructed, some variables are defined which are denoted by l_x , d_x , q_x and p_x . The formula of the variables is given as follows (Cunningham et al, 2006). l_x is defined as the number of lives expected to age x from a group of l_0 newborn lives. d_x represents the number of lives among l_0 newborns die in the age range x to $x+1$. It is formulated as:

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

In life table, q_x is defined as a probability that a person currently at age x will die within a year and it is calculated as:

$$q_x = \frac{d_x}{l_x} = \frac{l_x - l_{x+1}}{l_x}$$

In a life table, p_x is defined as a probability that a person currently at age x will survive the following age and it is calculated as:

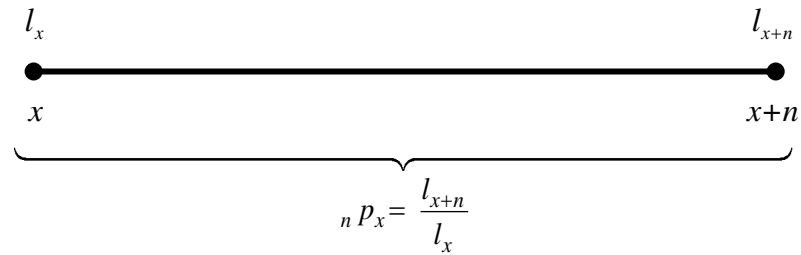
$$p_x = \frac{l_{x+1}}{l_x}$$

Clearly not the case, there are two options that a person at age x , will survive or die within a year. There is no other option. According to the general concept of

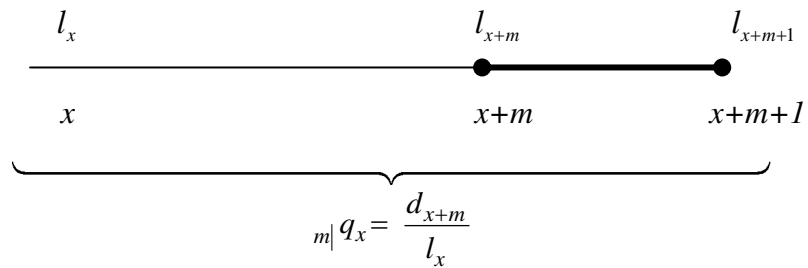
probability, life and death variables are complement of each other for any age. So the probability of death and life will be one for any age.

$$p_x + q_x = 1$$

Moreover, the probability of death and life can be calculated for each age interval (Gauger, 2006). The probability that a life currently at age x , will survive n years and it is denoted by ${}_n p_x$.



Another formula states the probability that a life currently at age x will survive for m years and then die within one year is denoted by ${}_m q_x$. d_{x+m} people die at the age of $x+m$ from the l_x people whom lives at the age of x then formula is attained as follows:



Lastly states the probability that a life currently at age x will survive for m years and then die within n years is denoted by ${}_m|_n q_x$. This probability can be calculated as:

$${}_{m|n}q_x = \frac{d_{x+m} + d_{x+m+1} + \dots + d_{x+m+n-1}}{l_x} = \frac{l_{x+m} - l_{x+m+n}}{l_x}$$

In actuary, at the expression ${}_{m|n}q_x$, sign m which is at the left side of the symbol $|$ shows waiting time and it is called deferred time, and which is at the right of the symbol $|$ shows desired time after waiting time.

Life tables can be defined as probabilistic. Let the random number of survivors at age x in life tables from the l_0 newborn babies. If the probability of any babies survival at the age of x states $p = \Pr(X > x) = s_x(x)$, the number of survivors at age x from the l_0 newborn babies can be distributed binomial (Slud, 2001). The parameters of binomial distribution are $n = l_0$ and $p = s_x(x) = {}_x p_0$. Because any individuals are bernoulli trials and the probability of success is survived at age x for any individuals. So the variance and the expected value of number of survivors at age x can be find by fallowing equations:

$$E[L(x)] = l_x = np = l_0 s_x(x)$$

$$Var[L(x)] = npq = l_0 s_x(x)(1 - s_x(x)).$$

Four mathematical functions will be defined at this part. Then these functions will be used to define new random variables and estimate future lifetime (Bowers et al).

2.1.1 Cumulative Distribution Function

X is assumed to be a continuous random variable of a newborn that has a random lifetime (age of death). The probability that a newborn will die at or before x is defined by cumulative distribution function (cdf) and denoted with $F_x(x)$:

$$F_X(x) = \Pr(X \leq x) = {}_x q_0.$$

It is possible to calculate cdf from probability density function (pdf). If the probability density function of random variable, X , is known, then the cumulative density function can be calculated by:

$$F_X(x) = \Pr(X \leq x) = \int_0^x f_X(u) du.$$

$F_X(x)$ is non-decreasing and continuous with $F_X(0) = 0$ and $F_X(w) = 1$ where w is the first age at which death is certain to have occurred for a newborn life.

2.1.2 Probability Density Function

The probability density function is obtained by derivation of cumulative density function of a continuous random variable. Then, the probability density function of a random lifetime is:

$$f_X(x) = F'_X(x) = \frac{d}{dx} F_X(x).$$

Assuming that X is a continuous random variable, then the probability that a newborn life dies between ages x and z :

$$\Pr(x < X \leq z) = \int_x^z f_X(u) du = F_X(z) - F_X(x).$$

It should be remarked that $F_X(x)$ is a probability of certain time interval as $f_X(x)$ is not a probability but also is a value. The probability that a newborn life dies in the interval $[x, x + \Delta x]$ can be estimated as:

$$\Pr(x \leq X \leq x + \Delta x) \approx f_X(x) \cdot \Delta x.$$

And the properties of probability density function of a newborn life at age x is:

- $f_X(x)$ is a continuous and nonnegative function in a range of $[0, w)$.
- $\int_0^w f_X(x) dx = 1$

2.1.3 Survival Function

The survival function, $s_x(x)$, is defined as the probability of a newborn life survives to age x or is alive at age x and represented as follows:

$$s_x(x) = \Pr(X > x) = 1 - \Pr(X \leq x) = 1 - F_x(x) = {}_x p_0.$$

Survival function is equal to one minus cumulative distribution function so this relation showed that survival function is a probability of a certain time interval. The listed properties of survival functions of a newborn life at age x are given as follows:

- $s_x(x)$ is a continuous and decreasing function.
- $s_x(0) = 1$ and $s_x(w) = s_x(\infty) = 0$
- $s_x(x) = \frac{l_x}{l_0} = {}_x p_0$
- $s_x(x) = 1 - F_x(x)$
- $f_x(x) = -s'_x(x) = -\frac{d}{dx} s_x(x)$
- $\Pr(x < X \leq z) = \int_x^z f_x(u) du = s_x(x) - s_x(z)$

2.1.4 Force of Mortality

In actuarial science, force of mortality represents the instantaneous rate of mortality at a certain age measured on an annualized basis. It is identical to failure rate in concept, also called hazard function in reliability theory. In a life table, we consider the probability of a person dying from age x to $x + 1$, called q_x . In the continuous case, we could also consider the conditional probability of a person who has attained age (x) dying between ages x and $x + \Delta x$, which is

$$\begin{aligned} \Pr(\Delta x) &= \Pr(x < X \leq x + \Delta x | X > x) = \frac{F_x(x + \Delta x) - F_x(x)}{1 - F_x(x)} \\ &\cong \frac{f_x(x) \Delta x}{1 - F_x(x)} = \frac{f_x(x)}{1 - F_x(x)} \end{aligned}$$

where $F_X(x)$ is the distribution function of the continuous age-at-death random variable, X . As Δx tends to zero, so does this probability in the continuous case. The approximate force of mortality is this probability divided by Δx . If we let Δx tend to zero, we get the function for **force of mortality**, denoted by $\mu(x)$:

$$\mu_X(x) = \frac{F'_X(x)}{1 - F_X(x)}$$

Since $f_X(x) = F'_X(x)$ is the probability density function of X , and $s_X(x) = 1 - F_X(x)$ is the survival function, the force of mortality can also be expressed variously as:

$$\mu_X(x) = \frac{f_X(x)}{1 - F_X(x)} = \frac{f_X(x)}{s_X(x)} = \frac{-\frac{d}{dx}s_X(x)}{s_X(x)} = -\frac{d}{dx} \ln s_X(x)$$

So the force of mortality is given, the survival function can be obtained by using integrated formula as:

$$\mu_X(x) = -\frac{d}{dx} \ln s_X(x) \Rightarrow \int_0^x \mu_X(t) dt = -\ln s_X(x)$$

To understand conceptually how the force of mortality operates within a population, consider that the ages, x , where the probability density function $f_X(x)$ is zero, there is no chance of dying. Thus the force of mortality at these ages is zero.

The force of mortality $\mu(x)$ can be interpreted as the conditional density of failure at age x , while $f_X(x)$ is the unconditional density of failure at age x . The unconditional density of failure at age x is the product of the probability of survival to age x , and the conditional density of failure at age x , given survival to age x .

This is expressed in properties of force mortality as

- $\mu(x)$ is a piece wise continuous and nonnegative where defined
- $\int_0^\infty \mu(y) dy = \infty$ in order that $s_X(\omega) = 0$
- $\mu_X(x) = \frac{f_X(x)}{s_X(x)} = -\frac{s'_X(x)}{s_X(x)} = -\left(\ln(s_X(x))\right)' = -\frac{l'_x}{l_x}$

- $s_X(x) = \exp\left(-\int_0^x \mu(y) dy\right)$
- $\mu_X(x) \cdot \Delta x \approx \Pr(X \leq x + \Delta x | X \geq x)$

Note that standard probabilities in a continuous survival model which is connected with life table functions defined that:

Conditional on survival to age x , the probability of living to reach age $x+t$ is:

$${}_t p_x = \frac{l_{x+t}}{l_x} = \frac{s_X(x+t)}{s_X(x)} = \frac{\Pr(X > x+t)}{\Pr(X > x)} = \Pr(X > x+t | X > x)$$

Conditional on survival to age x , the probability of dying within n years is:

$${}_t q_x = \frac{l_x - l_{x+t}}{l_x} = \frac{\Pr(X > x) - \Pr(X > x+t)}{\Pr(X > x)} = \Pr(X \leq x+t | X > x)$$

Conditional on survival to age x , the probability of living within s years but dying in the following t years is:

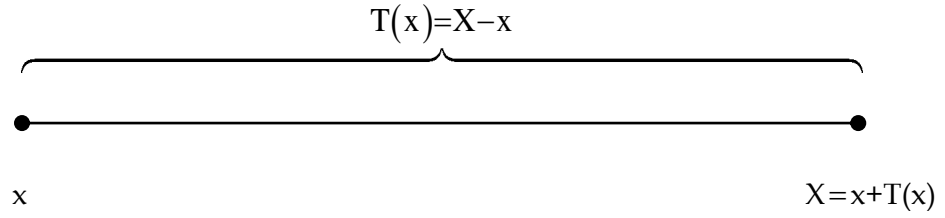
$${}_{s|t} q_x = \frac{l_{x+s} - l_{x+s+t}}{l_x} = \Pr(x+s < X \leq x+s+t | X > x)$$

2.1.5 Complete Future Lifetime

According to that X is a continuous random lifetime of a newborn that is given survival age x , the future lifetime after age x will be $X - x$. This random variable is called complete future lifetime and denoted by $T(x)$. The conditional distribution of the time lived after age x , given survival to age X , is:

$$T(x) = (X - x | X > x)$$

X and $T(x)$ are to be the same value for a newborn (age $x=0$). But it should be known that a random variable X is defined by $X = x + T(x)$ in here.



Using the relationship between the random variable X and random variable $T(x)$ and using the properties of conditional distribution, survival function of a complete future lifetime after age x is obtained as follows:

$$\begin{aligned} s_{T(x)}(t) = {}_t p_x &= \Pr(T(x) > t) = \Pr(X > x+t | X > x) \\ &= \frac{\Pr(X > x+t \cap X > x)}{\Pr(X > x)} = \frac{\Pr(X > x+t)}{\Pr(X > x)} = \frac{s_x(x+t)}{s_x(x)}. \end{aligned}$$

The distribution function of $T(x)$ is meant that conditional on survival age x , the probability of dying within t years and is obtained as follows:

$$F_{T(x)}(t) = {}_t q_x = \Pr(T(x) < t) = \Pr(X \leq x+t | X > x).$$

The probability density function of $T(x)$ is calculated to use the derivative of distribution and survival functions of complete future lifetime.

$$f_{T(x)}(t) = \frac{d}{dt} F_{T(x)}(t) = -\frac{d}{dt} \frac{s_x(x+t)}{s_x(x)} = \frac{f_x(x+t)}{s_x(x)} \quad 0 \leq t \leq w-x$$

Using the equation of $\mu_x(x) = \frac{f_x(x)}{s_x(x)}$, the force of mortality of $T(x)$ is computed

as follow:

$$f_{T(x)}(t) = \frac{f_x(x+t)}{s_x(x)} = \frac{s_x(x+t)\mu_x(x+t)}{s_x(x)} \Rightarrow \mu_x(x+t) = \frac{f_x(x+t)}{s_x(x+t)}.$$

There are expressed to properties of complete future lifetime as:

- $s_{T(x)}(t) = \Pr(T(x) > t) = {}_t p_x = \frac{s_x(x+t)}{s_x(x)} = \frac{l_{x+t}}{l_x}$

- $F_{T(x)}(t) = \Pr(T(x) \leq t) = {}_tq_x = \frac{F_X(x+t) - F_X(x)}{s_X(x)} = \frac{l_x - l_{x+t}}{l_x}$
- $f_{T(x)}(t) = \frac{f_X(x+t)}{s_X(x)} = {}_tp_x \cdot \mu_X(x+t)$.

2.1.6 Curtate Future Lifetime

Recall that X is a continuous random variable of a newborn life and $T(x)$ is a complete future lifetime currently at age x and $K(x)$ is a curtate future lifetime currently at age x , is an integer value of complete future lifetime. X and $T(x)$ are continuous random variables while $K(x)$ will be a discrete random variable. Under the survival models it is defined as $K(x) = [T(x)]$. The possible values of $K(x)$ are the numbers $(0, 1, 2, 3, \dots, w-x-1)$. The key observation is that $K(x) = k$, then we must have:

$$k \leq T(x) < k+1$$

It is simple to calculate the probability function of curtate future lifetime after age x from what it is known about $T(x)$:

$$\begin{aligned} {}_k|q_x &= \Pr(K(x) = k) = \Pr(k \leq T(x) < k+1) \\ &= \Pr(x+k \leq X < x+k+1 | X > x) \\ &= \frac{d_{x+k}}{l_x} = \frac{l_{x+k} - l_{x+k+1}}{l_x} \quad ; \quad k = 0, 1, 2, \dots, w-x-1 \end{aligned}$$

and the distribution function of $K(x)$ is calculated as:

$$\begin{aligned} F_{K(x)}(k) &= \Pr(K(x) \leq k) = \Pr(K(x) = 0) + \dots + \Pr(K(x) = k) \\ &= \sum_{h=0}^k {}_h|q_x = {}_{k+1}q_x \end{aligned}$$

and finally survival function of $K(x)$ is calculated from distribution function as:

$$s_{K(x)}(k) = \Pr(K(x) > k) = 1 - F_{K(x)}(k) = 1 - {}_{k+1}q_x = {}_{k+1}p_x.$$

2.1.7 The Functions of Life Table

Recall that relationship of the $s_x(x)$ and l_x is given as $l_x = l_0 \cdot s_x(x)$. In there, a new two mortality table function derived from l_x and these functions are useful devices in the calculation of life expectancy. First one is the number of person years lived by the survivors to age x during the next year and denoted by L_x .

$$L_x = \int_x^{x+1} l_y dy$$

The other function is aggregate person years lived from age x to last age $\omega - 1$ and denoted by T_x . Consider a brief time interval $[y, y + \Delta y]$ that is a part of the interval $[x, \omega]$. At the start of this brief period there are l_y survivors. It can be estimated that the total people years lived by the survivors during this brief period by $l_y \Delta y$. This approximation ignores the possibility that anyone dies in the short time available. These people years lived over a set of disjoint sub intervals of length Δy comprising the age interval $[x, \omega]$ are summed, then a Riemann sum for the integral $\int_x^w l_y dy$ is obtained. This Riemann sum can be interpreted as an approximation to the total number of people years lived after age x by the survivor to age x . Taking a limit as Δy goes to zero, then it has been the integral:

$$T_x = \int_x^w l_y dy = L_x + L_{x+1} + \dots + L_{w-1}$$

The function of L_x includes one year period as The function of T_x includes a time period from age x to last age $\omega - 1$.

2.2 Expected Survival Periods

In this part, we will deal with the expected future lifetime values of random survival future lifetime, X , random complete future lifetime, $T(x)$, and curtate future

lifetime, $K(x)$. We will be making assumptions on future lifetimes by making modifications on these random variables.

2.2.1 Curtate Life Expectancy

We can obtain moments of random variables for the lifetime of a newborn until death; in other words, survival period. Most important of these moments is the expected lifetime or survival period of a newborn. The continuous random variable that defined as X was a survival period of a newborn baby. If we can find the expected value of this variable; then we can find the curtate life expectancy of a newborn and symbolize this expected value with 0e_0 . In this section, we have attended to the calculations of this expected value. As we have mentioned in the earlier sections, X is a continuous random variable. The expected value of X is defined as follows;

$${}^0e_0 = E[X] = \int_0^{\infty} x f_X(x) dx$$

Since curtate life expectancy of a newborn can be calculated using survival function, the integral above can be solved with partial integration. It's form is given by

$$\int u dv = uv - \int v du$$

$$\text{where } u = x \Rightarrow du = dx \quad \text{and} \quad f_X(x) dx = dv \Rightarrow -s_X(x) = v$$

The curtate life expectancy of a newborn is again obtained by partial integration and the use of survival function

$${}^0e_0 = E[X] = \int_0^{\infty} x f_X(x) dx = \underbrace{\left(-x s_X(x) \right) \Big|_0^{\infty}}_0 + \int_0^{\infty} s_X(x) dx = \int_0^{\infty} s_X(x) dx$$

2.2.2 Remaining Life Expectancy

Under this heading, we will deal with the moments of $T(x)$ random variable defined for survival period. By calculation of the expected value of the random

variable $T(x)$, expected value of remaining life of a person aged x can be calculated.

The value is shown with ${}_x e_0$ and formulated as follows

$${}_x e_0 = E[T(x)] = \int_0^{\infty} t f_{T(x)}(t) dt = \int_0^{\infty} t \frac{f_X(x+t)}{s_X(x)} dt = \frac{1}{s_X(x)} \int_0^{\infty} t f_X(x+t) dt$$

Integral in the equation can be solved using partial integration as done in the previous section and

$${}_x e_0 = \frac{1}{s_X(x)} \int_0^{\infty} s_X(x+t) dt = \int_0^{\infty} \frac{s_X(x+t)}{s_X(x)} dt = \int_0^{\infty} {}_t p_x dt$$

is obtained. Expected value formula we have found can be denoted with L_x and T_x as following;

$${}_x e_0 = E[T(x)] = \int_0^{w-x} t f_{T(x)}(t) dt = \int_0^{w-x} s_{T(x)}(t) dt = \int_0^{w-x} \frac{l_{x+t}}{l_x} dt = \frac{\int_0^{w-x} l_{x+t} dt}{l_x}$$

if alteration of variable $y = x+t$ is made in the equation, we get the result as;

$${}_x e_0 = \frac{\int_0^{w-x} l_{x+t} dt}{l_x} = \frac{\int_x^w l_y dy}{l_x} = \frac{T_x}{l_x}$$

Another expected value is **expected survival of a person aged x in a given or limited period**. We shall define a new random variable and obtain a function of survival of an individual aged x in the following n year period before we find the expected value of such a variable.

$$T(x) \wedge n = \begin{cases} T(X) & ; \quad T(x) \leq n \\ n & ; \quad T(x) > n \end{cases}$$

Expected value of this newly defined variable gives us the life expectancy of an individual aged x in the following n years period. Calculated with the formula

$${}_x e_{\overline{n}|} = E[T(x) \wedge n] = \int_0^n s_{T(x)}(t) dt$$

and shown as ${}_0e_{x:n}$.

The expected value formula can be again expressed in terms of the L_x and the T_x functions as;

$${}_0e_{x:n} = E[T(x) \wedge n] = \int_0^n s_{T(x)}(t) dt = \int_0^n \frac{l_{x+t}}{l_x} dt = \frac{\int_0^n l_{x+t} dt}{l_x}$$

If variable alteration is made in the equation $y = x + t$, we then get

$${}_0e_{x:n} = \frac{\int_0^n l_{x+t} dt}{l_x} = \frac{\int_x^{x+n} l_y dy}{l_x} = \frac{T_x - T_{x+n}}{l_x}.$$

2.2.3 Remaining Curtate Lifetime Expectancy

Expected value of the discrete random variable $K(x)$ defined for survival period found and remaining **curtate life expectancy value** can then be calculated and shown with the symbol e_x . Expected value of the $K(x)$ random variable can be calculated as;

$$\begin{aligned} e_x &= E[K(x)] = \sum_{k=0}^{w-x-1} k \Pr(K(x) = k) \\ &= \sum_{k=0}^{w-x-1} k {}_k|q_x = \sum_{k=0}^{w-x-1} k \frac{d_{x+k}}{l_x} \\ &= \frac{d_{x+1} + 2d_{x+2} + \dots + (w-x-1)d_{w-1}}{l_x} \\ &= \frac{l_{x+1} - l_{x+2} + 2(l_{x+2} - l_{x+3}) + \dots + (w-x-1)(l_{w-1} - l_w)}{l_x} \\ &= \frac{l_{x+1} + l_{x+2} + l_{x+3} + \dots + l_{w-1}}{l_x} \\ &= p_x + {}_2p_x + {}_3p_x + \dots + {}_{w-x-1}p_x \end{aligned}$$

Now that let us find the curtate future lifetime expectancy formula of a person aged x limited with n years. Before finding the formula, a variable is defined and

shown as $K(X) \wedge n$. The expected value we are looking for then be shown as $e_{x:\overline{n}}$ and calculated as;

$$e_{x:\overline{n}} = E[K(x) \wedge n] = p_x + {}_2p_x + \dots + {}_np_x = \frac{l_{x+1} + l_{x+2} + \dots + l_{x+n}}{l_x}$$

2.2.4 Central Death Rate

Another conditional criterion is central death rate defined in the interval x and $x+n$. Central death rate is useful to find gross average death rate in an age interval or n years period, and is shown as ${}_nm_x$. General formula for computation of central death rate is as follows (Bowers et. al., 1997)

$${}_nm_x = \frac{\int_x^{x+n} s_X(y) \mu_X(y) dy}{\int_x^{x+n} s_X(y) dy}$$

Let us further extend and open the general definition above, by replacing the variable $y = x + t$

$${}_nm_x = \frac{\int_0^n s_X(x+t) \mu_X(x+t) dt}{\int_0^n s_X(x+t) dt} = \frac{\int_0^n {}_tP_x \mu_X(x+t) dt}{\int_0^n {}_tP_x dt} = \frac{{}_nq_x}{e_{x:\overline{n}}}$$

Now that we can say central death rate is the ratio of the probability of a persons' death aged x before reaching age $x+n$ to the life expectancy of a person aged x in following n years. Let us find our last expression in terms of T_x .

$${}_nm_x = \frac{{}_nd_x / l_x}{T_x - T_{x+n} / l_x} = \frac{{}_nd_x}{T_x - T_{x+n}}$$

2.3 Parametric Survival Models

In this section, it is defined some parametric distributions and models related to survival times (Lee & Wang, 2003). These distributions are supposed to be defined

in the positive domain and continuous. The aim of defining of the distributions is that they are simple and good in modeling the survival times.

2.3.1 Uniform Distribution

As it is known, uniform distribution is a two-parameter continuous distribution defined in the $[a, b]$ interval. Although it is not very suitable for human lifetime and survival times; it can be used for short periods like 1 year (Gauger, 2006). Parameters of the distribution are defined as; $a = 0$ for lower age limit and $b = w$ for upper last age. Some probabilities about the distribution are given in the table below.

Probability Function:

$$f_x(x) = \frac{1}{w} \quad 0 \leq x < w$$

Cumulative Distribution Function:

$$F_x(x) = \int_0^x f_x(t) dt = \frac{x}{w} \quad 0 \leq x \leq w$$

Survival Function:

$$s_x(x) = 1 - F_x(x) = \frac{w-x}{w} \quad 0 \leq x \leq w$$

Force of Mortality:

$$\mu_x(x) = \frac{f_x(x)}{s_x(x)} = \frac{1}{w-x} \quad 0 \leq x < w$$

Remaining Life Probability Function:

$$f_{T(x)}(t) = s_{T(x)}(t) \mu_x(x+t) = \frac{w-x-t}{w-x} \times \frac{1}{w-x-t} = \frac{1}{w-x} \quad 0 \leq t < w-x$$

2.3.2 Exponential Distribution

Exponential distribution is a single parameter non-negative continuous distribution. Most important feature of the distribution for survival models is the instant death rate is constant and equal to the value of the parameter. Although the distribution is not very suitable for human lifetimes, it is used in many different fields like in engineering, reliability analysis, service life of a machine or a lamp. Some probabilities related to the distribution are given in the table below.

Probability Function:

$$f_X(x) = \lambda e^{-\lambda x} \quad x > 0$$

Cumulative Distribution Function:

$$F_X(x) = \int_0^x f_X(t) dt = 1 - e^{-\lambda x} \quad x > 0$$

Survival Function:

$$s_X(x) = 1 - F_X(x) = e^{-\lambda x} \quad x > 0$$

Force of Mortality:

$$\mu_X(x) = \frac{f_X(x)}{s_X(x)} = \lambda \quad \text{for all } x$$

Remaining Life Probability Function:

$$f_{T(x)}(t) = s_{T(x)}(t) \mu_X(x+t) = \frac{e^{-\mu(x+t)}}{e^{-\mu x}} \times \mu = \mu e^{-\mu t} \quad t > 0$$

2.3.4 Gompertz Distribution

This distribution is a two-parameter continuous distribution proposed for lifetimes of people by Gompertz, who named the equation in 1825 (Bowers et al, 1997). Since

it is not easy to calculate all the probabilities of the distribution, most important ones are given below.

Force of Mortality:

$$\mu_x(x) = Bc^x \quad x > 0; B > 0; c > 1$$

Survival Function:

$$s_x(x) = \exp\left(-\int_0^x \mu_x(t) dt\right) = \exp\left(\frac{B}{\ln c}(1 - c^x)\right)$$

2.3.5 Makeham Distribution

This distribution is proposed for lifetimes of people by Makeham in 1860 with minor changes on the distribution proposed by Gompertz. This rearranged distribution is continuous and three-parameter (Bowers et al, 1997). Since it is not easy to calculate some of the probabilities of the distribution, most important ones are given below.

Force of Mortality:

$$\mu_x(x) = A + Bc^x \quad x > 0; B > 0; c > 1; A > -B$$

Survival Function:

$$s_x(x) = \exp\left(-\int_0^x \mu_x(t) dt\right) = \exp\left(\frac{B}{\ln c}(1 - c^x) - Ax\right)$$

2.3.6 Weibull Distribution

In the analysis of lifetime and survival periods data, Weibull distribution is widely used because it is elastic and easily changeable. Weibull distribution is a two-parameter continuous distribution which can be reduced into the more popular normal and exponential statistical distributions by using different values for parameters. Probabilities of the distribution related to survival period are given in the table below.

Force of Mortality:

$$\mu_x(x) = \lambda x^n \quad \lambda > 0; n > 0; x \geq 0$$

Survival Function:

$$s_x(x) = \exp\left(-\int_0^x \mu_x(t) dt\right) = \exp\left(\frac{-\lambda x^{n+1}}{n+1}\right)$$

CHAPTER THREE

PERIOD LIFE TABLE

3.1 Demographic Approach for Life Table

Demography is the statistical study of human populations and sub-populations. Public health and demography utilizes life tables for several uses of them. One of the basic statistical inferences can be made from life tables is the lifetime expected for a certain population. Life tables can be considered as an appropriate shortening index of death rate circumstances effective in a society (Brisbane, 2007).

It would provide a measure for the rate of death taking place at specified ages over particular periods of time by ideal depiction of human mortality. This condition is satisfied by analytical methods roughly over an extensive range of ages in the past, such as the Gompertz, Makeham, or logistics curves. Nevertheless, the uses of approximate analytical methods have become less required and suitable as the actual data have become more abundant and more dependable. In our present day, life tables, which give probabilities of death within one year at each exact integral age, are more commonly utilized to represent mortality. Such probabilities are usually founded on tabulations of deaths in a given populace and anticipation of the size of that population. In this study, life table functions can be produced from the q_x , which is the probability of deaths for a person aged x within a year. Mathematical formulas can be used to compute mortality at non-integral ages or for non-integral intervals. Although, life tables do not give such information, appropriate methods for estimating such values are identified (Bell & Miller, 2005).

Two principal forms of life tables are the cohort and period life tables. The cohort life tables record the true mortality occurrence of a particular group of individuals from the birth of its first member to the death of its last member. Period of life tables are constructed from the circumstances of mortality actualized during a single year or a given period of years by means of the experience of an artificial cohort. These

tables are practical in analyzing changes in the mortality experienced by a populace through time (Tucek, 2011).

Before the methodology of life period tables are clarified, some definitions in demography are given (Preston et al, 2001).

The term “population” is defined by demographers to denote the collection of persons alive at a specified point in time meeting certain criterion. We can count four ways of entering or leaving a population, changes in the size of population must be attributable to the extent of these flows. In particular,

$$N(T) = N(0) + B[0, T] - D[0, T] + I[0, T] - O[0, T]$$

where

$N(T)$: number of persons alive in the population at time T .

$B[0, T]$: number of births in the population between time 0 and T .

$D[0, T]$: number of deaths in the population between time 0 and T .

$I[0, T]$: number of in-migrations between time 0 and T .

$O[0, T]$: number of out-migrations from the population between time 0 and T .

We can come across with the term "rate" everywhere in demography, and it is frequently inappropriately used. Firmly speaking, a rate is a relation of a number of events (such as births, deaths, migrations) in its numerator, to a number of "person-years of exposure to risk" experienced by a populace during a certain time period in its denominator. Keeping the danger of over-simplifying in mind, we can articulate that a rate is a measure of the speed at which events take place.

$$Rate = \frac{\text{Number of Occurrences}}{\text{Person-years of Exposure to the Risk of Occurance}}$$

A period rate for a population is constructed by limiting the count of occurrences and exposure times to those pertaining to members of the population during a specified period of time.

$$Rate[0,T] = \frac{\text{Number of Occurances between time 0 and } T}{\text{Person-years of Lived in the Population between time 0 and } T}$$

There are some principal period rates in demography:

Crude birth rate: Number of births over a given period divided by the person-years lived by the population over that period. It is expressed as number of births per 1,000 populations.

$$CBR[0,T] = \frac{\text{Number of births in the population between times 0 and } T}{\text{Number of person years lived in the population between times 0 and } T} \times 1.000$$

Crude death rate: Number of deaths over a given period divided by the person-years lived by the population over that period. It is expressed as number of deaths per 1,000 populations.

$$CDR[0,T] = \frac{\text{Number of deaths in the population between times 0 and } T}{\text{Number of person years lived in the population between times 0 and } T} \times 1.000$$

Crude rate of in-migrations: Number of in-migrations per 1.000 persons into the population over a given period of time.

$$CRIM[0,T] = \frac{\text{Number of in-migrations into the population between times 0 and } T}{\text{Number of person years lived in the population between times 0 and } T} \times 1.000$$

Crude rate of out-migrations: Number of out-migrations per 1.000 persons from the population over a given period of time.

$$CROM[0,T] = \frac{\text{Number of out-migrations from the population between times 0 and } T}{\text{Number of person years lived in the population between times 0 and } T} \times 1.000$$

Crude growth rate: Rate at which population grows (increase/decrease) during a given year, as the result of natural increase plus net migration; expressed as a percentage of the base population

$$CGR[0,T] = CBR[0,T] - CDR[0,T] + CRIM[0,T] - CROM[0,T]$$

where

$$CGR[0,T] = \frac{N(T) - N(0)}{PY[0,T]}$$

Exponential population growth: Under simplified conditions, such as a constant environment (and with no migration), it can be shown that change in population size $N(t)$ through time (t) will depend on the difference between individual birth rate $b(t)$ and death rate $d(t)$, and given by:

$$\frac{dN(t)}{dt} = \frac{b(t) - d(t)}{N(0)}$$

$b(t)$: Instantaneous birth rate, births per individual per time period (t) .

$d(t)$: Instantaneous death rate, deaths per individual per time period.

$N(0)$: Current population size.

The difference between birth and death rates $(b(t) - d(t))$ is also called r , the intrinsic rate of natural increase, or the Malthusian parameter. It is the theoretical maximum number of individuals added to the population per individual per time. By solving the differential equation 1, we get a formula to estimate a population size at any time:

$$N(t) = N(0)e^{rt}$$

This equation shows us that if birth and death rates are constant, population size increases exponentially. If you transform the equation to natural logarithms (ln), the exponential curve becomes linear, and the slope of that line can be shown to be r :

$$\ln N(t) = \ln N(0) + \ln e^{rt}$$

$$\begin{aligned}
r &= \frac{\ln N(t) - \ln N(0)}{t} = \ln \frac{N(2010)}{N(2009)} \\
&= \ln \frac{6.178.723}{6.155.321} = 0,003794 \\
N_{2010} &= \frac{N(t) - N(0)}{r} = \frac{6.178.723 - 6.155.321}{0,003794} = 6.167.015 \\
{}_4m_1 &= \frac{{}_4D_1}{{}_4N_1} = \frac{4.183}{4.911.332} = 0,00085
\end{aligned}$$

where $\ln(e) = 1$. The population growth rate, r , is a basic measure in population studies, and it can be used as a basis of comparison for different populations and species (Bennett & Horiouchi, 1984).

Age-Specific rate: Rate obtained for specific age groups (age-specific fertility rate, death rate, marriage rate, illiteracy rate, or school enrollment rate etc.).

Mortality: Deaths as a component of population change.

Infant mortality rate: The number of deaths of infants under age 1 per 1,000 live births in a given year.

3.2 Construction of Period Life Table

The life table is one of the oldest statistical methods for measuring mortality or for the study of any event which has an associated waiting time. The data source dichotomizes life tables into the actuarial/demographic type constructed from vital statistics data. In this type of life table the event of interest is death. Usually the life table is viewed as the experience of an actual or synthetic cohort.

The notation and definitions are those given by Shryock, Siegel, and Associates (1971). Numerous methods are available for constructing an actuarial/demographic life table. Some well known methods are those of Reed and Herrel (1939), Greville (1943), Chiang (1968, 1972), Fergany (1971), and Keyfitz and Frauenthal (1975). Construction of period life table steps is listed as follow:

Step 1: The ratio ${}_nM_x$ is often called the age specific death rate and it is obtained that number of deaths in the age range x to $x+n$ between time 0 and T divided by number of person years lived in the age x to $x+n$ between time 0 and T . We define as (NVSR, 2010):

$${}_nM_x = \frac{{}_nD_x}{{}_nN_x} \approx {}_nm_x$$

Step 2: the average person years lived in the interval by those dying in the interval is denoted by ${}_na_x$ and it is estimated in this step. Methods for estimating ${}_na_x$ are as follows (Preston et al 2001):

- Direct observations
- Graduation of the ${}_nm_x$ function
- Barrowing values
- Rules of thumb

Step 3: The likelihood of dying in age between x and $x+n$ is calculated and it is denoted by ${}_nq_x$. To obtain ${}_nq_x$, the ${}_nm_x$ values needs to be adapted. Death rates of specific age are altered to probabilities of dying at a specific age. By this transformation, from the set of observed period age specific death rates are converted into a set of age specific probabilities of dying. Conversion of these death rates of specific age to the probabilities of dying at a specific age is usually accomplished by referring to the relation between them in an actual cohort. An equal expression of the related formula for the conversion can be derived by replacing the l_x term in the formula for age specific probabilities of dying.

$${}_nL_x = n.l_{x+n} + {}_na_x \cdot {}_nd_x \rightarrow {}_nq_x = \frac{{}_nd_x}{l_x} = \frac{{}_nm_x}{1 + (1 - {}_na_x) {}_nm_x}$$

${}_nL_x$: Number of person years lived by the cohort between ages x and $x+n$

$n.l_{x+n}$: Number of person years lived in the interval by members of the cohort who survive the interval

${}_na_x$: Mean number of person years lived in the interval by those dying in the interval

${}_nd_x$: Number of members of the cohort dying in the interval

Then we can rewrite the formula as follows:

$${}_nL_x = n(l_x - {}_nd_x) + {}_na_x \cdot {}_nd_x$$

$${}_n l_x = {}_n L_x + n \cdot {}_n d_x - {}_n a_x \cdot {}_n d_x$$

$$l_x = \frac{1}{n} [{}_n L_x + (n - {}_n a_x) \cdot {}_n d_x]$$

Thus, substituting l_x into the formula for ${}_n q_x$ is obtained by given:

$${}_n q_x = \frac{{}_n d_x}{l_x} = \frac{n \cdot {}_n d_x}{{}_n L_x + (n - {}_n a_x) \cdot {}_n d_x}$$

Both numerator and denominator of above equation is divided by ${}_n L_x$ and is obtained as follows:

$${}_n q_x = \frac{n \cdot \frac{{}_n d_x}{{}_n L_x}}{\frac{{}_n L_x}{{}_n L_x} + (n - {}_n a_x) \cdot \frac{{}_n d_x}{{}_n L_x}} = \frac{n \cdot {}_n m_x}{1 + (n - {}_n a_x) \cdot {}_n d_x}$$

Then the probability can be written as follows:

$${}_n q_x = \frac{n \cdot {}_n m_x}{1 + (1 - {}_n a_x) \cdot {}_n m_x} \quad \text{and} \quad q_\infty = 1$$

Above equation by Greville (1943) and Chiang (1968), shows us that for a cohort, the conversion from ${}_n m_x$ to ${}_n q_x$ depend on one parameter only, which is the average number of person years lived in the interval by those dying in the same interval.

Since ${}_n m_x$ and ${}_n q_x$ are both observable, the ${}_n a_x$ function bares little importance in a cohort life table. It is important because it is utilized in making the ${}_n m_x \rightarrow {}_n q_x$ conversion useful in a period life table. Particularly, supposing the hypothetical cohort in a period life table is to experience an observed set of period age specific death rates then all that remains to complete the period life table is the implementation of a set of ${}_n a_x$ values in order to convert the ${}_n m_x \rightarrow {}_n q_x$. This conversion is very common and If we choose to make it, then we have supposed that the observed period age specific death rates (${}_n M_x$) are to be reproduced in the hypothetical cohort passing through life in the period life table (${}_n m_x$). The rest to be

done is to convert the ${}_n m_x$'s to ${}_n q_x$'s. Whether the strategy is implied or clear, techniques for period life table construction that start out with a set of ${}_n m_x$'s are focused on the selection of a set of ${}_n a_x$ values (Preston et al, 2001).

Step 4: We calculate the probability of surviving an age interval x to $x+n$ as the following (Bell & Miller, 2005):

$${}_n p_x = 1 - {}_n q_x$$

$$p_{w+} = 0$$

Step 5: We choose radix which is denoted by l_0 . Then we calculate the number of people alive at exact age x as following (Bell & Miller, 2005):

$$l_{x+n} = l_x \cdot {}_n p_x$$

Step 6: We calculate the number of deaths an age interval x to $x+n$ as the following (Bell & Miller, 2005):

$${}_n d_x = l_x - l_{x+n}$$

Step 7: We calculate the total number of person years lived between exact ages x and $x+n$ as the following formula (Preston et al, 2001):

$${}_n L_x = n(l_{x+n} + {}_n a_x \cdot {}_n d_x)$$

This formula does not apply for age 0 and for age interval 1 to 4. There are obtained using the following formula:

$$L_0 = l_1 + (a_0 \cdot d_0)$$

$${}_4 L_1 = 4 \cdot l_5 + 4({}_4 a_1 \cdot d_1)$$

The above mentioned open ended interval does not bare any defined length; therefore an assumption is necessary concerning how many more years individuals will live at the start of the life interval. a good approximation is provided by the following formula:

$$L_{w+} = \frac{d_{w+}}{m_{w+}} = \frac{l_{w+}}{m_{w+}}$$

Step 8: We calculate the total number of person years lived after age x . It is obtained by cumulating the ${}_nL_x$ function from the bottom (highest age interval) up. It refers to exact age x , not an age interval (Pfaff & Seltzer, 2012).

For any age x :

$$T_x = T_{x+n} + {}_nL_x$$

For last age w :

$$T_w = L_{w+}$$

Step 9: We calculate the expected number of years of life left for a person aged x (Pfaff & Seltzer, 2012). And it is generally referred to the life expectancy at age x and is given by the following formula

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

The expectation of life at birth is given by the ratio

$$e_0 = \frac{T_0}{l_0}$$

CHAPTER FOUR

METHODOLOGY OF EXPONENTIAL SMOOTHING

4.1 Exponential Smoothing

Time series arise in many different contexts whenever something is observed over time. Exponential smoothing has become very popular as a forecasting method for a wide variety of time series data. The basic structures were provided independently by Robert G. Brown in about 1944 and C.C. Hold in 1957 and his student Peter Winters in 1960. The method is popular because it is simple, has low data-storage and computational effort requirements, and easily automated. But the most important reason for the popularity of exponential smoothing is the surprising accuracy that can be obtained with minimal effort in model identification.

There are many forecasting methods but the most successful forecasting methods are based on the concept of exponential smoothing. Exponential smoothing assigns exponentially decreasing weights as the observation get older. In other words, recent observations are given relatively more weight in forecasting than the older observations. Many researchers believed that exponential smoothing should be disregarded because it was either a special case of ARIMA modeling or an ad hoc procedure with no statistical rationale. Gardner (1985) proposed an excellent classification of exponential smoothing methods. Since 1985, the special case argument has been turned on its head, and today we know that exponential smoothing methods are optimal for a very general class of state-space models that is in fact broader than the ARIMA models. There is large body of research on exponential smoothing since the original work by Brown and Hold in the 1950s. The most important and critical review of research in exponential smoothing presented by Gardner (1985) and (2006).

Historically, the method was independently developed by Brown and Hold. The idea seems to have originated with Robert G. Brown in about 1944 while he was working for the US Navy as an Operations Research analyst. Independently, Charles Holt was also working on an exponential smoothing method and his method differed

from Brown' with respect to the smoothing of the trend and seasonal components. Holt's work on additive and multiplicative seasonal exponential smoothing became well known through a paper by his student Peter Winters (1960). As a result, the seasonal versions of Holt's methods are usually called Holt-Winters' methods. Pegels (1969) provided a simple but useful classification of the trend and the seasonal patterns depending on whether they are additive or multiplicative.

Muth (1960) was the first to suggest a statistical foundation for simple exponential smoothing (SES) by demonstrating that it provided the optimal forecasts for a random walk plus noise. Further steps towards putting exponential smoothing within a statistical framework were provided by Box and Jenkins (1970), Roberts (1982), and Abraham and Ledolter (1983, 1986), who showed that some linear exponential smoothing forecasts arise as special cases of ARIMA models. The remarkably good forecasting performance of exponential smoothing methods has been addressed by several authors. Satchell and Timmermann (1995) and Chatfield et al. (2001) showed that SES is optimal for a wide range of data generating process. Hyndman (2001) showed that SES performed better than first order ARIMA models.

4.1.1 Simple Exponential Smoothing (SES) Method

Simple smoothing represents the time series $y_t = a + \varepsilon_t$ where ε_t is a random component with mean zero and variance σ_ε^2 . The level a is assumed to be constant in any local segment of the series but may change slowly over time. We would now like to estimate the current value of that coefficient a by some sort of an average. The new smoothed value is equal to the previous smoothed value plus a fraction α of the difference between the new observation and the previous smoothed value. That is, the forecast for the next period is

$$S_t = S_{t-1} + \alpha(y_t - S_{t-1})$$

Where α is a constant between 0 and 1. Another way of writing (1.1) is

$$S_t = \alpha y_t + (1 - \alpha)S_{t-1}$$

The forecast, S_t is based on weighting the most recent observation y_t with a weight value α , and weighting the most recent forecast S_{t-1} with a weight of $(1-\alpha)$. Let us expand the second equation by first substituting for S_{t-1} with its components to obtain

$$\begin{aligned} S_t &= \alpha y_t + (1-\alpha)[\alpha y_{t-1} + (1-\alpha)S_{t-2}] \\ &= \alpha y_t + \alpha(1-\alpha)y_{t-1} + (1-\alpha)^2 S_{t-2} \end{aligned}$$

If this substitution process repeated by replacing S_{t-2} with its components, S_{t-3} with its components, and so on, the result is

$$S_t = \alpha y_t + \alpha(1-\alpha)y_{t-1} + \alpha(1-\alpha)^2 y_{t-2} + \dots + \alpha(1-\alpha)^{t-1} y_1 + (1-\alpha)^t S_0,$$

or the expanding equation can be written as

$$S_t = \alpha \sum_{k=0}^{t-1} (1-\alpha)^k y_{t-k} + (1-\alpha)^t S_0$$

So S_t represents a weighted moving average of all past observations with weights decreasing exponentially, hence the name “exponential smoothing” and their sum is unity; We note that the weight of S_0 may be quite large when α is small and the time series is relatively short. The choice of starting value then becomes particularly important and is known as the initialization problem”. Setting it to y_1 is one method of initialization, another possibility would be to average the first four or five observations. The smoothing coefficient α is a value between 0 and 1. In the extreme, if the coefficient is zero then the next period’s forecast will be the same as the last period’s forecast $S_t = S_{t-1}$, and if the coefficient is one, or unity, then the next period’s forecast will be the same as the current period’s data $S_t = y_t$. The expected value of this function of the observations is

$$E[S_t] = \alpha \sum_{k=0}^{\infty} (1-\alpha)^k E[y_{t-k}] = E[y]$$

Since the expectation of the function is equal to the expectation of the data, it is right to call it an average and the value of the coefficient in a constant model $\hat{a}_t = S_t$.

The statistics S_t is an unbiased estimator of the level as well as the forecast for any period ahead. The average age is the age of each piece of data used in the average. In the exponential smoothing process, the weight given data k periods ago is $\alpha(1-\alpha)^k$, therefore the average age of the data used in exponential smoothing is

$$\bar{k} = 0\alpha + 1\alpha(1-\alpha) + 2\alpha(1-\alpha)^2 + \dots = \alpha \sum_{k=0}^{\infty} k(1-\alpha)^k = \frac{1-\alpha}{\alpha}$$

In the exponential smoothing scheme, the variance of the estimates is

$$\text{Var}[S_t] = \alpha^2 \sum_{k=0}^{\infty} (1-\alpha)^{2k} \text{Var}(y_{t-k}) = \frac{\alpha^2 \sigma_\varepsilon^2}{1-(1-\alpha)^2} = \frac{\alpha}{2-\alpha} \sigma_\varepsilon^2$$

Now we have a new way of estimating the value of the coefficient in a constant model.

$$\hat{a}_t = S_t$$

When the smoothing constant is small, the function S_t behaves like the average of a great deal of past data, and therefore the variance of the estimate of the coefficient is small. When the smoothing constant is large S_t will respond rapidly to changes in pattern. Exponential smoothing always requires a previous value of the smoothing function. When the process is started, there must be some value that can be used as the previous value S_{t-1} . If there are past data at that time one starts to use exponential smoothing, then the best initial value would be a simple average of the most recent observations. Frequently there will be no past data to average then smoothing starts with the first observation. After k observations, the weight given to the initial value is $(1-\alpha)^k$. If we have a great deal of confidence in the prediction of initial conditions, use small value of smoothing constant. If we have very little confidence in our initial prediction, use a larger value, so that the initial conditions will quickly be discounted.

In order to calculate the forecasts using SES, we need to specify the initial value, S_0 and the parameter value α . Gardner (1985) discusses various theoretical and empirical arguments for selecting an appropriate smoothing parameter. By the most

of practitioners, an α smaller than 0.3 is usually recommended. However, in the study by Makridakis *et al.* (1982), α values above 0.30 frequently yielded the best forecast. Gardner (1985) concludes that it is best to estimate an optimum α from the data rather than to guess and set an artificially low value. In practice, the smoothing parameter is often chosen by a grid search of the parameter space so as to produce the smallest sums of squares (or mean squares) for the residuals (i.e., observed values minus one-step-ahead forecasts). Methods for computing initial value S_0 have been developed by a number of researchers but there is no empirical evidence favoring any particular method. Brown's (1959) original suggestion, simply using the mean of the data for S_0 , is popular in practice.

Holt (1960) extended simple exponential smoothing to linear exponential smoothing to allow forecasting of data with trends. The forecast for Holt's linear exponential smoothing method is found using two smoothing constants, α and β (with values between 0 and 1), and three equations:

$$\begin{aligned} \text{Level:} \quad & S_t = \alpha y_t + (1-\alpha)(S_{t-1} + b_{t-1}) \\ \text{Trend:} \quad & b_t = \beta(S_t - S_{t-1}) + (1-\beta)b_{t-1} \\ \text{Forecast:} \quad & S_{t+h|t} = S_t + b_t h, \quad h = 1, 2, 3, \dots \end{aligned}$$

CHAPTER FIVE

APPLICATION

In this part of the study, period life table will be formed, summarized by using death, birth and population datum which reflect demographic structure of Turkey. Source of data set will be explained as the first step. Following the analyses of the descriptive statistics of the data set, datum will smoothened with exponential smoothing method and will be compared with the real data. And finally, abridged period life tables will formed both by gender and age-groups for Turkey and by age-groups only for regions.

5.1 Data Sources

Life and death records in Turkey are compiled and published by Turkish Statistical Institute (TUIK). Data sets employed in this study are obtained from the information published by the TUIK under the heading 'Population and Demographical Statistics'. In this study, population, death and birth statistics are separately obtained on the basis of gender and year.

5.1.1 Population Data

Population of Turkey is identified by the TUIK with periodical censuses. Total of 14 censuses held after the declaration of the republic, first of which held in 1927, second in 1935, every five years between 1935-1990 and every ten years after 1990. These censuses performed under country-wide curfew. These censuses performed to identify the size, demographical, social and economical distribution of the population within the borders of the country on the specific date of application. After the last census under curfew in 2000, the new 'Address Quoted Civil Registration System' (ADNKS) started to be utilized without curfew in 2007.

Address Quoted Civil Registration System (ADNKS) is established in 2007 to keep up-to-date information of the population of settlements and to monitor migration statistics. Address information of citizens of the Republic of Turkey and foreign nationals residing within Turkey matched with the information recorded in

the MERNIS index of population data-base for Turkish nationals. Information on size and basic features of the populations with respect to settlements produced and presented annually.

Populations of the settlements are calculated with the data acquired from Address Registration System (AKS), which is updated by the Ministry of the Interior Affairs, General Directorate of Civil Registration and Nationality and taking population into account in public Institutional places. As required by the international definition, people residing in Institutional places (military settlements, penal institutions, nursing homes, dormitories etc.) counted in the population of the Institution they are in, and not in their address of residence.

Also it is taken into consideration that while populations of the provinces, towns, cities, villages and districts are determined, administrative attachments, legal entities, name alterations etc. information, which is taken from National Address Data Base taken into consideration with the requirement of the law of NVIGM (TUIK, 2012).

Age, age groups, region and gender based information acquired from ADNKS published between 2007 and 2011 used in this study.

5.1.2 Deaths Data

Turkish Statistical Institute (TUIK) started to compile statistics on death in 1931 and published information on death of; the 25 most populated city centers until 1949, all of the city centers between 1950 and 1956, and all city centers along with towns after 1957. After 1982, it is aimed to compile death events from rural areas and disseminate statistical information to nation-wide; however, it could not be published because of lack of complete information that must be obtained. Thence, the application of collection of death statistics from rural areas was ended in 1986 until a new system is to be established.

When The Central Civil Registration System (MERNIS) started on line application in 2001, it is decided to keep death statistics in this data-base. For this

purpose to come true, Ministry of the Interior, General Directorate of Civil Registration and Nationality and TUIK signed a protocol on data-exchange on 7th February 2006.

According to this protocol, after 2009, Turkish Statistical Institute (TUIK), started acquiring information on death statistics from the Central Civil Registration System (MERNIS) data base and publish these information with death reasons data compiled by TUIK. Since MERNIS has a dynamic structure, death statistics are continuously updated retroactively. Updated on March 31, 2012, death statistics of 2009 published on the same date with death statistics of 2010. Moreover, death statistics have been published based on the permanent residence address since 2009 (TUIK, 2012).

In this study, death statistics based on provinces and towns published by TUIK annually between the years 2002-2008, and death statistics of Turkey in general and based on regional classification published in 2009 and 2010 are utilized.

5.1.2 Births Data

T.C. Birth statistics published by Turkish Statistical Institute (TUIK), are obtained from the on-line data base of MERNIS since the start of the on-line application in 2001. Updated on August 31, 2012, birth statistics of years 2001 to 2009 published on the same date with birth statistics of 2010. Moreover, after 2009, birth statistics started to be published on the basis of the permanent address of the mother, instead of the place that birth takes place (TUIK, 2011).

Birth statistics published between the years 2007-2010 are utilized in this study.

5.2 Descriptive Statistics

In this part, descriptive statistics of the data obtained from TUIK analyzed and interpreted. Moreover, visuals contributing to represent demographical structure of Turkey better examined.

5.2.1 Descriptive Statistics Per Population

In this part, size of population, population growth rate and population data with regional classifications will be examined. While it was 13.6 million in the 1927 census, the population of Turkey is calculated to be 74.7 million according to the 2011 census based on the Central Civil Registration System (MERNIS) data base. Increasing size of population in Turkey had been stable between the years 1950-2000 and started to decrease after 2000 (TUIK, 2012).

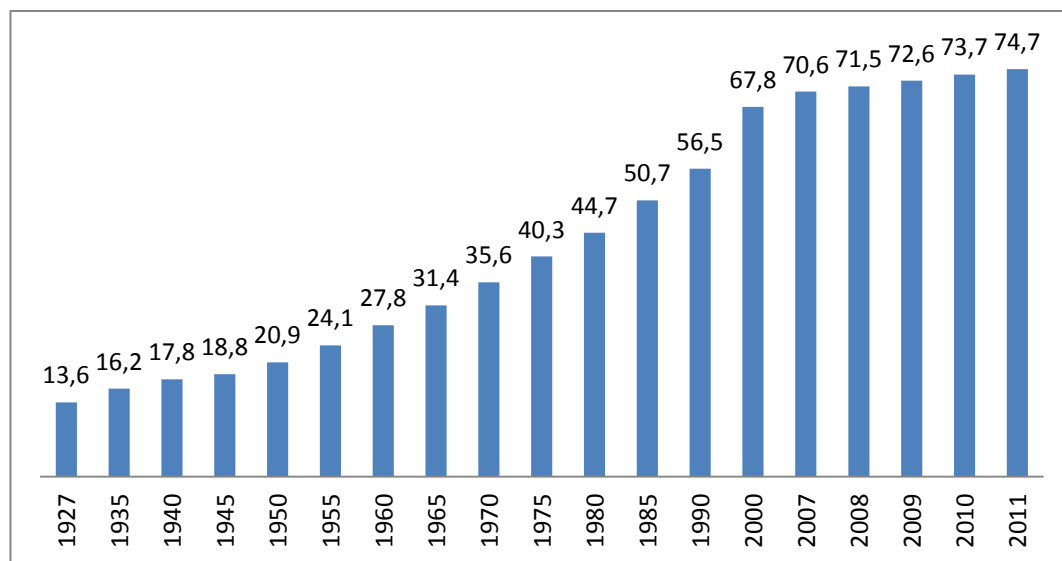


Figure 5.1 The bar graph of population size between 1927 and 2011 years.

Population growth rate in Turkey, as seen on Figure 5.2, started decreasing in 1980's and was 1.7 percent in 1990 and dropped to 1.18 percent in 2007. Nowadays, population growth rate in Turkey is as low as 10 in a thousandth. This rate is forecasted to be 9.9 in a thousandth in 2015, 8.8 in 2020 and drop down to 7.4 in 2025 (TUIK, 2009).

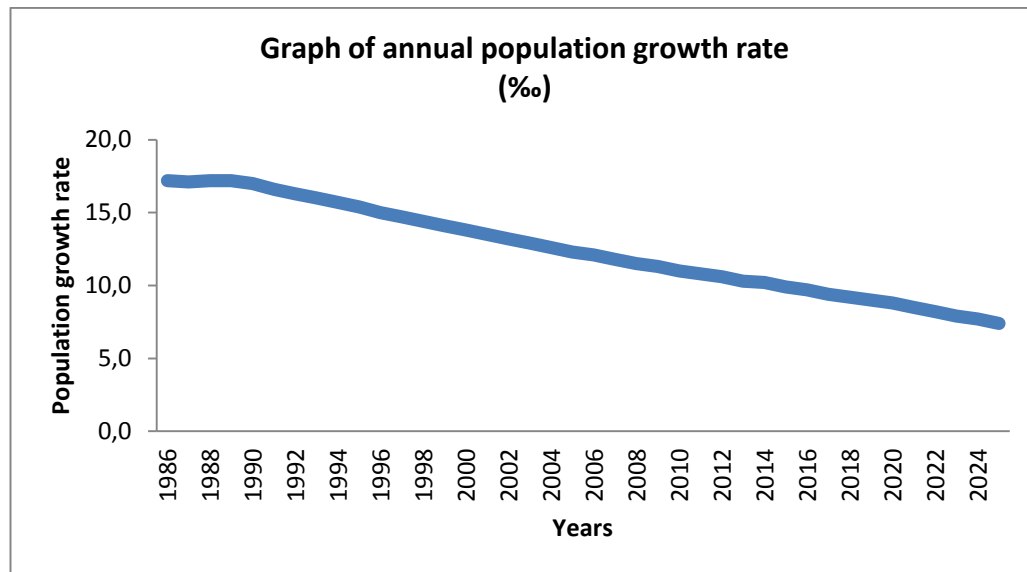


Figure 5.2 The graph of estimations and projections of population growth rate, 1986-2025, TÜİK.

Examining Figure 5.1 and 5.2, it is observed that despite there is an increase in the size of the population, population growth rate is declining. According to population forecasts, the increase in the size of the population and decrease in the rate will continue. This study handles the population data from 2007 and onwards. Population-size statistics published on Address Quoted Civil Registration System (ADNKS) are in four different formats including 'Turkey in general', 'Province and Town centers', and 'rural areas' and 'region'.

5.2.1 Descriptive Statistics per Deaths

In this part, death statistics, which play an important role in determining the demographic features of a community and its' features will be examined. Death statistics in Turkey were in the form of town and province centers format between the years 2002-2008. Data in use under such format results in calculation of crude death rates in Turkey lower than the real values because it excludes the death counts in rural areas. This calculation also results in estimation of life expectancies at birth higher than actual. However, construction of a life table for the whole Turkey is enabled by retroactively updated death statistics from 2009. Here we will represent demographical structure of Turkey with visuals to be able to examine patterns of death.

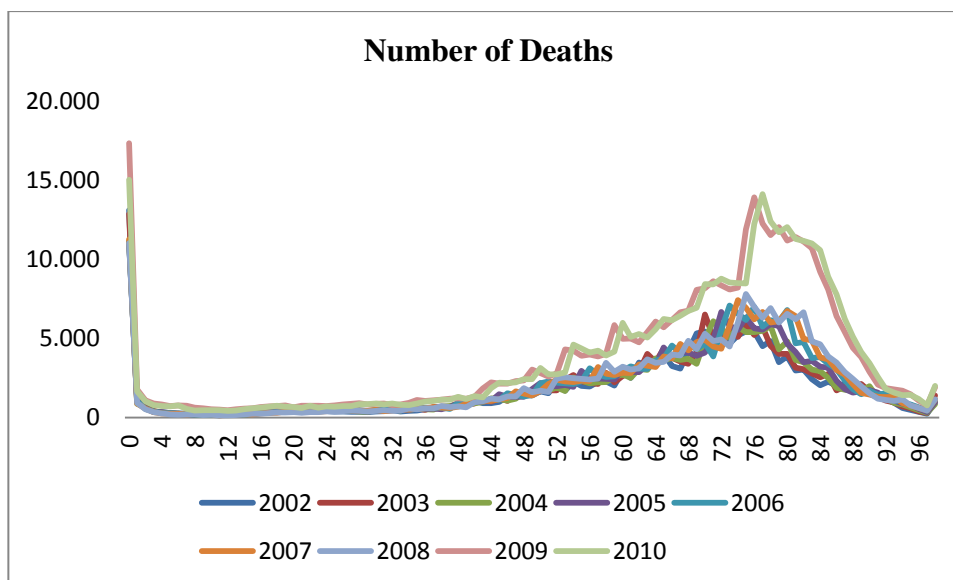


Figure 5.3 Graph of deaths between 2002 and 2010 years by age groups.

As can be seen on Figure 5.3, death rates have increased for all age groups after addition of data from rural areas and increase in the quality of the data record system after 2009. Number of deaths in 2002 was 175,434 and increased to 206,296 in 2008. In 2009 however, number of deaths was 367,010 and in 2010, dropped to 365,076. Improved living conditions may account for this decrease.

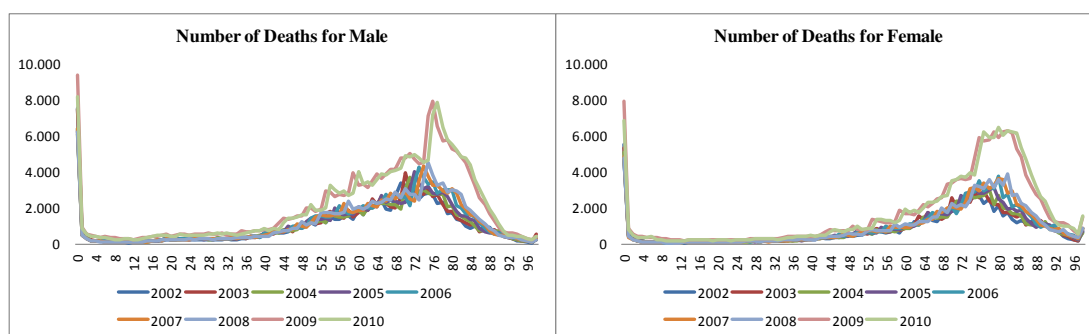


Figure 5.4 Graphs of number of deaths for male and female between 2002 and 2010 years by age groups.

Examining Figure 5.4, it is observed that deaths in males are less steady than in females. For males in city or town centers, it is observed that number of deaths for males between the ages 40-75 is higher than females. Also with the addition of rural settlements' data, number of males dying at 74 years of age is seriously decreased.

Together with these, peak value of deaths for males, this was 76 years of age in 2009, shifted to 77 in 2010. Number of deaths of males in 2002 was 98,757 and became 114,413 in 2008. In 2009, number of deaths of males in Turkey was 202,368, and dropped to 199,873 in 2010. Examining deaths of females, it is revealed that deaths of females are steadier than of males. It is observed that the interval of peak age where number of deaths increase is wider for females. This range is between the ages 75 and 85. Number of deaths of females in 2002 was 76,677 and became 91,883 in 2008. In 2009, number of deaths of females in Turkey was 164,642, and increased to 165,203 in 2010.

Purifying the dataset from random variations and then examination enables to understand death patterns better. For smoothing the data-set, moving averages method is utilized. First thing to recall when the moving averages method is of use is time-series analysis. The purpose of 'moving averages' method which is widely used for time series is to decrease the effects of random variations observed in the series by taking averages of several periods and make forecasts. It is based on arithmetical average. Moving average of m time series is represented as average of m respective time series and it is quoted as a way of taking averages allowing adjusting seasonal or conjectural constituents of the series (Brown, 1962).

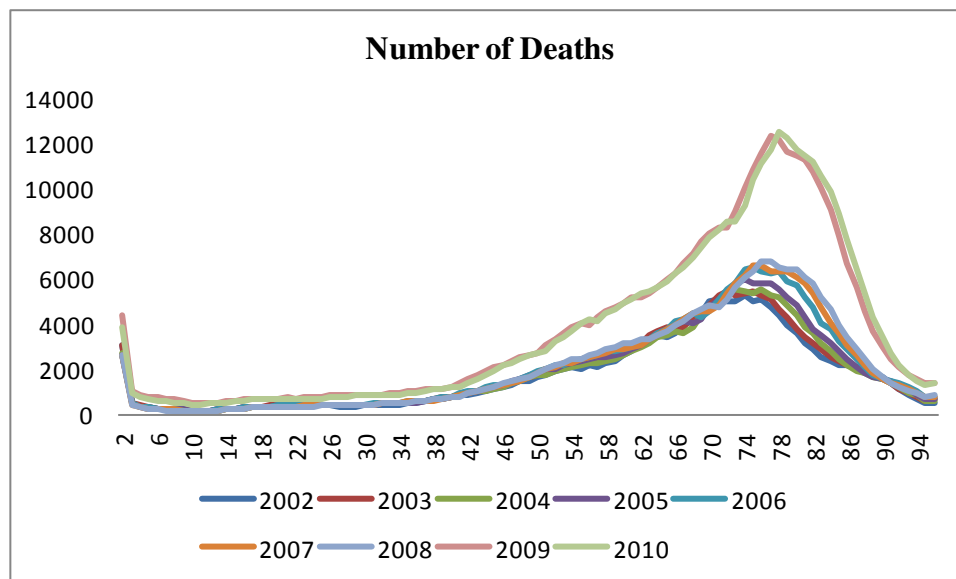


Figure 5.5 Smoothed deaths by moving average method between 2002 and 2010 years

Examination of Figure 5.5 reveals that as the years pass, increase in number of deaths shift towards older ages. The meaning of this is that people in Turkey die older as the time passes. This can be presented as a proof that lives of people living in our country is prolonged. Lowest number of deaths is observed to be between the ages 10 to 14. The highest number of deaths on the other hand, observed to be between 70 to 74 years of age in 2002 and 75 to 79 years of age in 2005.

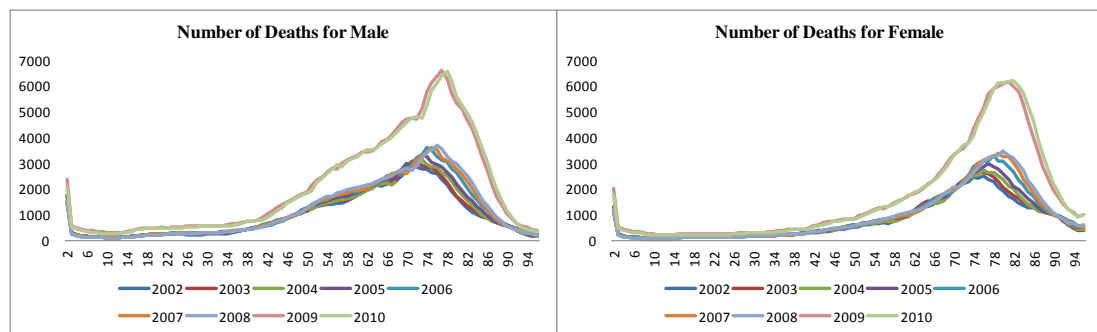


Figure 5.6 Smoothed deaths for male and female population between 2002 and 2010 years by moving average method.

Examination of Figure 5.6, general patterns of deaths is observed for both males and females. However, number of deaths for males prior to 70 years of age is observed to be higher than females. Moreover, number of deaths is observed to increase with a higher rate for males after 70 years of age than for females. The lowest number of deaths is observed between ages 10 to 14 for both sexes. The highest number of deaths is observed to be between 70 to 74 years of age in 2002 and 75 to 79 years of age after 2007. The highest number of deaths is observed to be between 75 to 80 years of age in 2002 and 80 to 84 years of age after 2009. Interpreting visuals, life expectancies for females can be concluded to be longer than males; however, it is possible to calculate life expectancies by formation of life tables.

Table 5.1 Death rates between 2002 and 2010 years by age group.

Age	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	0,075	0,070	0,061	0,057	0,054	0,055	0,052	0,047	0,041
1-4	0,013	0,013	0,012	0,012	0,011	0,010	0,010	0,013	0,011
5-9	0,006	0,006	0,006	0,006	0,005	0,005	0,004	0,009	0,008
10-14	0,005	0,005	0,005	0,005	0,004	0,004	0,004	0,007	0,006
15-19	0,009	0,009	0,008	0,008	0,008	0,007	0,007	0,009	0,009
20-24	0,011	0,011	0,012	0,010	0,009	0,009	0,008	0,010	0,009
25-29	0,010	0,012	0,011	0,011	0,011	0,011	0,010	0,011	0,010
30-34	0,012	0,013	0,013	0,012	0,012	0,011	0,011	0,012	0,011
35-39	0,016	0,017	0,016	0,015	0,014	0,015	0,015	0,015	0,014
40-44	0,025	0,025	0,026	0,025	0,025	0,023	0,021	0,021	0,019
45-49	0,038	0,038	0,037	0,037	0,033	0,034	0,034	0,032	0,031
50-54	0,054	0,056	0,053	0,053	0,053	0,052	0,051	0,045	0,044
55-59	0,060	0,063	0,063	0,066	0,065	0,064	0,065	0,059	0,057
60-64	0,089	0,086	0,083	0,080	0,078	0,075	0,078	0,071	0,074
65-69	0,113	0,104	0,100	0,107	0,104	0,103	0,098	0,091	0,089
70-74	0,144	0,148	0,151	0,141	0,136	0,131	0,121	0,113	0,117
75-79	0,135	0,138	0,145	0,152	0,152	0,155	0,162	0,168	0,162
80-84	0,082	0,085	0,099	0,099	0,117	0,130	0,137	0,146	0,154
85-89	0,059	0,057	0,052	0,055	0,059	0,063	0,069	0,077	0,088
90+	0,044	0,045	0,046	0,047	0,048	0,045	0,043	0,042	0,044

In Table 5.1, rates of number of deaths based on age groups per total deaths are examined. While an increase in death rates is observed for city and town centers and for the age groups 55-49, 60-64 and 75-79, addition of the records from rural areas after 2009, has lowered the rate of this increase. Although there was an increase in death rates of age groups 70-74 and 85-89 until 2004, the situation reversed until 2008. In the general death records on the other hand, death rates increased in this age interval. While an increase is observed for 90 years of age and over from 2002 until 2006, a decrease is observed until 2008. Within this age range, death rates increased in years 2009 and 2010. The aim here is to acquire preliminary information on the differences patterns of death rates of urban and general areas. Examining the Table, changing the registration system, there are some variations observed for the elderly people; death rates of age groups 1-24 and 80-89 are increasing, death rates of 40-74 age group are decreasing.

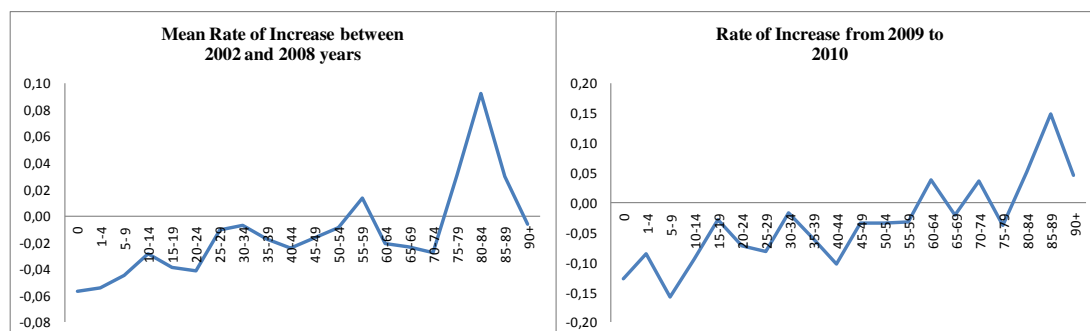


Figure 5.7 Rate of increase for ‘cities & towns’ and ‘general’ death rates by age group.

In Figure 5.7, Mean rates of increase are demonstrated on graphical format for urban area and rates of increase are demonstrated for general area by age group in Turkey. For urban, there is a decrease in death until 75 years of age and only increase is observed to be between ages 55 to 59. For 75 years of age and over, increase rates are observed to have positive values, meaning increasing deaths. For ages 90 and over on the other hand, mortalities tend to decrease. Considering mortality data for Turkey in general, while there is a decrease tendency in deaths of ages until 80, there is an increase for the age group of 60 to 64 based on the data from rural areas different from the urban. This situation can be interpreted as people living in rural areas and between ages 60-64 are more likely to lose their lives than people living in cities and towns. Although there is an increase observed for 80 years of age and over, it is remarkable that the rate is lower than the rate for urban areas. And this can be interpreted as there is an increase in the population of elderly.

Table 5.2 Crude death, birth and growth rate per thousand for Turkey between 2007 and 2010 years.

Rate(‰)	CBR	CDR	CGR
2007	18.20	...	...
2008	18.02	...	...
2009	17.29	5.06	12.24
2010	16.81	4.95	11.85

In the Table 5.2, for the years from 2007 to 2010, crude population growth rates are calculated using crude birth and death rates. Crude birth rate decreased by 8,2 %. In 2010, there was a decrease by 2.8 % compared to 2009. It is impossible to

calculate crude death rates for urban areas between 2007 and 2008 since published statistics does not meet the population. Crude death rate in 2010 decreased by 2.09 % compared to 2009. Crude population growth rate of a society under assumption of zero migration, is calculated by subtraction of crude death rate from crude birth rate. Here, population crude growth rate is decreased by 3.13 % in 2010 compared to previous year.

5.3 Exponential Smoothing

In this section, death rates of age groups for the years between 2002 and 2008 smoothened with exponential smoothing and purified from random variations. Death rates acquired by division of number of people died in an age group by total number of people died. Choosing rate is because of elimination of numerical variation in the death registration system. Death rates for the years 2009 and 2010 are forecasted by using the smoothing method and the trend between the years 2002 and 2008.

Two version of double exponential smoothing are commonly used and the method is explained as following (Bowermen & O'Connell, 1987). The first discussed in this subsection employs one smoothing constant and, therefore, is often called one parameter double exponential smoothing. The second, Holt Winters' two parameter double exponential smoothing, employs two smoothing constants. The smoothing constant determines how much weight is attached to each time series observation. In this thesis, we use one parameter double exponential smoothing method. Supposed that a time series $y_1, \dots, y_n$ is described by the model

$$y_t = \beta_0 + \beta_1 t + \varepsilon_t$$

where the parameters of β_0 and β_1 are slowly changing over time. Also suppose that in time period $T-1$ we have observed time series values $y_1, y_2, \dots, y_{T-1}$ and have computed estimates $b_0(T-1)$ and $b_1(T-1)$ of the model parameters β_0 and β_1 . We observed y_T in time period T and updated our estimates of β_0 and β_1 .

We obtain updated values of the smoothed statistics S_T and $S_T^{(2)}$ by using the smoothing equations as follow:

$$S_T = \alpha y_T + (1 - \alpha) S_{T-1}$$

$$S_T^{(2)} = \alpha S_T + (1 - \alpha) S_{T-1}^{(2)}$$

Where S_{T-1} and $S_{T-1}^{(2)}$ are values of the smoothed statistics computed in time period $T-1$. Both of these equations employ the same smoothing constant α , which is defined to be between 0 and 1. The first of these equations are smoothed the origin time series observations. The second S_T values that are obtained by using the first equation. Using S_T and $S_T^{(2)}$, we obtain updated estimates as follows:

$$b_1(T) = \frac{\alpha}{1 - \alpha} (S_T - S_T^{(2)})$$

$$b_0(T) = 2S_T - S_T^{(2)} - Tb_1(T)$$

We omit the derivations of these equations; they are nor intuitive.

Given the estimates $b_1(T)$ and $b_0(T)$, a forecast made at time T for the future value $y_{T+\tau}$ is:

$$\hat{y}_{T+\tau}(T) = \left(2 + \frac{\alpha\tau}{(1-\alpha)} \right) S_T - \left(1 + \frac{\alpha\tau}{(1-\alpha)} \right) S_T^{(2)}$$

In this application we use one parameter double exponential smoothing to forecast the death rates by age group time series. Given in Table 3, we begin by choosing a smoothing constant. It is considered to be suitable to use first real observed value for $b_0(0)$. For $b_1(0)$ on the other hand, use of calculated mean values of increase rates of previous year is considered to be more suitable. For age 0, initial values are calculated as follows.

$$S_0 = b_0(0) - \left(\frac{1-\alpha}{\alpha} \right) b_1(0)$$

$$= 0.075 - \left(\frac{1-0.3}{0.3} \right) (-0.004)$$

$$= 0.0835$$

$$S_0^{(2)} = b_0(0) - 2 \left(\frac{1-\alpha}{\alpha} \right) b_1(0)$$

$$= 0.075 - 2 \left(\frac{1-0.3}{0.3} \right) (-0.004)$$

$$= 0.0923$$

Therefore the forecast of y_{2002} is:

$$\hat{y}_{0+1}(0) = \left(2 + \frac{\alpha(1)}{(1-\alpha)} \right) S_T - \left(1 + \frac{\alpha(1)}{(1-\alpha)} \right) S_T^{(2)}$$

$$\hat{y}_{2002}(0) = \left(2 + \frac{0.3}{(1-0.3)} \right) 0.0835 - \left(1 + \frac{0.3}{(1-0.3)} \right) 0.0923$$

$$= 0.0711$$

Table 5.3 Initial values for OPDES by age group.

Alpha	Age	$b_0(0)$	$b_1(0)$	S_0	$S_0^{(2)}$	$\hat{y}_t(0)$
0.30	0	0.0748	-0.0037	0.0835	0.0923	0.0711
0.30	1-4	0.0135	-0.0007	0.0150	0.0165	0.0128
0.30	5-9	0.0058	-0.0002	0.0064	0.0070	0.0056
0.30	10-14	0.0046	-0.0001	0.0049	0.0052	0.0045
0.30	15-19	0.0085	-0.0003	0.0092	0.0100	0.0082
0.30	20-24	0.0106	-0.0004	0.0116	0.0125	0.0102
0.30	25-29	0.0103	-0.0001	0.0106	0.0109	0.0102
0.30	30-34	0.0115	-0.0001	0.0118	0.0120	0.0114
0.30	35-39	0.0164	-0.0003	0.0170	0.0177	0.0161
0.30	40-44	0.0249	-0.0006	0.0263	0.0276	0.0243
0.30	45-49	0.0382	-0.0006	0.0396	0.0411	0.0375
0.30	50-54	0.0541	-0.0005	0.0552	0.0563	0.0536
0.30	55-59	0.0600	0.0008	0.0581	0.0562	0.0608
0.30	60-64	0.0891	-0.0018	0.0932	0.0974	0.0873
0.30	65-69	0.1134	-0.0026	0.1194	0.1255	0.1108
0.30	70-74	0.1441	-0.0038	0.1530	0.1618	0.1403
0.30	75-79	0.1352	0.0044	0.1248	0.1145	0.1396
0.30	80-84	0.0816	0.0092	0.0600	0.0385	0.0909
0.30	85-89	0.0591	0.0017	0.0551	0.0511	0.0608
0.30	90+	0.0445	-0.0003	0.0452	0.0460	0.0442

In Table 5.3, Initial constants and forecasted values are calculated with alpha values taken as 0.3 and shown in the table above. S_{2002} and $S_{2002}^{(2)}$ smoothing constants are calculated for every age group using observation value of $y_{2002} = 0,075$ among S_0 and $S_0^{(2)}$ values.

$$\begin{aligned} S_{2002} &= \alpha y_{2002} + (1 - \alpha) S_0 \\ &= 0.3(0.075) + (1 - 0.3)(0.0835) \\ &= 0.081 \end{aligned}$$

$$\begin{aligned} S_{2003} &= \alpha y_{2003} + (1 - \alpha) S_{2002} \\ &= 0.3(0.070) + (1 - 0.3)(0.081) \\ &= 0.078 \end{aligned}$$

Table 5.4 : Smoothed Constants for OPDES by age group.

Age	2002	2003	2004	2005	2006	2007	2008
0	0.081	0.078	0.073	0.068	0.064	0.061	0.059
1-4	0.015	0.014	0.014	0.013	0.012	0.012	0.011
5-9	0.006	0.006	0.006	0.006	0.006	0.006	0.005
10-14	0.005	0.005	0.005	0.005	0.005	0.005	0.004
15-19	0.009	0.009	0.009	0.009	0.008	0.008	0.008
20-24	0.011	0.011	0.011	0.011	0.011	0.010	0.009
25-29	0.011	0.011	0.011	0.011	0.011	0.011	0.010
30-34	0.012	0.012	0.012	0.012	0.012	0.012	0.012
35-39	0.017	0.017	0.017	0.016	0.016	0.015	0.015
40-44	0.026	0.026	0.026	0.025	0.025	0.025	0.024
45-49	0.039	0.039	0.038	0.038	0.037	0.036	0.035
50-54	0.055	0.055	0.055	0.054	0.054	0.053	0.053
55-59	0.059	0.060	0.061	0.063	0.063	0.064	0.064
60-64	0.092	0.090	0.088	0.086	0.083	0.081	0.080
65-69	0.118	0.114	0.109	0.109	0.107	0.106	0.104
70-74	0.150	0.150	0.150	0.147	0.144	0.140	0.134
75-79	0.128	0.131	0.135	0.140	0.144	0.147	0.152
80-84	0.067	0.072	0.080	0.086	0.095	0.106	0.115
85-89	0.056	0.056	0.055	0.055	0.056	0.058	0.062
90+	0.045	0.045	0.045	0.046	0.046	0.046	0.045

In Table 5.4, values of smoothing constants calculated for every age-group are shown. Every constant calculated using forecasts of previous year and observed real value of the current year. Procedure shown above repeated for every age-group.

$$\begin{aligned}
 S_{2002}^{(2)} &= \alpha S_{2002} + (1-\alpha) S_0^{(2)} \\
 &= 0.3(0.081) + (1-0.3)(0.0923) \\
 &= 0.089 \\
 S_{2003}^{(2)} &= \alpha S_{2003} + (1-\alpha) S_{2002}^{(2)} \\
 &= 0.3(0.078) + (1-0.3)(0.089) \\
 &= 0.085
 \end{aligned}$$

Table 5.5 Smoothed trend constants for OPDES by age group.

Age	2002	2003	2004	2005	2006	2007	2008
0	0.089	0.085	0.082	0.078	0.074	0.070	0.066
1-4	0.016	0.015	0.015	0.014	0.014	0.013	0.012
5-9	0.007	0.007	0.006	0.006	0.006	0.006	0.006
10-14	0.005	0.005	0.005	0.005	0.005	0.005	0.005
15-19	0.010	0.009	0.009	0.009	0.009	0.009	0.008
20-24	0.012	0.012	0.012	0.012	0.011	0.011	0.010
25-29	0.011	0.011	0.011	0.011	0.011	0.011	0.011
30-34	0.012	0.012	0.012	0.012	0.012	0.012	0.012
35-39	0.017	0.017	0.017	0.017	0.016	0.016	0.016
40-44	0.027	0.027	0.026	0.026	0.026	0.025	0.025
45-49	0.041	0.040	0.040	0.039	0.038	0.038	0.037
50-54	0.056	0.056	0.055	0.055	0.055	0.054	0.054
55-59	0.057	0.058	0.059	0.060	0.061	0.062	0.062
60-64	0.096	0.094	0.092	0.090	0.088	0.086	0.084
65-69	0.123	0.120	0.117	0.114	0.112	0.110	0.108
70-74	0.158	0.156	0.154	0.152	0.150	0.147	0.143
75-79	0.119	0.122	0.126	0.130	0.134	0.138	0.142
80-84	0.047	0.054	0.062	0.069	0.077	0.086	0.094
85-89	0.053	0.054	0.054	0.054	0.055	0.056	0.058
90+	0.046	0.045	0.045	0.046	0.046	0.046	0.046

In Table 5.5, values of the calculated trend constant have shown for every age-group. Every constant calculated using forecasts of previous year and observed real

value of the current year. Procedure shown above repeated for every age-group and for following years. In Table 5.6, forecasts shown below are obtained using smoothing constants.

$$\begin{aligned}\hat{y}_{2002+1}(2002) &= \left(2 + \frac{\alpha(1)}{(1-\alpha)}\right) S_{2002} - \left(1 + \frac{\alpha(1)}{(1-\alpha)}\right) S_{2002}^{(2)} \\ \hat{y}_{2003}(2002) &= \left(2 + \frac{0.3}{(1-0.3)}\right) 0.081 - \left(1 + \frac{0.3}{(1-0.3)}\right) 0.089 = 0.070 \\ \hat{y}_{2003+1}(2007) &= \left(2 + \frac{\alpha(1)}{(1-\alpha)}\right) S_{2003} - \left(1 + \frac{\alpha(1)}{(1-\alpha)}\right) S_{2003}^{(2)} \\ \hat{y}_{2003}(2002) &= \left(2 + \frac{0.3}{(1-0.3)}\right) 0.078 - \left(1 + \frac{0.3}{(1-0.3)}\right) 0.085 = 0.066\end{aligned}$$

Table 5.6: Smoothed forecasts for OPDES by age group

Age	F_2002	F_2003	F_2004	F_2005	F_2006	F_2007	F_2008
0	0.071	0.070	0.066	0.060	0.055	0.050	0.049
1-4	0.013	0.013	0.012	0.012	0.011	0.010	0.009
5-9	0.006	0.006	0.006	0.006	0.006	0.005	0.005
10-14	0.004	0.004	0.005	0.005	0.005	0.005	0.004
15-19	0.008	0.008	0.008	0.008	0.008	0.008	0.007
20-24	0.010	0.010	0.010	0.011	0.010	0.010	0.009
25-29	0.010	0.010	0.011	0.011	0.011	0.011	0.011
30-34	0.011	0.011	0.012	0.013	0.013	0.012	0.012
35-39	0.016	0.016	0.016	0.016	0.015	0.014	0.014
40-44	0.024	0.024	0.024	0.025	0.025	0.025	0.023
45-49	0.038	0.037	0.037	0.037	0.037	0.034	0.033
50-54	0.054	0.053	0.055	0.054	0.053	0.053	0.052
55-59	0.061	0.061	0.063	0.064	0.066	0.067	0.066
60-64	0.087	0.087	0.085	0.082	0.079	0.077	0.073
65-69	0.111	0.110	0.104	0.099	0.100	0.100	0.100
70-74	0.140	0.139	0.141	0.144	0.141	0.136	0.130
75-79	0.140	0.141	0.143	0.148	0.154	0.157	0.160
80-84	0.091	0.095	0.097	0.105	0.110	0.121	0.134
85-89	0.061	0.062	0.060	0.057	0.056	0.058	0.062
90+	0.044	0.044	0.044	0.045	0.046	0.047	0.046

Forecast errors obtained as follows:

$$y_{2002} - \hat{y}_{2002}(0) = 0.075 - 0.070 = 0.004$$

$$y_{2003} - \hat{y}_{2003}(2002) = 0.070 - 0.066 = 0.0003$$

To be able to make correct forecasts, alpha values resulting in minimum error should be chosen. In this application separate smoothing applied for every age group. However, errors examined considering whole data-set and total error is considered while forecasting all data on death.

Table 5.7: Sum of squared error and mean squared error for smoothed forecasts

Alpha	SSE	MSE
0.01	0.00262	0.00002
0.02	0.00242	0.00002
0.04	0.00209	0.00001
0.06	0.00186	0.00001
0.08	0.00169	0.00001
0.10	0.00158	0.00001
0.12	0.00150	0.00001
0.14	0.00144	0.00001
0.16	0.00141	0.00001
0.18	0.00138	0.00001
0.20	0.00137	0.00001
0.22	0.00136	0.00001
0.24	0.00135	0.00001
0.26	0.00135	0.00001
0.28	0.00135	0.00001
0.30	0.00134	0.00001

In Table 5.7, sum of squares of forecasting errors and means of squares of forecasting errors are shown for various alpha values. Accordingly, 0.3 alpha value is chosen which results in minimum sum of errors and one parameter double exponential smoothing is calculated with 0.3 alpha.

In the following stage, 2009-2010 mortality data is forecasted using the trend of 2002-2008 data. Forecasted value for 2009 is calculated as follows:

$$\hat{y}_{2008+1}(2008) = \left(2 + \frac{\alpha(1)}{(1-\alpha)}\right) S_{2008} - \left(1 + \frac{\alpha(1)}{(1-\alpha)}\right) S_{2008}^{(2)}$$

$$\hat{y}_{2009}(2008) = \left(2 + \frac{0.3}{(1-0.3)}\right) 0.059 - \left(1 + \frac{0.3}{(1-0.3)}\right) 0.066 = 0.049$$

$$= 0.049$$

Forecasted value for 2010 is calculated as follows:

$$\hat{y}_{2008+2}(2008) = \left(2 + \frac{\alpha(2)}{(1-\alpha)}\right) S_{2008} - \left(1 + \frac{\alpha(2)}{(1-\alpha)}\right) S_{2008}^{(2)}$$

$$\hat{y}_{2010}(2008) = \left(2 + \frac{0.6}{(1-0.3)}\right) 0.059 - \left(1 + \frac{0.6}{(1-0.3)}\right) 0.066$$

$$= 0.044$$

Calculations for the following years performed as shown above.

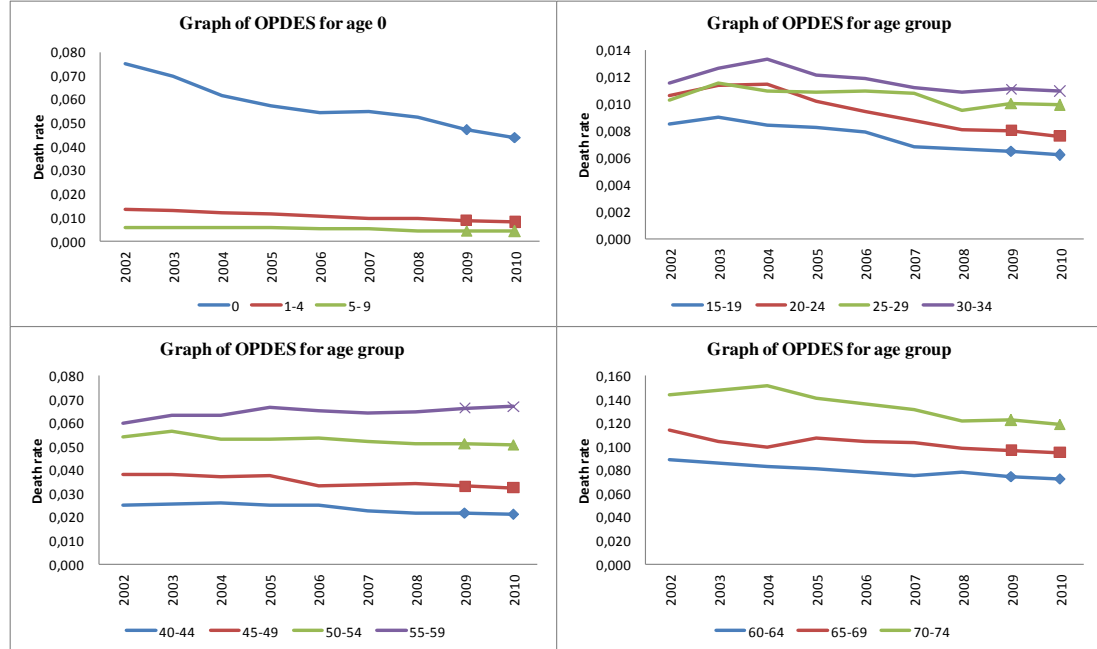


Figure 5.8 OPDES forecasts.

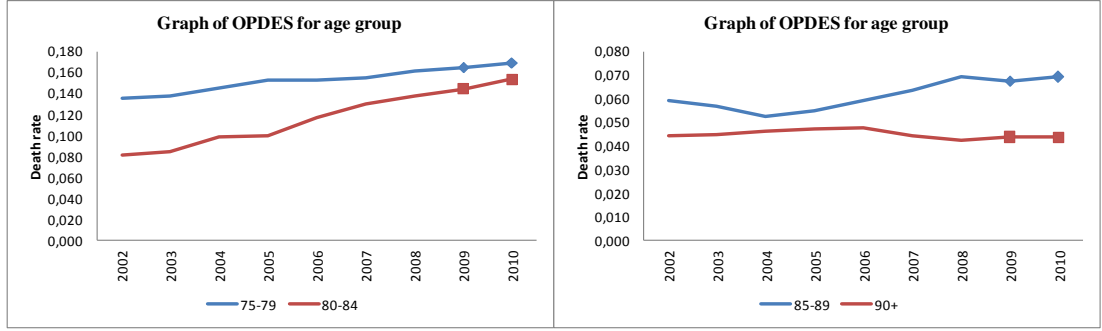


Figure 5.9 OPDES forecasts.

In Figure 5.8, results of one parameter double exponential smoothing is shown for age groups. However, forecast values obtained here are based upon the data from urban areas and actual forecast values required are deaths data covering whole Turkey. Since the published mortality data for 2009-2010 is present, a constant set for the difference between forecasted 2009-2010 mortality data for urban areas. The set constant will be as following if we represent urban areas' mortality data with $\hat{y}$, mortality data for whole Turkey with x , and smoothed mortality data with z .

$$\beta_i = \frac{\sum_{j=2009}^{2010} \left(\frac{|x_{i,j} - \hat{y}_{i,j}|}{c_j} \right)}{2} \quad i = 0,1-4,5-9,...,85-89,90+ \quad , \quad j = 2009,2010$$

where,

$$c = \sum_{i=0}^{90+} |x_i - \hat{y}_i|$$

Afterwards, in order to include the trend of present difference, signs of forecasted observations and smoothing constant obtained by age groups are matched. Forecasted values by city and town centers increased by smoothing constant obtained for every age group.

$$z_i = \hat{y}_i (1 + \beta_i)$$

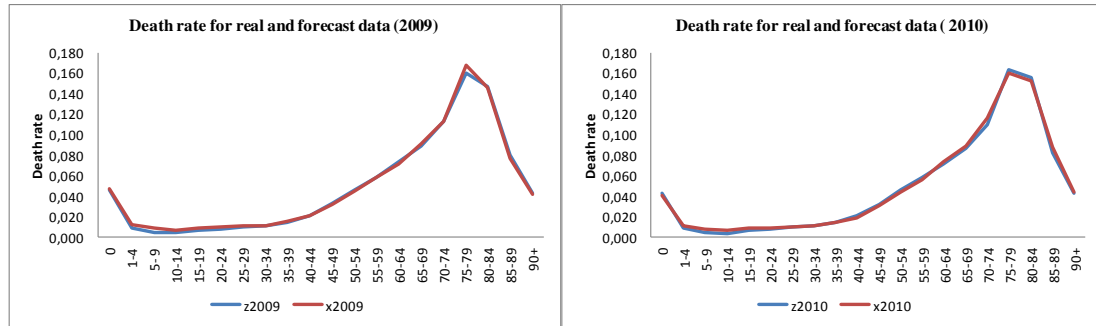


Figure 5.10 Modified forecasts values and real forecasts values for 2009 and 2010.

In Figure 5.9, mortality data for Turkey in general and mortality data obtained by using forecasting values of urban areas are shown. However, different trends these two data-sets bear do not allow the use of data from past years. In case of use, it is seen that life tables created to forecast future will result in incorrect outcomes. Hence, use of real data published in 2009 and 2010 for creating period life table and since the 2 year data is inadequate for future forecasting, analysis current structure is decided.

5.4 Construction of Period Life Table

In this section, for years 2009 and 2010, Abridged Period Life Table is constructed for Turkey. In order to construct this table, age-groups based mid-year population and deaths data are required. Data-set is obtained from mortality data for whole Turkey published by TUIK and population data published based upon ADNKS. Mortality data are examined in section 4.3. Mid-year population forecasts for age groups are calculated using population data of 2008, 2009 and 2010. Mid-year population forecasts of the years 2009 and 2010 for age group 0 to 4 are shown below (Preston et al, 2001).

$$\begin{aligned}
 r &= \frac{\ln N(t) - \ln N(0)}{t} = \ln \frac{N(2009)}{N(2008)} \\
 &= \ln \frac{6.155.321}{5.998.258} = 0,02584 \\
 N_t &= \frac{N(t) - N(0)}{r} = \frac{6.155.321 - 5.998.258}{0,02584} = 6.076.451
 \end{aligned}$$

$$\begin{aligned}
 r &= \frac{\ln N(t) - \ln N(0)}{t} = \ln \frac{N(2010)}{N(2009)} \\
 &= \ln \frac{6.178.723}{6.155.321} = 0,003794 \\
 N_{2010} &= \frac{N(t) - N(0)}{r} = \frac{6.178.723 - 6.155.321}{0,003794} = 6.167.015
 \end{aligned}$$

Procedure above is applied for all age groups.

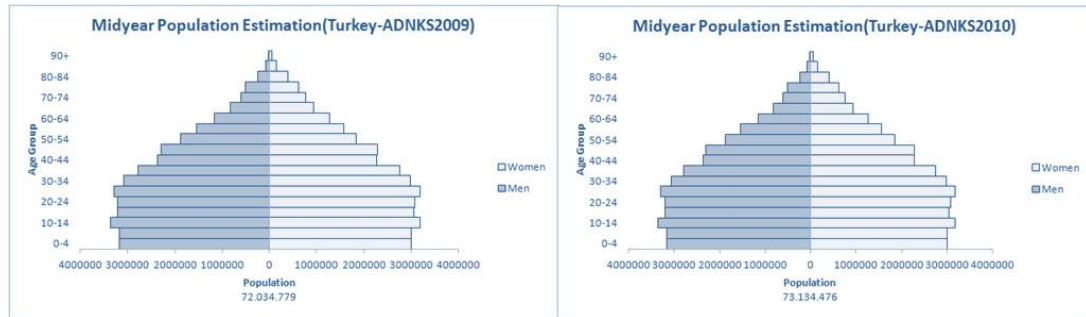


Figure 5.10 Midyear population estimation by gender, age group.

Afterwards, age specific death rates are obtained by dividing number of deaths in every age interval to alive number of person years in that specific age group. Number of person-years is equal to mid-year population forecasts. While creating life tables, infant mortality, in other words 0-age mortality is forecasted separately and instead of mid-year population data, number of newborns within that specific year is used. 0-age age specific death rates are calculated for 2009 as

$$m_0 = \frac{D_0}{B_0} = \frac{17,354}{1,272,300} = 0.0136$$

And calculated for 2010 as

$$m_0 = \frac{D_0}{B_0} = \frac{15,049}{1,238,970} = 0.0121$$

2009 age specific death rate for age group 1-4 is:

$${}_4m_1 = \frac{{}_4D_1}{{}_4N_1} = \frac{4,564}{4,795,730} = 0.00095$$

And for 2010 is:

$${}_4m_1 = \frac{{}_4D_1}{{}_4N_1} = \frac{4,183}{4,911,332} = 0.00085$$

Table 5.8 Age specific death rates per thousand for every age group by 2009 and 2010 years.

	2009			2010		
Age Group	All	Female	Male	All*	Female*	Male*
0	13.55	13.06	14.61	12.15	11.40	12.85
1-4	0.95	0.93	0.99	0.85	0.82	0.88
5- 9	0.55	0.54	0.56	0.47	0.47	0.47
10-14	0.39	0.35	0.44	0.35	0.31	0.39
15-19	0.55	0.39	0.71	0.53	0.36	0.69
20-24	0.57	0.38	0.76	0.53	0.33	0.72
25-29	0.64	0.43	0.85	0.59	0.39	0.78
30-34	0.73	0.52	0.93	0.69	0.48	0.89
35-39	1.03	0.76	1.29	0.94	0.69	1.19
40-44	1.65	1.17	2.13	1.49	1.10	1.88
45-49	2.73	1.83	3.62	2.50	1.65	3.34
50-54	4.54	2.78	6.28	4.32	2.64	5.96
55-59	7.42	4.54	10.35	6.70	4.13	9.31
60-64	11.52	7.58	15.90	11.14	7.35	15.29
65-69	19.49	13.89	26.00	18.41	13.21	24.33
70-74	31.92	24.91	40.65	31.14	24.39	39.58
75-79	54.69	45.75	65.86	52.12	43.36	62.83
80-84	90.82	81.06	107.36	88.02	78.08	104.79
85-89	145.99	134.29	169.82	141.36	130.52	162.61
90+	244.53	229.32	291.09	231.20	218.52	269.99

Calculated age specific death rates are shown in Table 5.8. According to the findings, infant mortality rate is decreased by 10.3 % in the general population, by 12.7 % in the female population and by 12.1 % in the male population. Age specific death rate of the 40-44 age group is decreased by 9.7 % in the general population, by 6 % in the female population and by 11.7 % in the male population. Maximum decrease in the 60-65 age groups is in the male population with 6.4 %.

Correspondingly, lowest decrease in the age specific death rates of 90 years of age and older realized for female population with 4.7 %.

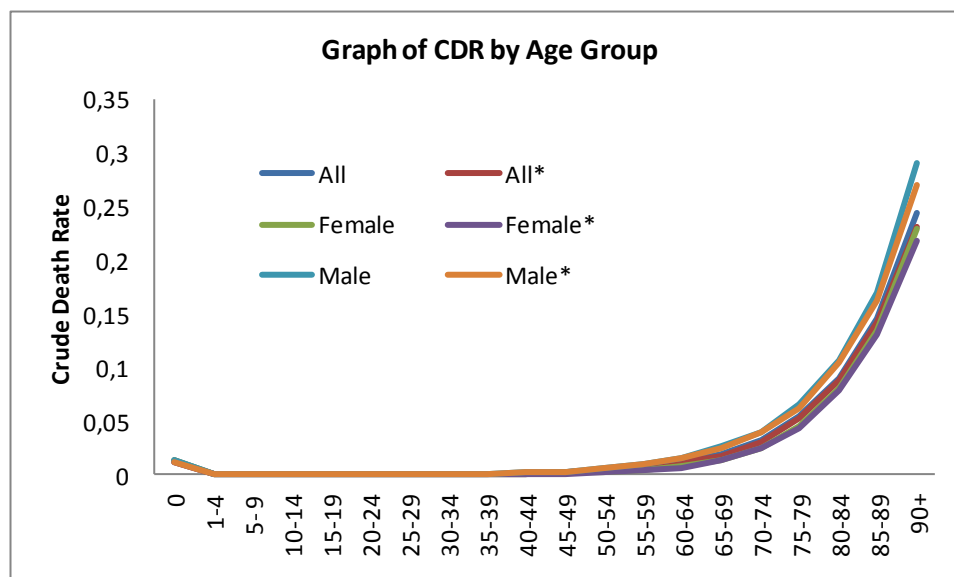


Figure 5.11 Graph of crude deaths by age groups (* shows that 2010 year).

Figure 5.11, shows crude death rates. Here it can be seen that crude death rates of males is the highest and crude death rates of females is the lowest.

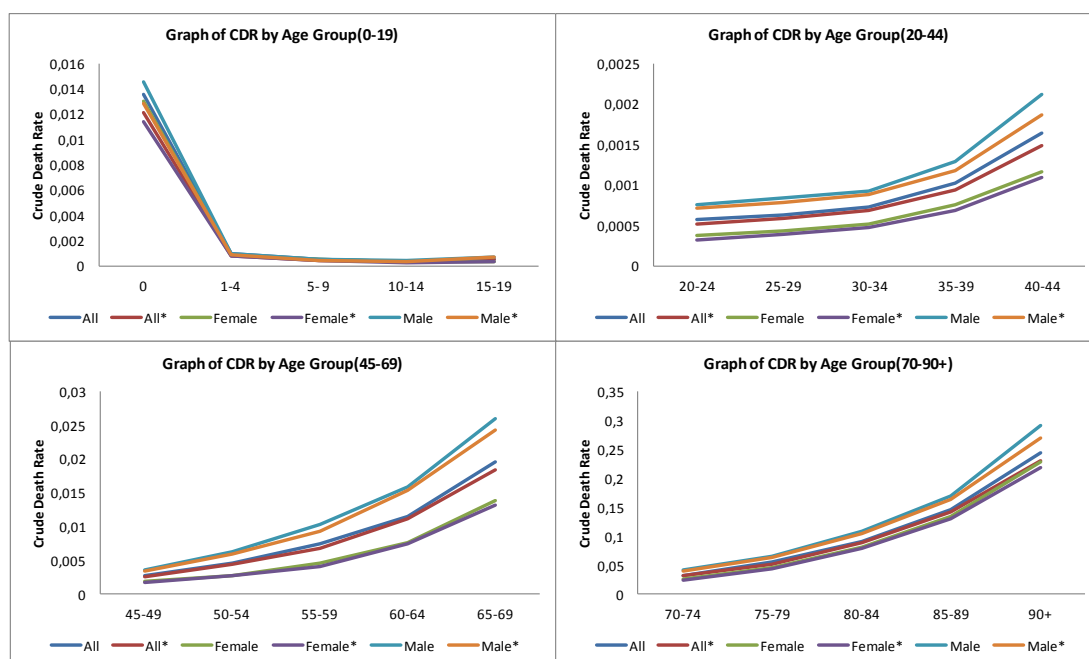


Figure 5.12 Graph of crude death rate for all age group by sex (* shows that 2010 year).

Crude death rates for various age groups are shown in Figure 5.12.

Next stage for creating life tables is to obtain age specific death rates by using crude death rates and mean number of live person-years. At this stage, number of live person-years is calculated initially using real observations. Mean number of alive people in the 1-4 age group in 2009 is calculated as

$${}_n a_x = \frac{d_x \cdot (0) + d_{x+1} \cdot (1) + d_{x+2} \cdot (2) + d_{x+3} \cdot (3) + d_{x+4} \cdot (4)}{{}_n d_x}, \quad n = 5$$

$$\frac{1,782(0) + 1,086(1) + 894(2) + 845(3)}{4,607} = 1.174$$

And mean number of alive people in the 1-4 age group in 2010 is calculated as

$$= \frac{1,661(0) + 1,028(1) + 772(2) + 722(3)}{4,607} = 1.133$$

And the variable is obtained generally for male and female age groups. Afterwards, age specific death rates are calculated as follows using the equation.

$$q_0 = m_0 = 0.0136$$

$${}_4 q_1 = \frac{{}_4 m_1}{1 + (1 - {}_4 a_1) {}_4 m_1} = \frac{4(0.00095)}{1 + (1 - 1.174)(0.00095)} = 0.0038$$

$${}_5 q_5 = \frac{{}_5 m_5}{1 + (1 - {}_5 a_5) {}_5 m_5} = \frac{5(0.00055)}{1 + (1 - 1.870)(0.00055)} = 0.0027$$

We assume that all population is died infinite age and its' also equal

$$q_\infty = 1$$

For 2010,

$$q_0 = m_0 = 0.0121$$

$${}_4q_1 = \frac{{}_4m_1}{1 + (1 - {}_4a_1){}_4m_1} = \frac{4(0.00085)}{1 + (1 - 1.133)(0.00085)} = 0.0034$$

$${}_5q_5 = \frac{{}_5m_5}{1 + (1 - {}_5a_5){}_5m_5} = \frac{5(0.00047)}{1 + (1 - 1.715)(0.00047)} = 0.0023$$

$$q_\infty = 1$$

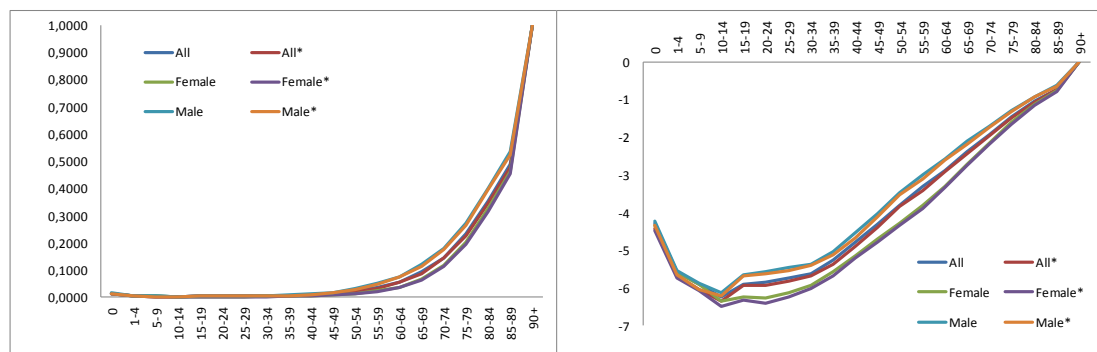


Figure 5.13 Probabilities of age specific death rates for age groups in two different forms and (* shows 2010 year).

Taking the graph of general probabilities of age specific death rates into account, there is a decrease observed in 2010 compared with 2009. Death probabilities for males take greater values than for females.

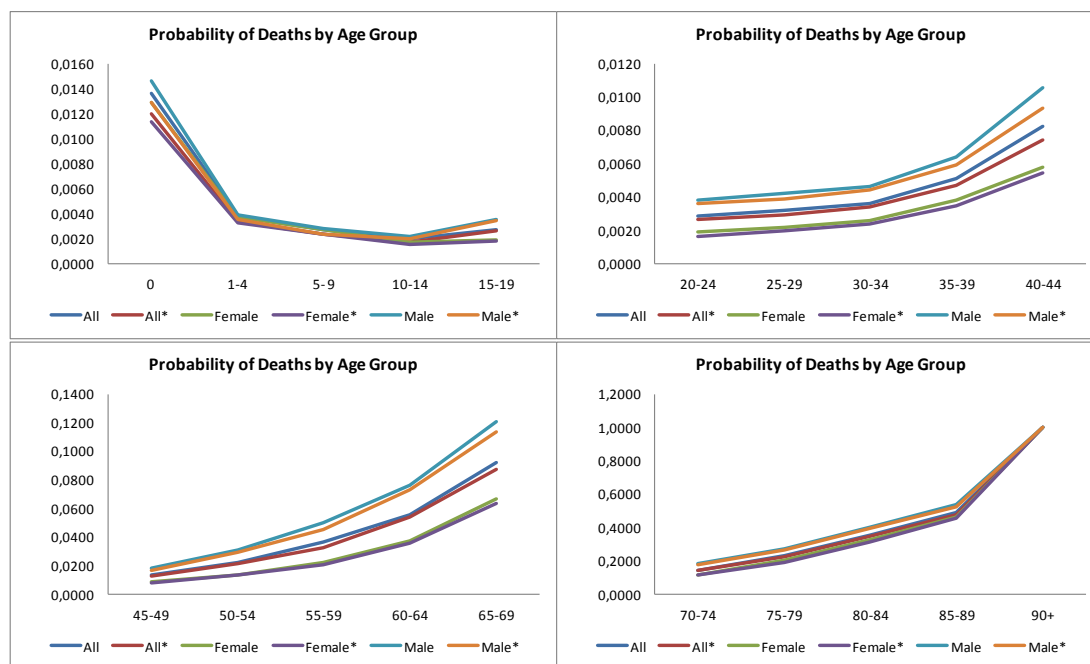


Figure 5.14 Age specific death probabilities for all age group by sex (* shows that 2010 year).

In Figure 5.14, death probabilities are examined for various age groups. Infant mortalities in 2010 decreased by 11.02 % in the general population, by 14.5 % in the female population and by 13.2 % in the male population compared with 2009. This decrease trend continues until the age of 15. While an increase trend is observed in death probabilities after the age of 15, there is a decrease in death probabilities in 2010 compared to 2009. Increase in the death probabilities of 40-44 age group is 13.9 % for males and 5.5 % for females. Increase in the death probabilities of 65-69 age group is observed to be 6.4 % for males and 4.8 % for females. Increase in the death probabilities of 75-79 age group is observed to be 3.9 % for males and 4.8 % for females. Increase in the death probabilities of 80-84 age group is observed to be 1.8 % for males and 3.04 % for females. As can be seen, decrease in the death probabilities of infants and children with years and decrease in the death probabilities of males over 70 are lower than the ones for females. And oppositely, it is higher in the middle-age interval.

According to the general probability theory, a person can either survive or die, in other words, probabilities of death and survival are complements of each other.

Therefore, survival probability of a person aged x is calculated as follows and so, survival probabilities of 0 age and 1-4 age group in 2009 are:

$$p_x = 1 - q_x$$

$$p_0 = 1 - q_0 = 1 - 0.0136 = 0.9864$$

$${}_n p_x = 1 - {}_n q_x$$

$${}_4 p_1 = 1 - {}_4 q_1 = 1 - 0.0038 = 0.9962$$

Survival probabilities of 0 age and 1-4 age group in 2010 are:

$$p_0 = 1 - q_0 = 1 - 0.0121 = 0.9879$$

$${}_4 p_1 = 1 - {}_4 q_1 = 1 - 0.0034 = 0.9966$$

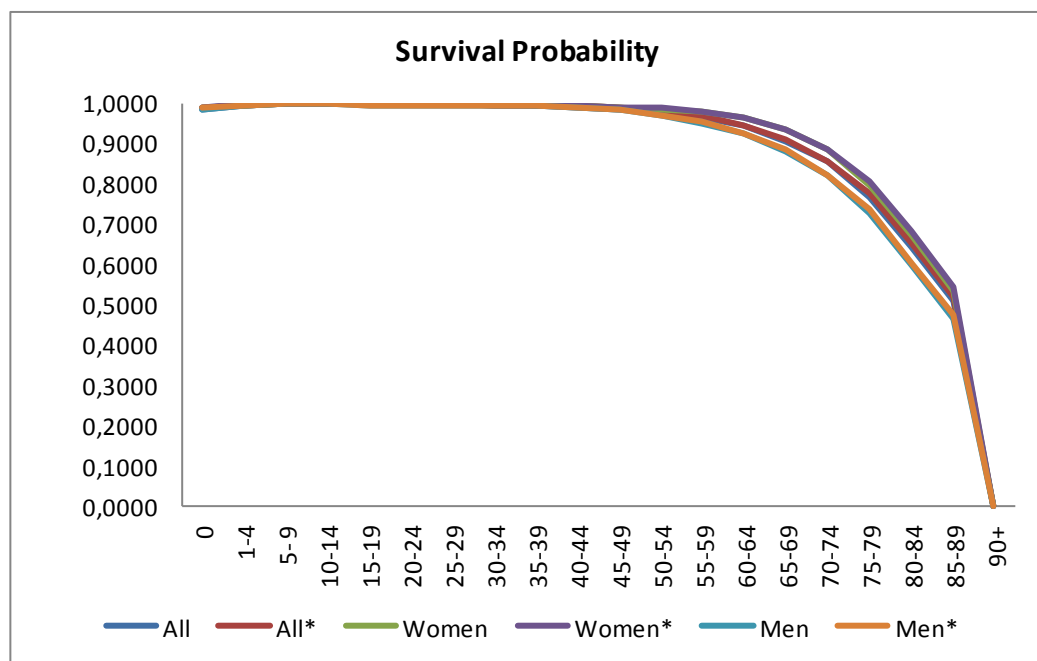


Figure 5.15 Graph of probabilities of survive by sex and age groups.

Survival probabilities of whole population, males and females in 2009 and 2010 are separately shown in Figure 5.15. As can be seen in the graph, survival probabilities of females take greater values than males.

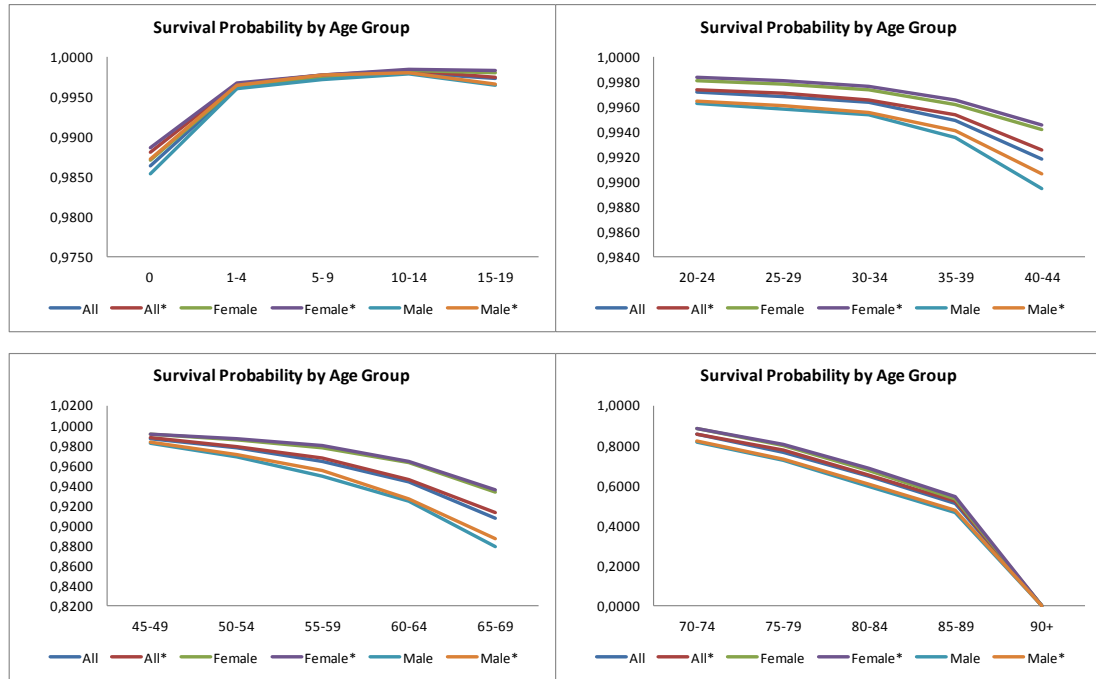


Figure 5.16 Graph of probabilities of survive for all age interval by sex (* shows that 2010 year).

Survival probabilities are shown in Figure 5.16 for various age groups. Since they are complements of death probabilities, survival probabilities behave oppositely.

After the death and survival probabilities which make up the basis for life tables, number of alive and death people are obtained. 1.000.000 people assumed to be present in the population of the research and assigned as radix. Number of live people is obtained as follows for every age group.

$$l_{x+n} = l_x \cdot {}_n p_x$$

$$l_1 = l_0 \cdot p_0 = (0.9864) \cdot (1,000,000) = 986,448$$

$$l_5 = l_1 \cdot {}_5 p_5 = (0.9962) \cdot (986,448) = 982,703$$

Number of alive people obtained is calculated for every age group according to general population, male population and female population separately for 2009 and 2010.

Number of death people for every age group is obtained as follows.

$${}_n d_x = l_x - l_{x+n}$$

$$d_0 = l_0 - l_1 = 1,000,000 - 986,448 = 13,552$$

$${}_4 d_1 = l_5 - l_1 = 986,448 - 982,703 = 3,745$$

Number of death people obtained is calculated for every age group according to general population, male population and female population separately for 2009 and 2010. Number of deaths calculated for male and female populations are shown in the graph below. Accordingly, while the number of deaths for elderly population of males is decreasing, it continues to shift towards further ages for females.

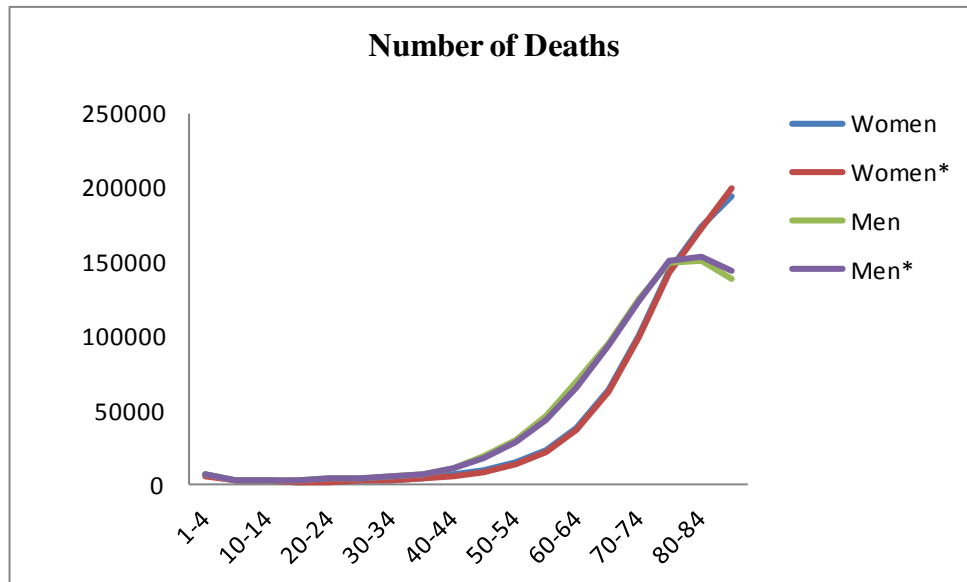


Figure 5.17 Graph of smoothed deaths by moving averages method by sex, (* show 2010 year)

The most important function of life tables is expected life spans. In order to calculate expected life spans, number of live person-years in every age group and total number of alive person-years must be identified. For every age group, number of live people is calculated using the equation and obtained as follows:

$${}_n L_x = n(l_{x+n} + {}_n a_x \cdot {}_n d_x)$$

$$L_0 = l_1 + (a_0 \cdot d_0) = 986,448 + ((0.0136) \cdot (13,552)) = 986,631$$

$${}_4L_1 = 4 \cdot l_5 + 4({}_4a_1 \cdot {}_4d_1) = 4(982,703) + 4((1.174)(3,745)) = 3,935,207$$

$${}_5L_5 = 5 \cdot l_{10} + 5({}_5a_5 \cdot {}_5d_5) = 5(980,013) + 5((1.870)(2,690)) = 4,905,093$$

For calculation of number of person-years aged 90 and over, the equation is used (Preston et al, 2001).

$$L_{w+} = \frac{d_{w+}}{m_{w+}} = \frac{l_{w+}}{m_{w+}}$$

$$L_{90+} = \frac{d_{90+}}{m_{90+}} = \frac{l_{90+}}{m_{90+}} = \frac{163,728}{0.2445} = 669,569$$

Total number of live person-years for every age group is obtained as shown below and life expectancy is calculated by dividing it into number of alive people in that specific age group. Total number of live people (Cunningham, 2005):

$$T_x = T_{x+n} + {}_nL_x = \sum {}_nL_x \quad x = 0, 1, 5, \dots, 90 +$$

$$T_0 = 75,806,516$$

$$T_1 = 74,820,156$$

Total number of live people at the age 90 and over:

$$T_w = L_{w+}$$

$$T_{90} = 669,569$$

As specified earlier, these calculations are given separately for general, male and female populations.

Expected life at birth in 2009 is calculated as:

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

$$e_0 = \frac{T_0}{l_0} = \frac{75,806,516}{1,000,000} = 75.8$$

And for 2010:

$$e_0 = \frac{T_0}{l_0} = \frac{76,508,760}{1,000,000} = 76.5$$

According to these findings, while the expected life of the general population in 2009 is 75.8, it is 78.5 for females and 73.1 for males. And for 2010, expected life span is increased to 76.5 for the general population, to 79.1 for females and to 73.9 for males. Expected life span of the general population is increased by 0.92 % in 2010 compared to 2009. This increase is 0.76 % for females and 1.1 % for males. Life expectancy of males achieved greater increase than female life expectancy.

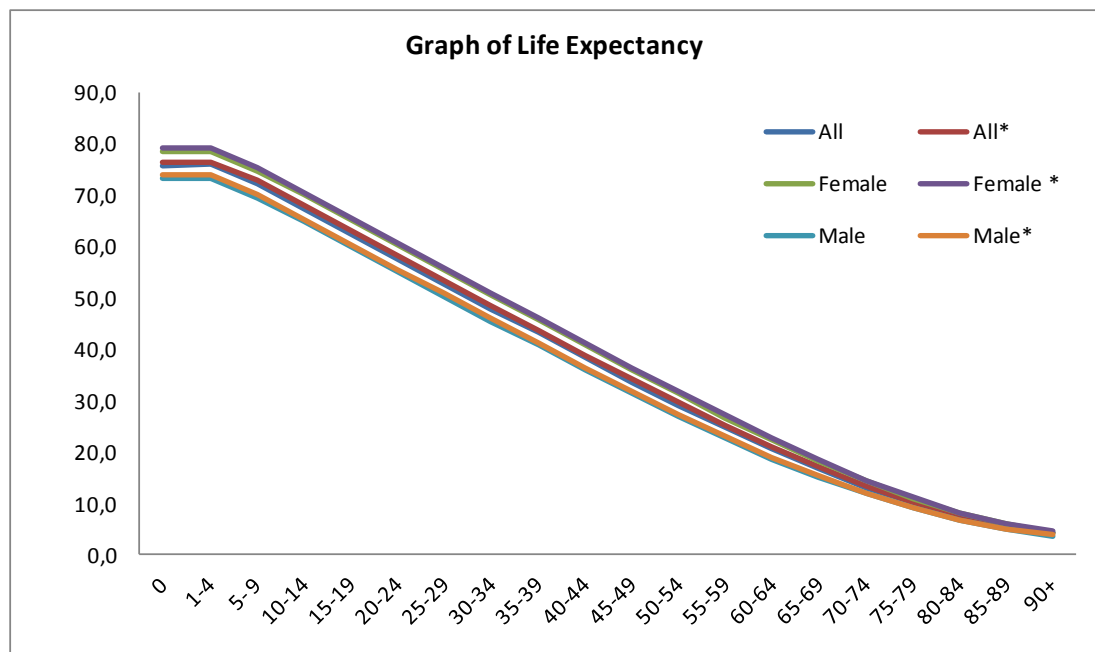


Figure 5.11 Graph of life expectancy by sex and age groups, (* shows 2010 year).

5.4.1 Estimate Survivors at Older Ages by Using Gompertz Law of Mortality

Demographic features of our country shows that number of elderly population is increasing and expected life are prolonged. Thence, number of live people for age groups 90 and over is forecasted. As a way of forecasting, law of mortality developed by Gompertz is utilized. General model of Gompertz approach which is utilized for analyzing pattern of mortality of a population according to time and age, is as follows (Preston et. al., 2001):

$$l_x = C \cdot a^{b^x}$$

Parameters obtained using last three values of the life table survival function. Parameter forecasts for total population in 2009 are as follows:

$$b = \left(\frac{\ln \frac{l_{x+2n}}{l_{x+n}}}{\ln \frac{l_{x+n}}{l_x}} \right)^{\frac{1}{n}} = \left(\frac{\ln \frac{l_{85}}{l_{80}}}{\ln \frac{l_{80}}{l_{75}}} \right)^{\frac{1}{5}} = 1.10382$$

$$a = \exp \left(\frac{\ln \frac{l_{x+n}}{l_x}}{b^x (b^n - 1)} \right) = \exp \left(\frac{\ln \frac{l_{80}}{l_{75}}}{b^{75} (b^5 - 1)} \right) = 0.99974$$

$$C = l_x \cdot \exp(-b^x \cdot \ln a) = l_{75} \cdot \exp(-1.10382^{75} \cdot \ln(0.99974)) = 985,674.6$$

Forecast of number of alive people in 90-94 age group after parameter forecasts is calculated as follows using the general model:

$$\hat{l}_{90} = (985,674.6) \cdot (0.99974^{1.10382^{90}}) = 156,320$$

$$\hat{l}_{95} = (985,674.6) \cdot (0.99974^{1.10382^{95}}) = 48,221$$

$$\hat{l}_{100} = (985,674.6) \cdot (0.99974^{1.10382^{100}}) = 7,018$$

$$\hat{l}_{105} = (985,674.6) \cdot (0.99974^{1.10382^{105}}) = 298$$

$$\hat{l}_{110} = (985,674.6) \cdot (0.99974^{1.10382^{110}}) = 2$$

$$\hat{l}_{115} = (985,674.6) \cdot (0.99974^{1.10382^{115}}) \approx 0$$

It is applied for forecasting of number of live people for elderly population in 2009 and 2010 for whole, male and female populations. Accordingly, graphs for death probabilities are given below:

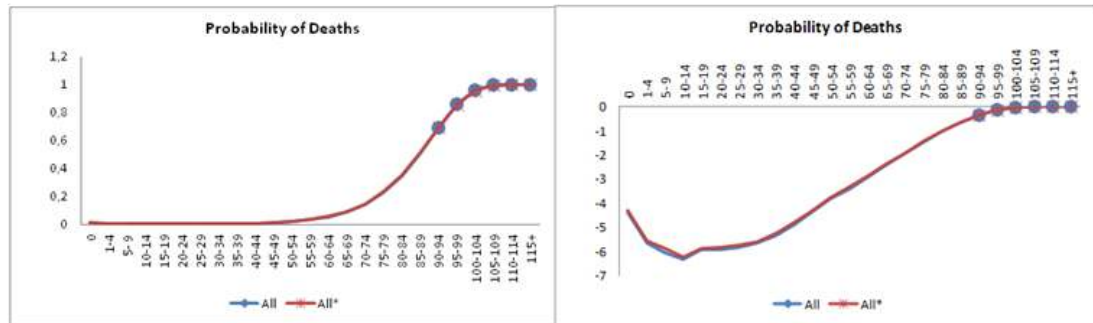


Figure 5.129 Graphs of age specific death probabilities estimations of older ages in two forms (* shows 2010 year)

In Figure 5.19, age specific death probabilities are calculated with forecast of number of live people aged 85 and over within general population and the logarithm taken values of these forecasts are shown. According to this, increase in the death probabilities continue until the age of 105. Almost everyone in Turkey dies before the age of 115.

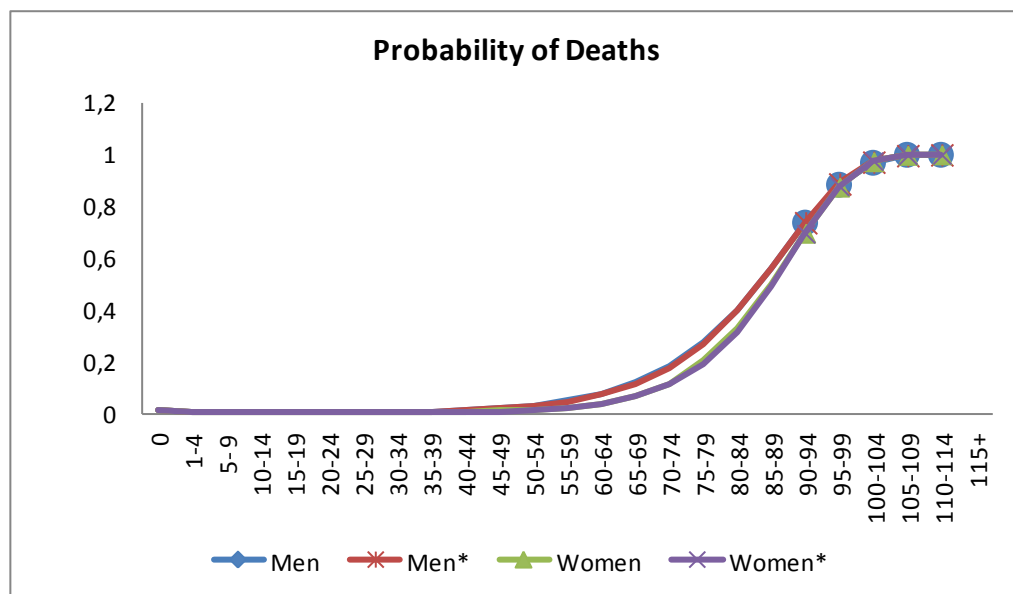


Figure 5.13 Graphs of age specific death probabilities estimations of older ages by gender

(* shows 2010 year)

In Figure 5.20, age specific death probabilities are calculated with forecast of number of live male and female populations aged 85 and over are shown. According to this, increase in the death probabilities continue until the age of 105. Almost everyone in Turkey dies before the age of 115.

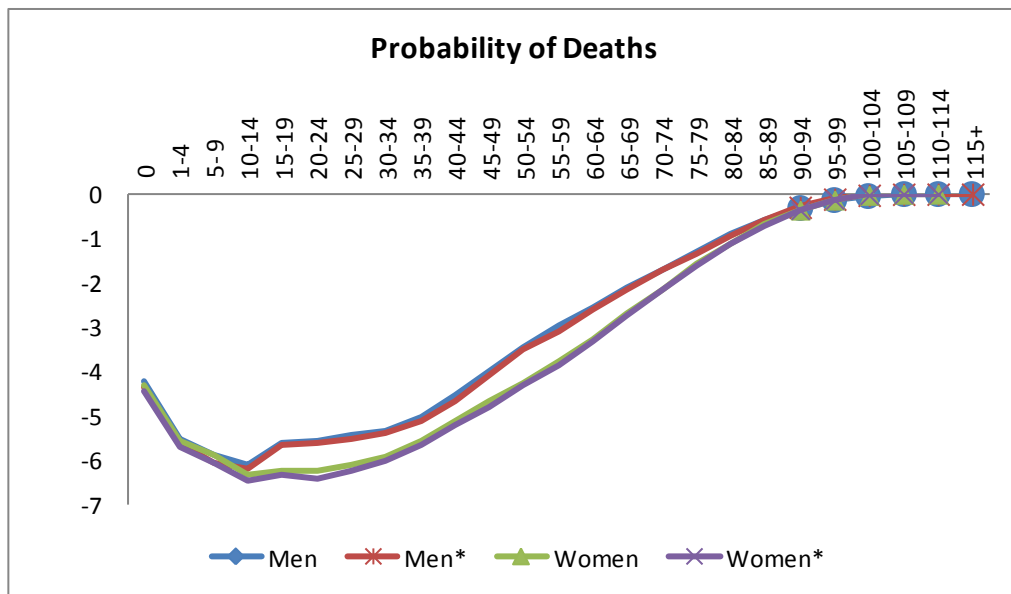


Figure 5.14 Graph of age specific death probabilities in logarithm form with estimation of older ages, (* shows 2010 year).

In Figure 5.21, logarithm taken values of death probabilities are calculated with forecast of number of live male and female populations aged 85 and over are shown.

Table 5.9 Life expectancy and rate of increase for specific age group, (* shows 2010 year).

Age	All	All*	Rate of Increase %	Women	Women*	Rate of Increase %	Men	Men*	Rate of Increase %
0	75.8	76.5	0.9%	78.5	79.1	0.8%	73.1	73.9	1.1%
20	57.6	58.1	0.9%	60.2	60.7	0.8%	55.0	55.6	1.1%
40	38.3	38.8	1.2%	40.7	41.1	1.0%	35.9	36.4	1.5%
60	20.5	20.9	1.7%	22.2	22.6	1.5%	18.6	19.0	2.0%
80	7.4	7.6	2.8%	7.9	8.1	2.7%	6.6	6.8	3.1%

In Table 5.9, expected lifetime and increase rates based upon years are shown for some specific age groups of elderly population calculated with forecasts and

expected life. The greatest increase in expected lifetime is observed in males. Life spans of males are extended more than life spans of females in 2010. This can be inferred as life spans of males will increase more than life spans of females in the following years. However, while the expected life of females was 5.4 years more than males in 2009, it is 5.2 years more in 2010. Increase in the expected life spans in 2010 compared to 2009 is a sign that the population of Turkey is getting older.

5.4.2 Construction of Turkey Period Life Table by Region

In this section, for years 2009 and 2010, An Abridged Period Life Table, which has been constructed in section 4.4, is expanded by region. The methodology of construction of the table is the same with section 4.4. Firstly the data set, is ordered, which include population, birth and death data by region and sex and also midyear population is estimated for years 2009 and 2010 by region. Before the tables are constructed, regions are determined with their abridgment codes. The codes which are expressed to regions as listed in Table 10:

Table 5.10 Region code for IBBS Level 1 (TÜİK).

Code	Region
TR1	İstanbul
TR2	West Marmara
TR3	Aegean
TR4	East Marmara
TR5	Western Anatolia
TR6	Mediterranean
TR7	Center Anatolia
TR8	Western Black Sea
TR9	Eastern Black Sea
TRA	Northeast Anatolia
TRB	Middle East Anatolia
TRC	Southeastern Anatolia

Table 5.11 Infant mortality and decrease rate in infant mortality for years 2009 and 2010 by region which defined İBBS level 1 by TÜİK.

İBBS (1)	TR1	TR2	TR3	TR4	TR5	TR6	TR7	TR8	TR9	TRA	TRB	TRC
2009	11,1	13,3	14,0	12,7	12,7	13,4	11,9	13,1	11,7	12,9	17,3	17,2
2010	9,8	10,3	11,4	10,0	11,6	12,1	10,7	11,1	10,4	14,0	14,3	16,0
Rate	11,7%	22,3%	18,1%	21,5%	9,1%	9,4%	10,1%	15,5%	10,5%	7,93%	17,1%	6,8%

In Table 5.11 shows that a decrease rate gets a minimum value for Southeastern Anatolia, TRC and a decrease rate gets a maximum value for West Marmara, TR2 following East Marmara, TR4. The lowest infant mortality rate is 11.1 per thousand for İstanbul, TR1 and also the highest infant mortality rate is 17.3 per thousand for Middle East Anatolia, TRB at 2009. Against, the lowest infant mortality rate is 9.8 per thousand for İstanbul, TR1 and also the highest infant mortality rate is 16.0 per thousand for Southeastern Anatolia, TRC at 2010.

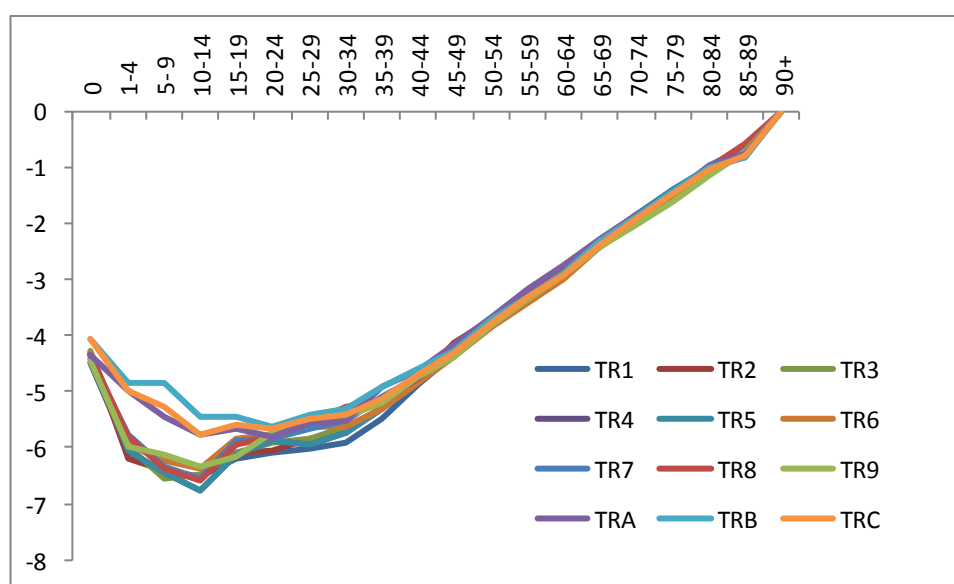


Figure 5.152 Age specific death probabilities (logarithm forms) for region, 2009.

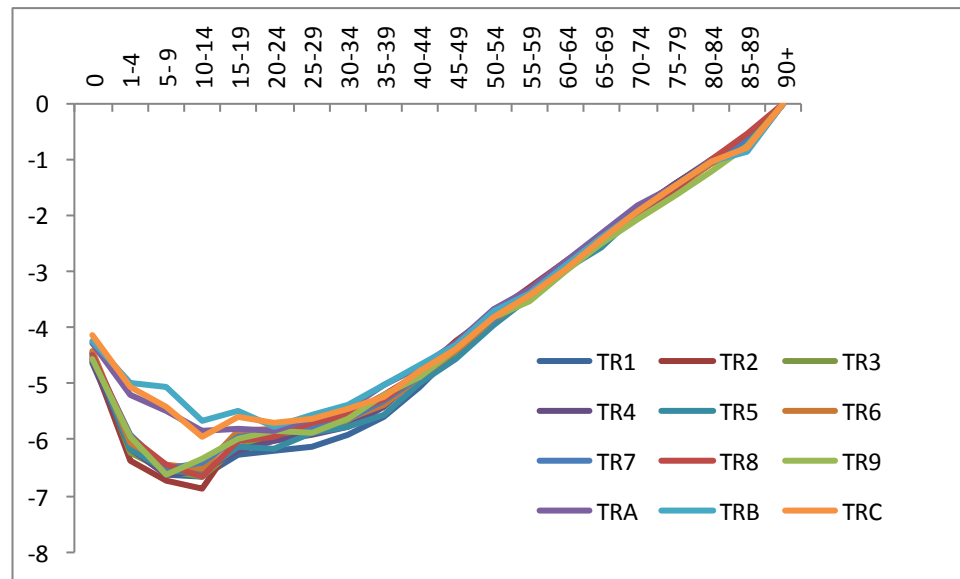


Figure 5.163 Age specific death probabilities (logarithm forms) for region, 2010.

In Figures 5.22 and 5.23, the age specific death probabilities for twelve region by 2009 and 2010 in Turkey. Infant mortalities in 2010 decreased in all region according to 2009. As can be seen, in the death probabilities of infants and children are decreasing with years and oppositely, in the middle age and older age intervals the probabilities are starts to increase.

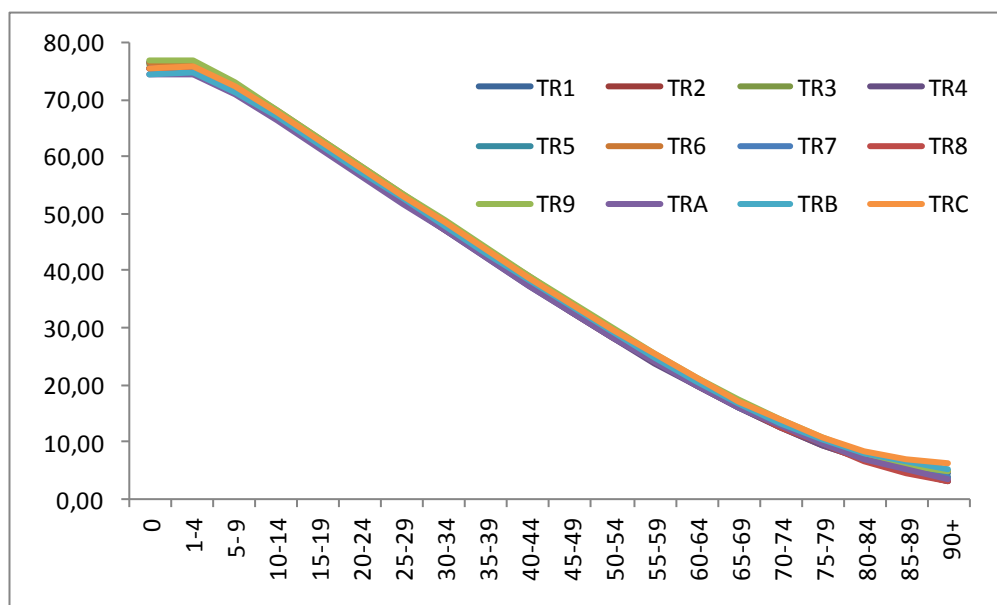


Figure 5.174 The life expectancy by regions, 2009.

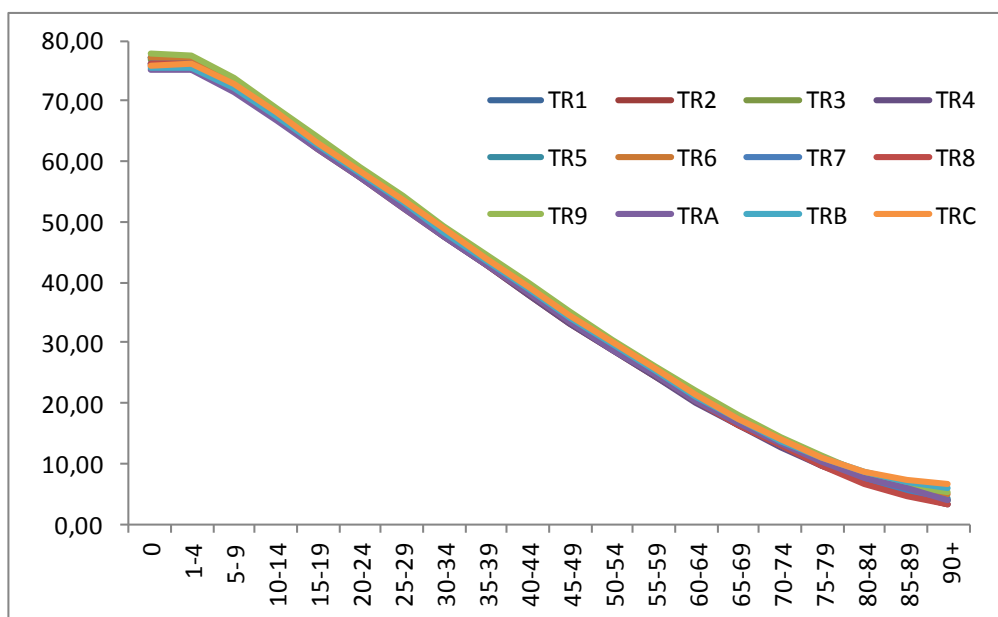


Figure 5.185 The life expectancy by regions, 2010.

The life expectancies of region are showed in Figure 5.25 and 5.24.

Table 5.12 The life expectancies of certain ages for regions and years (* shows 2010)

Age	TR1	TR2	TR3	TR4	TR5	TR6	TR7	TR8	TR9	TRA	TRB	TRC
0	76,5	75,5	76,1	75,4	76,4	76,6	75,5	75,4	76,9	74,4	74,5	75,4
0*	77,1	76,0	76,9	76,1	77,3	77,0	76,3	76,2	77,7	75,1	75,4	76,0
20	57,9	57,0	57,7	56,9	58,0	58,3	57,0	57,0	58,4	56,6	57,4	58,0
20*	58,3	57,2	58,3	57,3	58,7	58,6	57,7	57,5	59,1	57,3	58,0	58,4
40	38,4	37,6	38,4	37,5	38,6	39,0	37,8	37,8	39,2	37,4	38,4	38,9
40*	38,8	37,9	38,9	37,9	39,3	39,3	38,3	38,2	39,8	38,1	38,8	39,2
60	20,6	20,0	20,6	19,8	20,7	21,1	20,1	20,1	21,4	19,9	20,7	21,2
60*	20,8	20,2	20,9	20,1	21,1	21,3	20,4	20,3	21,9	20,4	21,1	21,4
80	7,8	7,1	7,4	6,8	7,3	7,8	6,9	6,8	8,1	7,1	8,0	8,4
80*	7,6	7,2	7,5	6,9	7,7	7,9	7,1	6,7	8,4	7,7	8,4	8,5

The highest increase of life expectancy is observed in TRB and TR5, oppositely, the lowest increase of life expectancy is observed in TR6 at age 0. As similarly, for age group 20-24, the highest increase of life expectancy is observed in TR9 and TR5, oppositely, the lowest increase of life expectancy is observed in TR2. In age group 40-44, the highest increase of life expectancy is observed in TRA and TR5, oppositely, the lowest increase of life expectancy is observed in TR6. In age group 60-64, the highest increase of life expectancy is observed in TRA and TR9, oppositely, the lowest increase of life expectancy is observed in TR1. In age group

80-84, the highest increase of life expectancy is observed in TRA and TRB, oppositely, the lowest increase of life expectancy is observed in TR1.



Figure 5 196 The life expectancies of regions at age 0 for 2009



Figure 5 207 The life expectancies of regions at age 0 for 2010

In Figure 5.26 and 5.27, life expectancies of regions are demonstrated for a period 2009 and 2010.

CHAPTER SIX

CONCLUSION

In the application chapter of this thesis, the real population and demographic data is used. By using the life table analysis, the age pattern and demographic structure are modeled. The life table analysis is applied for Turkey and its' region. In this study, it is observed that age specific death probabilities are decreasing at younger population and babies, the probabilities are increasing at older population. As a result of this observation, it is demonstrated that the life expectancy is increased. The females' life expectancy is higher than the males although in this application showed us the rate of increasing in life expectancy of males is expeditiously increased according to females in time passes. Besides the life expectancy for Eastern Black Sea Region is the highest, the life expectancy for Northeast Anatolia Region is the lowest in Turkey.

Another result which is observed in this study is the death patterns of age group is not demonstrated same trend for general and urban population. So the database which includes number of deaths for urban population cannot be used for forecasting patterns of mortality of general population.

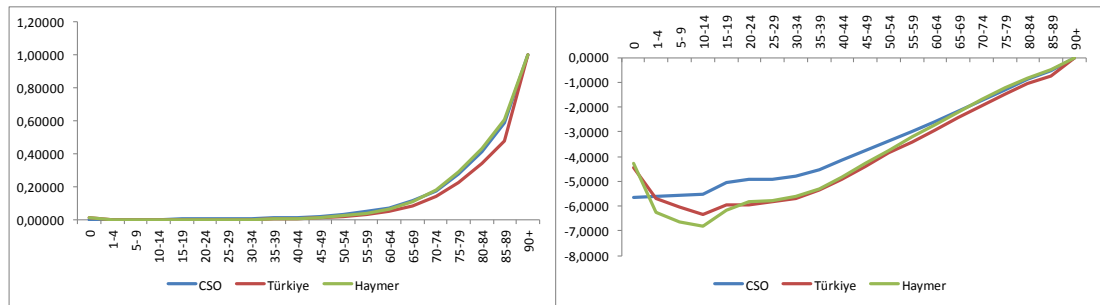


Figure 5 218: Age specific death probabilities by age group

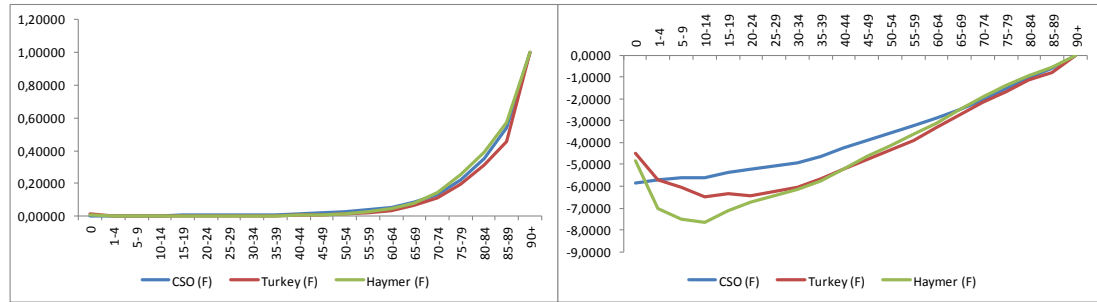


Figure 5 229: Age specific death probabilities for female by age group

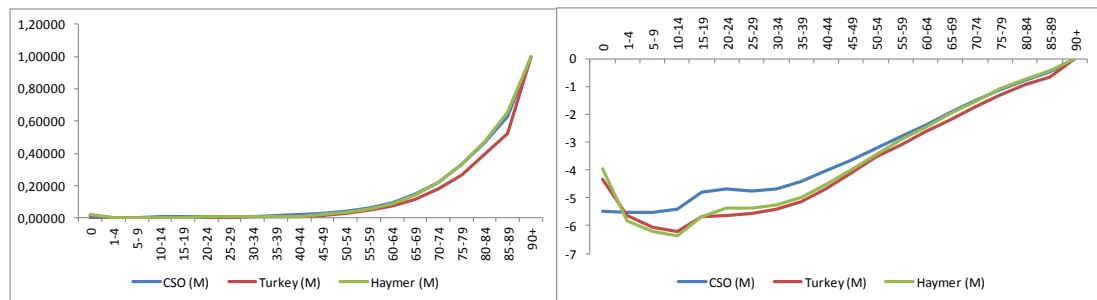


Figure 5 23: Age specific death probabilities for male by age group

In Figures 5.28, 5.29 and 5.30, the age specific death probabilities are compared for three life tables which are constructed by gender and age group. These tables are The Commissioners 1980 Standard Ordinary Mortality Table (CSO) which is actively used in our country, Turkey which is constructed in this thesis and Haymer which is constructed for Turkey by Haymer et. al. The figures showed us, the expected life in Turkey is longer than CSO. According to the HAYMER, the reasons of increasing life expectancy are lower infant and child mortality but the real data shows that the reasons are increasing older population in Turkey besides lower infant and child mortality. The life table which is demonstrated Turkey's demographic structure cannot be able to construct yet and an another country's life table is used such as The Commissioners 1980 Standard Ordinary Mortality Table (CSO) for actuarial analysis in Turkey. So many problems are available in insurance sector and in pension system. Finally The Turkey's Life Table should be constructed and actively used. This thesis summarized that:

- The life expectancy is lengthen as time passes in Turkey.
- The probabilities of dying of a newborns are regularly decreasing.
- The deaths are shifting from middle ages to older ages as time passes.

- Increase in the expected life spans in 2010 compared to 2009 is a sign that the population of Turkey is getting older. So Turkey is expeditiously getting older.

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APPENDIX

ABRIDGED PERIOD LIFE TABLES

Appendix 1: Turkey Abridged Period Life Table, 2009.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0136	-	0,0136	0,9864	1.000.000	13.640	986.360	75.806.516	75,8
1	0,0010	1,1741	0,0038	0,9962	986.360	3.745	3.934.858	74.820.156	75,9
5	0,0005	1,8700	0,0027	0,9973	982.615	2.690	4.904.658	70.885.298	72,1
10	0,0004	2,0485	0,0020	0,9980	979.926	1.917	4.893.970	65.980.640	67,3
15	0,0005	2,1152	0,0027	0,9973	978.009	2.683	4.882.305	61.086.670	62,5
20	0,0006	2,0526	0,0029	0,9971	975.326	2.784	4.868.424	56.204.366	57,6
25	0,0006	2,0498	0,0032	0,9968	972.542	3.104	4.853.551	51.335.942	52,8
30	0,0007	2,0023	0,0036	0,9964	969.438	3.523	4.836.626	46.482.391	47,9
35	0,0010	2,0388	0,0051	0,9949	965.914	4.936	4.814.954	41.645.765	43,1
40	0,0017	2,3455	0,0082	0,9918	960.978	7.902	4.783.913	36.830.811	38,3
45	0,0027	2,1649	0,0135	0,9865	953.076	12.890	4.728.836	32.046.898	33,6
50	0,0045	2,2713	0,0224	0,9776	940.186	21.061	4.643.460	27.318.061	29,1
55	0,0074	2,1821	0,0363	0,9637	919.125	33.398	4.501.512	22.674.602	24,7
60	0,0115	2,0985	0,0558	0,9442	885.727	49.383	4.285.344	18.173.090	20,5
65	0,0195	2,1600	0,0923	0,9077	836.343	77.229	3.962.388	13.887.745	16,6
70	0,0319	1,9883	0,1456	0,8544	759.114	110.539	3.462.660	9.925.357	13,1
75	0,0547	1,9660	0,2345	0,7655	648.575	152.113	2.781.368	6.462.697	10,0
80	0,0908	1,9127	0,3547	0,6453	496.461	176.075	1.938.709	3.681.329	7,4
85	0,1460	1,6240	0,4890	0,5110	320.387	156.659	1.073.051	1.742.620	5,4
90+	0,2445	4,0160	1,0000	0,0000	163.728	163.728	669.569	669.569	4,1

Note: For figures in columns L_x , d_x , p_x , q_x and m_x the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 2: Turkey Abridged Period Life Table, Male, 2009.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0146		0,0146	0,9854	1.000.000	14.609	985.391	73.125.122	73,1
1	0,0010	1,1825	0,0039	0,9961	985.391	3.883	3.930.623	72.139.732	73,2
5	0,0006	1,9033	0,0028	0,9972	981.508	2.758	4.898.997	68.209.109	69,5
10	0,0004	2,0932	0,0022	0,9978	978.749	2.143	4.887.517	63.310.112	64,7
15	0,0007	2,1886	0,0035	0,9965	976.606	3.448	4.873.338	58.422.595	59,8
20	0,0008	2,0656	0,0038	0,9962	973.158	3.682	4.854.988	53.549.257	55,0
25	0,0008	2,0279	0,0042	0,9958	969.476	4.091	4.835.224	48.694.269	50,2
30	0,0009	1,9783	0,0046	0,9954	965.386	4.473	4.813.411	43.859.045	45,4
35	0,0013	2,0333	0,0064	0,9936	960.912	6.177	4.786.236	39.045.634	40,6
40	0,0021	2,3287	0,0106	0,9894	954.735	10.090	4.746.723	34.259.398	35,9
45	0,0036	2,1793	0,0179	0,9821	944.645	16.909	4.675.532	29.512.675	31,2
50	0,0063	2,2578	0,0309	0,9691	927.737	28.622	4.560.196	24.837.143	26,8
55	0,0104	2,1793	0,0503	0,9497	899.114	45.218	4.368.026	20.276.947	22,6
60	0,0159	2,0828	0,0760	0,9240	853.896	64.868	4.080.244	15.908.921	18,6
65	0,0260	2,1245	0,1210	0,8790	789.028	95.444	3.670.688	11.828.677	15,0
70	0,0406	1,9521	0,1808	0,8192	693.583	125.430	3.085.622	8.157.990	11,8
75	0,0659	1,8506	0,2727	0,7273	568.154	154.950	2.352.769	5.072.368	8,9
80	0,1074	1,8566	0,4014	0,5986	413.204	165.844	1.544.699	2.719.599	6,6
85	0,1698	1,5563	0,5358	0,4642	247.360	132.528	780.412	1.174.900	4,7
90+	0,2911	1,1064	1,0000	0,0000	114.831	114.831	394.488	394.488	3,4

Note: For figures in columns L_x , d_x , p_x , q_x and m_x the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 3: Turkey Abridged Period Life Table, Female, 2009.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0131		0,0131	0,9869	1.000.000	13.057	986.943	78.455.381	78,5
1	0,0009	1,1646	0,0037	0,9963	986.943	3.655	3.937.409	77.468.438	78,5
5	0,0005	1,8334	0,0027	0,9973	983.288	2.650	4.908.049	73.531.029	74,8
10	0,0003	1,9891	0,0017	0,9983	980.638	1.703	4.898.063	68.622.979	70,0
15	0,0004	1,9745	0,0019	0,9981	978.935	1.899	4.888.930	63.724.917	65,1
20	0,0004	2,0257	0,0019	0,9981	977.036	1.854	4.879.667	58.835.987	60,2
25	0,0004	2,0940	0,0022	0,9978	975.183	2.098	4.869.816	53.956.320	55,3
30	0,0005	2,0462	0,0026	0,9974	973.085	2.544	4.857.910	49.086.504	50,4
35	0,0008	2,0484	0,0038	0,9962	970.541	3.676	4.841.854	44.228.594	45,6
40	0,0012	2,3768	0,0058	0,9942	966.865	5.624	4.819.570	39.386.739	40,7
45	0,0018	2,1363	0,0091	0,9909	961.240	8.756	4.781.127	34.567.169	36,0
50	0,0028	2,3019	0,0138	0,9862	952.484	13.147	4.726.949	29.786.042	31,3
55	0,0045	2,1884	0,0224	0,9776	939.337	21.074	4.637.436	25.059.093	26,7
60	0,0076	2,1282	0,0371	0,9629	918.264	34.072	4.493.471	20.421.657	22,2
65	0,0139	2,2175	0,0668	0,9332	884.192	59.107	4.256.493	15.928.186	18,0
70	0,0249	2,0361	0,1160	0,8840	825.085	95.682	3.841.836	11.671.693	14,1
75	0,0457	2,1004	0,2020	0,7980	729.403	147.308	3.219.878	7.829.858	10,7
80	0,0811	1,9571	0,3251	0,6749	582.095	189.250	2.334.603	4.609.980	7,9
85	0,1343	1,6673	0,4639	0,5361	392.845	182.224	1.356.926	2.275.377	5,8
90+	0,2293	2,9096	1,0000	0,0000	210.621	210.621	918.451	918.451	4,4

Note: For figures in columns L_x , d_x , p_x , q_x and m_x the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 4: Turkey Abridged Period Life Table, 2010.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0121		0,0121	0,9879	1.000.000	12.146	987.854	76.508.760	76,5
1	0,0009	1,1327	0,0034	0,9966	987.854	3.357	3.941.788	75.520.906	76,4
5	0,0005	1,7153	0,0023	0,9977	984.496	2.301	4.914.923	71.579.118	72,7
10	0,0004	2,0392	0,0018	0,9982	982.195	1.724	4.905.871	66.664.194	67,9
15	0,0005	2,0938	0,0026	0,9974	980.471	2.586	4.894.840	61.758.323	63,0
20	0,0005	2,0308	0,0026	0,9974	977.885	2.573	4.881.785	56.863.483	58,1
25	0,0006	2,1150	0,0029	0,9971	975.312	2.865	4.868.293	51.981.698	53,3
30	0,0007	1,9504	0,0034	0,9966	972.447	3.342	4.852.040	47.113.405	48,4
35	0,0009	2,1165	0,0047	0,9953	969.104	4.540	4.832.429	42.261.365	43,6
40	0,0015	2,1707	0,0074	0,9926	964.564	7.179	4.802.508	37.428.936	38,8
45	0,0025	2,0608	0,0124	0,9876	957.385	11.873	4.752.026	32.626.428	34,1
50	0,0043	2,1916	0,0213	0,9787	945.512	20.163	4.670.932	27.874.401	29,5
55	0,0067	1,9701	0,0328	0,9672	925.348	30.367	4.534.734	23.203.469	25,1
60	0,0111	1,9684	0,0539	0,9461	894.982	48.206	4.328.766	18.668.735	20,9
65	0,0184	2,0615	0,0873	0,9127	846.776	73.941	4.016.604	14.339.969	16,9
70	0,0311	2,0058	0,1424	0,8576	772.834	110.067	3.534.608	10.323.365	13,4
75	0,0521	2,1127	0,2265	0,7735	662.768	150.127	2.880.376	6.788.757	10,2
80	0,0880	1,9431	0,3468	0,6532	512.641	177.783	2.019.736	3.908.381	7,6
85	0,1414	1,6207	0,4783	0,5217	334.857	160.165	1.133.044	1.888.645	5,6
90+	0,2312	3,9820	1,0000	0,0000	174.692	174.692	755.601	755.601	4,3

Note: For figures in columns L_x , d_x , p_x , q_x and m_x the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 5: Turkey Abridged Period Life Table, Male, 2010.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0129		0,0129	0,9871	1.000.000	12.853	987.147	73.903.595	73,9
1	0,0009	1,1515	0,0035	0,9965	987.147	3.479	3.938.677	72.916.448	73,9
5	0,0005	1,7758	0,0023	0,9977	983.668	2.311	4.910.887	68.977.771	70,1
10	0,0004	2,0498	0,0020	0,9980	981.357	1.935	4.901.074	64.066.884	65,3
15	0,0007	2,1516	0,0034	0,9966	979.422	3.367	4.887.518	59.165.809	60,4
20	0,0007	2,0443	0,0036	0,9964	976.055	3.500	4.869.928	54.278.292	55,6
25	0,0008	2,0778	0,0039	0,9961	972.555	3.789	4.851.701	49.408.363	50,8
30	0,0009	1,9395	0,0045	0,9955	968.766	4.312	4.830.631	44.556.662	46,0
35	0,0012	2,1330	0,0059	0,9941	964.454	5.703	4.805.918	39.726.031	41,2
40	0,0019	2,1778	0,0093	0,9907	958.751	8.946	4.768.508	34.920.112	36,4
45	0,0033	2,0876	0,0165	0,9835	949.805	15.697	4.703.310	30.151.604	31,7
50	0,0060	2,2003	0,0293	0,9707	934.109	27.385	4.593.872	25.448.294	27,2
55	0,0093	1,9756	0,0453	0,9547	906.724	41.046	4.409.479	20.854.422	23,0
60	0,0153	1,9470	0,0730	0,9270	865.678	63.224	4.135.365	16.444.943	19,0
65	0,0243	2,0423	0,1135	0,8865	802.454	91.057	3.742.945	12.309.578	15,3
70	0,0396	1,9676	0,1767	0,8233	711.396	125.703	3.175.804	8.566.633	12,0
75	0,0628	2,0502	0,2650	0,7350	585.693	155.234	2.470.555	5.390.829	9,2
80	0,1048	1,8881	0,3951	0,6049	430.460	170.077	1.623.039	2.920.273	6,8
85	0,1626	1,5822	0,5226	0,4774	260.383	136.078	836.826	1.297.234	5,0
90+	0,2700	1,0542	1,0000	0,0000	124.305	124.305	460.408	460.408	3,7

Note: For figures in columns L_x , d_x , p_x , q_x and m_x the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 6: Turkey Abridged Period Life Table, Female, 2010.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0114		0,0114	0,9886	1.000.000	11.399	988.601	79.121.557	79,1
1	0,0008	1,1112	0,0033	0,9967	988.601	3.217	3.945.112	78.132.956	79,0
5	0,0005	1,6507	0,0023	0,9977	985.385	2.290	4.919.251	74.187.844	75,3
10	0,0003	2,0247	0,0015	0,9985	983.094	1.502	4.911.002	69.268.592	70,5
15	0,0004	1,9772	0,0018	0,9982	981.592	1.761	4.902.637	64.357.590	65,6
20	0,0003	2,0000	0,0016	0,9984	979.831	1.602	4.894.350	59.454.953	60,7
25	0,0004	2,1919	0,0019	0,9981	978.229	1.904	4.885.801	54.560.603	55,8
30	0,0005	1,9714	0,0024	0,9976	976.326	2.337	4.874.551	49.674.802	50,9
35	0,0007	2,0879	0,0034	0,9966	973.989	3.353	4.860.180	44.800.251	46,0
40	0,0011	2,1581	0,0055	0,9945	970.636	5.316	4.838.071	39.940.071	41,1
45	0,0017	2,0064	0,0082	0,9918	965.320	7.945	4.802.814	35.101.999	36,4
50	0,0026	2,1718	0,0131	0,9869	957.375	12.554	4.751.367	30.299.186	31,6
55	0,0041	1,9579	0,0204	0,9796	944.820	19.272	4.665.472	25.547.819	27,0
60	0,0073	2,0089	0,0360	0,9640	925.548	33.275	4.528.209	20.882.346	22,6
65	0,0132	2,0927	0,0636	0,9364	892.273	56.744	4.296.391	16.354.137	18,3
70	0,0244	2,0553	0,1138	0,8862	835.529	95.052	3.897.746	12.057.746	14,4
75	0,0434	2,1868	0,1932	0,8068	740.477	143.070	3.299.904	8.160.000	11,0
80	0,0781	1,9868	0,3161	0,6839	597.407	188.810	2.418.120	4.860.096	8,1
85	0,1305	1,6452	0,4539	0,5461	408.596	185.453	1.420.825	2.441.976	6,0
90+	0,2185	2,9278	1,0000	0,0000	223.144	223.144	1.021.151	1.021.151	4,6

Note: For figures in columns L_x , d_x , p_x , q_x and m_x the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 7: Turkey Abridged Period Life Table, TR1, 2009.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0111		0,0111	0,9889	1.000.000	11.055	988.945	76.540.448	76,5
1	0,0006	1,1741	0,0023	0,9977	988.945	2.314	3.949.241	75.551.503	76,4
5	0,0003	1,8700	0,0015	0,9985	986.631	1.489	4.928.494	71.602.262	72,6
10	0,0003	2,0485	0,0015	0,9985	985.142	1.451	4.921.427	66.673.768	67,7
15	0,0004	2,1152	0,0020	0,9980	983.691	2.014	4.912.645	61.752.341	62,8
20	0,0005	2,0526	0,0023	0,9977	981.677	2.234	4.901.800	56.839.696	57,9
25	0,0005	2,0498	0,0024	0,9976	979.443	2.353	4.890.272	51.937.896	53,0
30	0,0005	2,0023	0,0027	0,9973	977.090	2.604	4.877.645	47.047.624	48,2
35	0,0008	2,0388	0,0042	0,9958	974.486	4.068	4.860.385	42.169.979	43,3
40	0,0015	2,3455	0,0077	0,9923	970.418	7.466	4.832.273	37.309.594	38,4
45	0,0026	2,1649	0,0131	0,9869	962.953	12.658	4.778.877	32.477.321	33,7
50	0,0045	2,2713	0,0221	0,9779	950.295	20.966	4.694.262	27.698.445	29,1
55	0,0076	2,1821	0,0373	0,9627	929.329	34.689	4.548.894	23.004.183	24,8
60	0,0116	2,0985	0,0560	0,9440	894.639	50.073	4.327.908	18.455.289	20,6
65	0,0194	2,1600	0,0921	0,9079	844.566	77.769	4.001.970	14.127.381	16,7
70	0,0310	1,9883	0,1418	0,8582	766.797	108.766	3.506.416	10.125.411	13,2
75	0,0593	1,9660	0,2513	0,7487	658.031	165.380	2.788.397	6.618.995	10,1
80	0,0907	1,9127	0,3542	0,6458	492.650	174.487	1.924.556	3.830.598	7,8
85	0,1298	1,6240	0,4512	0,5488	318.163	143.568	1.106.128	1.906.042	6,0
90+	0,2183	4,0160	1,0000	0,0000	174.595	174.595	799.914	799.914	4,6

Note: For figures in columns L_x , dx , px , qx and mx the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 8: Turkey Abridged Period Life Table, TR1, 2010.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0098		0,0098	0,9902	1.000.000	9.752	990.248	77.053.802	77,1
1	0,0005	1,1327	0,0021	0,9979	990.248	2.070	3.955.058	76.063.553	76,8
5	0,0003	1,7153	0,0013	0,9987	988.178	1.292	4.936.647	72.108.496	73,0
10	0,0003	2,0392	0,0013	0,9987	986.886	1.269	4.930.674	67.171.849	68,1
15	0,0004	2,0938	0,0019	0,9981	985.617	1.890	4.922.594	62.241.174	63,1
20	0,0004	2,0308	0,0021	0,9979	983.727	2.017	4.912.648	57.318.580	58,3
25	0,0004	2,1150	0,0022	0,9978	981.710	2.139	4.902.380	52.405.932	53,4
30	0,0005	1,9504	0,0027	0,9973	979.571	2.660	4.889.742	47.503.553	48,5
35	0,0008	2,1165	0,0038	0,9962	976.911	3.702	4.873.878	42.613.811	43,6
40	0,0013	2,1707	0,0064	0,9936	973.208	6.243	4.848.378	37.739.933	38,8
45	0,0024	2,0608	0,0120	0,9880	966.965	11.574	4.800.806	32.891.554	34,0
50	0,0042	2,1916	0,0209	0,9791	955.391	20.002	4.720.781	28.090.748	29,4
55	0,0067	1,9701	0,0328	0,9672	935.389	30.723	4.583.857	23.369.967	25,0
60	0,0112	1,9684	0,0542	0,9458	904.666	48.990	4.374.810	18.786.110	20,8
65	0,0186	2,0615	0,0881	0,9119	855.676	75.390	4.056.849	14.411.299	16,8
70	0,0305	2,0058	0,1397	0,8603	780.286	109.003	3.575.053	10.354.451	13,3
75	0,0560	2,1127	0,2411	0,7589	671.283	161.858	2.889.085	6.779.398	10,1
80	0,0892	1,9431	0,3505	0,6495	509.426	178.572	2.001.249	3.890.313	7,6
85	0,1271	1,6207	0,4445	0,5555	330.853	147.075	1.157.258	1.889.064	5,7
90+	0,2051	3,9820	1,0000	0,0000	183.778	183.778	731.806	731.806	4,0

Note: For figures in columns L_x , dx , px , qx and mx the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 9: Turkey Abridged Period Life Table, TR2, 2009.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0133		0,0133	0,9867	1.000.000	13.296	986.704	75.486.572	75,5
1	0,0005	1,1741	0,0020	0,9980	986.704	1.981	3.941.220	74.499.868	75,5
5	0,0003	1,8700	0,0017	0,9983	984.724	1.640	4.918.486	70.558.648	71,7
10	0,0003	2,0485	0,0015	0,9985	983.084	1.466	4.911.092	65.640.161	66,8
15	0,0005	2,1152	0,0023	0,9977	981.618	2.253	4.901.589	60.729.069	61,9
20	0,0005	2,0526	0,0024	0,9976	979.365	2.317	4.889.995	55.827.480	57,0
25	0,0006	2,0498	0,0029	0,9971	977.048	2.800	4.876.978	50.937.485	52,1
30	0,0007	2,0023	0,0033	0,9967	974.248	3.188	4.861.683	46.060.507	47,3
35	0,0010	2,0388	0,0052	0,9948	971.060	5.070	4.840.287	41.198.824	42,4
40	0,0016	2,3455	0,0082	0,9918	965.990	7.909	4.808.955	36.358.537	37,6
45	0,0033	2,1649	0,0162	0,9838	958.081	15.481	4.746.515	31.549.582	32,9
50	0,0050	2,2713	0,0247	0,9753	942.600	23.241	4.649.580	26.803.067	28,4
55	0,0081	2,1821	0,0396	0,9604	919.359	36.403	4.494.214	22.153.487	24,1
60	0,0126	2,0985	0,0607	0,9393	882.955	53.568	4.259.347	17.659.274	20,0
65	0,0207	2,1600	0,0976	0,9024	829.387	80.946	3.917.053	13.399.927	16,2
70	0,0327	1,9883	0,1489	0,8511	748.441	111.414	3.406.664	9.482.873	12,7
75	0,0590	1,9660	0,2501	0,7499	637.028	159.293	2.701.852	6.076.209	9,5
80	0,0908	1,9127	0,3546	0,6454	477.735	169.409	1.865.656	3.374.358	7,1
85	0,1481	1,6240	0,4937	0,5063	308.326	152.224	1.027.720	1.508.702	4,9
90+	0,3245	4,0160	1,0000	0,0000	156.102	156.102	480.982	480.982	3,1

Note: For figures in columns L_x , d_x , p_x , q_x and m_x the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 10: Turkey Abridged Period Life Table, TR2, 2010.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0103		0,0103	0,9897	1.000.000	10.319	989.681	75.984.417	76,0
1	0,0004	1,1327	0,0017	0,9983	989.681	1.697	3.953.857	74.994.736	75,8
5	0,0002	1,7153	0,0012	0,9988	987.984	1.186	4.936.022	71.040.879	71,9
10	0,0002	2,0392	0,0010	0,9990	986.797	1.028	4.930.942	66.104.857	67,0
15	0,0005	2,0938	0,0026	0,9974	985.769	2.581	4.921.342	61.173.915	62,1
20	0,0006	2,0308	0,0028	0,9972	983.187	2.722	4.907.854	56.252.573	57,2
25	0,0007	2,1150	0,0033	0,9967	980.465	3.237	4.892.986	51.344.720	52,4
30	0,0008	1,9504	0,0039	0,9961	977.228	3.785	4.874.598	46.451.734	47,5
35	0,0011	2,1165	0,0054	0,9946	973.443	5.301	4.851.930	41.577.136	42,7
40	0,0016	2,1707	0,0080	0,9920	968.142	7.773	4.818.719	36.725.206	37,9
45	0,0029	2,0608	0,0141	0,9859	960.369	13.586	4.761.915	31.906.487	33,2
50	0,0047	2,1916	0,0234	0,9766	946.784	22.129	4.671.771	27.144.572	28,7
55	0,0077	1,9701	0,0376	0,9624	924.654	34.732	4.518.038	22.472.801	24,3
60	0,0124	1,9684	0,0598	0,9402	889.923	53.174	4.288.410	17.954.763	20,2
65	0,0196	2,0615	0,0926	0,9074	836.749	77.460	3.956.130	13.666.353	16,3
70	0,0334	2,0058	0,1520	0,8480	759.289	115.420	3.450.850	9.710.224	12,8
75	0,0565	2,1127	0,2429	0,7571	643.868	156.394	2.767.784	6.259.373	9,7
80	0,0902	1,9431	0,3535	0,6465	487.474	172.328	1.910.578	3.491.589	7,2
85	0,1467	1,6207	0,4904	0,5096	315.145	154.534	1.053.514	1.581.011	5,0
90+	0,3045	3,9820	1,0000	0,0000	160.612	160.612	527.497	527.497	3,3

Note: For figures in columns L_x , d_x , p_x , q_x and m_x the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 11: Turkey Abridged Period Life Table, TR3, 2009.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0140		0,0140	0,9860	1.000.000	13.981	986.019	76.141.599	76,1
1	0,0006	1,1741	0,0025	0,9975	986.019	2.447	3.937.161	75.155.579	76,2
5	0,0003	1,8700	0,0014	0,9986	983.572	1.379	4.913.543	71.218.419	72,4
10	0,0003	2,0485	0,0015	0,9985	982.193	1.513	4.906.499	66.304.875	67,5
15	0,0005	2,1152	0,0023	0,9977	980.680	2.260	4.896.880	61.398.376	62,6
20	0,0006	2,0526	0,0027	0,9973	978.420	2.687	4.884.180	56.501.496	57,7
25	0,0006	2,0498	0,0029	0,9971	975.733	2.822	4.870.340	51.617.316	52,9
30	0,0007	2,0023	0,0036	0,9964	972.911	3.507	4.854.045	46.746.975	48,0
35	0,0010	2,0388	0,0049	0,9951	969.405	4.784	4.832.857	41.892.931	43,2
40	0,0016	2,3455	0,0078	0,9922	964.621	7.544	4.803.078	37.060.073	38,4
45	0,0027	2,1649	0,0133	0,9867	957.077	12.756	4.749.219	32.256.996	33,7
50	0,0045	2,2713	0,0221	0,9779	944.321	20.841	4.664.734	27.507.777	29,1
55	0,0073	2,1821	0,0357	0,9643	923.480	33.003	4.524.399	22.843.043	24,7
60	0,0111	2,0985	0,0538	0,9462	890.476	47.915	4.313.353	18.318.643	20,6
65	0,0186	2,1600	0,0885	0,9115	842.561	74.598	4.000.948	14.005.290	16,6
70	0,0318	1,9883	0,1452	0,8548	767.963	111.530	3.503.920	10.004.342	13,0
75	0,0552	1,9660	0,2363	0,7637	656.433	155.147	2.811.456	6.500.422	9,9
80	0,0888	1,9127	0,3484	0,6516	501.286	174.629	1.967.297	3.688.967	7,4
85	0,1468	1,6240	0,4908	0,5092	326.657	160.336	1.091.991	1.721.670	5,3
90+	0,2641	4,0160	1,0000	0,0000	166.322	166.322	629.679	629.679	3,8

Note: For figures in columns L_x , dx , px , qx and mx the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 12: Turkey Abridged Period Life Table, TR3, 2010.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0114		0,0114	0,9886	1.000.000	11.439	988.561	76.900.415	76,9
1	0,0005	1,1327	0,0020	0,9980	988.561	1.974	3.948.584	75.911.854	76,8
5	0,0003	1,7153	0,0014	0,9986	986.587	1.392	4.928.361	71.963.270	72,9
10	0,0003	2,0392	0,0013	0,9987	985.195	1.274	4.922.202	67.034.909	68,0
15	0,0004	2,0938	0,0022	0,9978	983.921	2.143	4.913.379	62.112.706	63,1
20	0,0005	2,0308	0,0025	0,9975	981.778	2.423	4.901.697	57.199.328	58,3
25	0,0006	2,1150	0,0029	0,9971	979.355	2.837	4.888.590	52.297.630	53,4
30	0,0007	1,9504	0,0034	0,9966	976.518	3.327	4.872.443	47.409.040	48,5
35	0,0010	2,1165	0,0048	0,9952	973.191	4.642	4.852.568	42.536.597	43,7
40	0,0015	2,1707	0,0072	0,9928	968.549	7.003	4.822.930	37.684.029	38,9
45	0,0024	2,0608	0,0119	0,9881	961.546	11.422	4.774.156	32.861.099	34,2
50	0,0040	2,1916	0,0200	0,9800	950.124	18.968	4.697.349	28.086.943	29,6
55	0,0065	1,9701	0,0318	0,9682	931.156	29.588	4.566.131	23.389.593	25,1
60	0,0110	1,9684	0,0532	0,9468	901.568	47.997	4.362.329	18.823.463	20,9
65	0,0175	2,0615	0,0831	0,9169	853.571	70.970	4.059.311	14.461.134	16,9
70	0,0305	2,0058	0,1399	0,8601	782.601	109.491	3.585.165	10.401.823	13,3
75	0,0525	2,1127	0,2279	0,7721	673.110	153.374	2.922.712	6.816.658	10,1
80	0,0875	1,9431	0,3452	0,6548	519.736	179.419	2.050.210	3.893.946	7,5
85	0,1423	1,6207	0,4805	0,5195	340.316	163.522	1.148.995	1.843.736	5,4
90+	0,2545	3,9820	1,0000	0,0000	176.794	176.794	694.741	694.741	3,9

Note: For figures in columns L_x , dx , px , qx and mx the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 13: Turkey Abridged Period Life Table, TR4, 2009.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0127		0,0127	0,9873	1.000.000	12.731	987.269	75.422.029	75,4
1	0,0006	1,1741	0,0023	0,9977	987.269	2.311	3.942.545	74.434.761	75,4
5	0,0003	1,8700	0,0016	0,9984	984.958	1.545	4.919.955	70.492.216	71,6
10	0,0002	2,0485	0,0012	0,9988	983.413	1.135	4.913.715	65.572.261	66,7
15	0,0004	2,1152	0,0022	0,9978	982.278	2.157	4.905.167	60.658.546	61,8
20	0,0006	2,0526	0,0028	0,9972	980.121	2.783	4.892.402	55.753.379	56,9
25	0,0005	2,0498	0,0027	0,9973	977.338	2.597	4.879.027	50.860.976	52,0
30	0,0006	2,0023	0,0032	0,9968	974.741	3.152	4.864.254	45.981.949	47,2
35	0,0010	2,0388	0,0050	0,9950	971.589	4.839	4.843.615	41.117.695	42,3
40	0,0017	2,3455	0,0084	0,9916	966.750	8.084	4.812.291	36.274.080	37,5
45	0,0028	2,1649	0,0140	0,9860	958.666	13.406	4.755.325	31.461.788	32,8
50	0,0049	2,2713	0,0241	0,9759	945.260	22.734	4.664.267	26.706.464	28,3
55	0,0078	2,1821	0,0381	0,9619	922.527	35.135	4.513.628	22.042.197	23,9
60	0,0129	2,0985	0,0624	0,9376	887.392	55.374	4.276.289	17.528.570	19,8
65	0,0210	2,1600	0,0989	0,9011	832.018	82.272	3.926.442	13.252.281	15,9
70	0,0347	1,9883	0,1569	0,8431	749.746	117.656	3.394.390	9.325.839	12,4
75	0,0586	1,9660	0,2487	0,7513	632.091	157.187	2.683.554	5.931.449	9,4
80	0,0959	1,9127	0,3698	0,6302	474.903	175.638	1.832.267	3.247.895	6,8
85	0,1654	1,6240	0,5308	0,4692	299.265	158.838	960.088	1.415.629	4,7
90+	0,3083	4,0160	1,0000	0,0000	140.427	140.427	455.541	455.541	3,2

Note: For figures in columns L_x , dx , px , qx and mx the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 14: Turkey Abridged Period Life Table, TR4, 2010.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0100		0,0100	0,9900	1.000.000	9.984	990.016	76.094.920	76,1
1	0,0005	1,1327	0,0021	0,9979	990.016	2.070	3.954.130	75.104.904	75,9
5	0,0003	1,7153	0,0013	0,9987	987.946	1.326	4.935.377	71.150.774	72,0
10	0,0003	2,0392	0,0014	0,9986	986.621	1.416	4.928.911	66.215.397	67,1
15	0,0004	2,0938	0,0020	0,9980	985.205	1.991	4.920.236	61.286.486	62,2
20	0,0005	2,0308	0,0024	0,9976	983.213	2.353	4.909.080	56.366.250	57,3
25	0,0005	2,1150	0,0027	0,9973	980.860	2.654	4.896.646	51.457.169	52,5
30	0,0006	1,9504	0,0031	0,9969	978.207	3.009	4.881.859	46.560.523	47,6
35	0,0009	2,1165	0,0044	0,9956	975.198	4.311	4.863.560	41.678.665	42,7
40	0,0016	2,1707	0,0078	0,9922	970.887	7.591	4.832.959	36.815.104	37,9
45	0,0028	2,0608	0,0139	0,9861	963.296	13.431	4.777.005	31.982.145	33,2
50	0,0045	2,1916	0,0224	0,9776	949.865	21.263	4.689.614	27.205.141	28,6
55	0,0071	1,9701	0,0349	0,9651	928.603	32.402	4.544.838	22.515.527	24,2
60	0,0118	1,9684	0,0570	0,9430	896.200	51.068	4.326.180	17.970.689	20,1
65	0,0203	2,0615	0,0957	0,9043	845.132	80.920	3.987.877	13.644.509	16,1
70	0,0334	2,0058	0,1519	0,8481	764.212	116.113	3.473.390	9.656.632	12,6
75	0,0565	2,1127	0,2430	0,7570	648.098	157.493	2.785.762	6.183.242	9,5
80	0,0957	1,9431	0,3701	0,6299	490.605	181.584	1.897.940	3.397.480	6,9
85	0,1606	1,6207	0,5205	0,4795	309.021	160.841	1.001.578	1.499.540	4,9
90+	0,2976	3,9820	1,0000	0,0000	148.180	148.180	497.961	497.961	3,4

Note: For figures in columns L_x , dx , px , qx and mx the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 15: Turkey Abridged Period Life Table, TR5, 2009.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0129		0,0129	0,9871	1.000.000	12.914	987.086	76.381.012	76,4
1	0,0007	1,1741	0,0027	0,9973	987.086	2.666	3.940.812	75.393.926	76,4
5	0,0004	1,8700	0,0019	0,9981	984.421	1.873	4.916.239	71.453.114	72,6
10	0,0003	2,0485	0,0016	0,9984	982.547	1.527	4.908.229	66.536.875	67,7
15	0,0005	2,1152	0,0027	0,9973	981.020	2.622	4.897.538	61.628.646	62,8
20	0,0005	2,0526	0,0025	0,9975	978.399	2.492	4.884.649	56.731.108	58,0
25	0,0006	2,0498	0,0030	0,9970	975.907	2.889	4.871.010	51.846.458	53,1
30	0,0007	2,0023	0,0037	0,9963	973.018	3.592	4.854.320	46.975.448	48,3
35	0,0009	2,0388	0,0045	0,9955	969.425	4.362	4.834.212	42.121.128	43,4
40	0,0016	2,3455	0,0080	0,9920	965.064	7.698	4.804.885	37.286.916	38,6
45	0,0025	2,1649	0,0123	0,9877	957.366	11.780	4.753.434	32.482.031	33,9
50	0,0040	2,2713	0,0198	0,9802	945.586	18.679	4.676.961	27.728.597	29,3
55	0,0069	2,1821	0,0338	0,9662	926.907	31.358	4.546.173	23.051.636	24,9
60	0,0104	2,0985	0,0504	0,9496	895.549	45.107	4.346.867	18.505.463	20,7
65	0,0179	2,1600	0,0851	0,9149	850.443	72.407	4.046.580	14.158.596	16,6
70	0,0315	1,9883	0,1438	0,8562	778.036	111.882	3.553.226	10.112.016	13,0
75	0,0563	1,9660	0,2405	0,7595	666.154	160.236	2.844.621	6.558.790	9,8
80	0,0904	1,9127	0,3534	0,6466	505.918	178.779	1.977.644	3.714.169	7,3
85	0,1488	1,6240	0,4953	0,5047	327.139	162.041	1.088.644	1.736.525	5,3
90+	0,2548	4,0160	1,0000	0,0000	165.098	165.098	647.881	647.881	3,9

Note: For figures in columns L_x , d_x , p_x , q_x and m_x the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 16: Turkey Abridged Period Life Table, TR5, 2010.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0116		0,0116	0,9884	1.000.000	11.565	988.435	77.282.364	77,3
1	0,0005	1,1327	0,0021	0,9979	988.435	2.100	3.947.722	76.293.929	77,2
5	0,0003	1,7153	0,0014	0,9986	986.336	1.428	4.926.990	72.346.207	73,3
10	0,0003	2,0392	0,0014	0,9986	984.908	1.362	4.920.508	67.419.217	68,5
15	0,0004	2,0938	0,0022	0,9978	983.546	2.144	4.911.500	62.498.709	63,5
20	0,0004	2,0308	0,0021	0,9979	981.402	2.069	4.900.867	57.587.209	58,7
25	0,0006	2,1150	0,0028	0,9972	979.333	2.741	4.888.758	52.686.342	53,8
30	0,0006	1,9504	0,0031	0,9969	976.592	2.996	4.873.825	47.797.584	48,9
35	0,0008	2,1165	0,0039	0,9961	973.596	3.791	4.857.049	42.923.759	44,1
40	0,0014	2,1707	0,0068	0,9932	969.805	6.554	4.830.483	38.066.710	39,3
45	0,0021	2,0608	0,0106	0,9894	963.251	10.198	4.786.282	33.236.228	34,5
50	0,0038	2,1916	0,0190	0,9810	953.053	18.115	4.714.393	28.449.945	29,9
55	0,0064	1,9701	0,0315	0,9685	934.938	29.432	4.585.517	23.735.553	25,4
60	0,0105	1,9684	0,0509	0,9491	905.507	46.075	4.387.851	19.150.035	21,1
65	0,0161	2,0615	0,0770	0,9230	859.432	66.175	4.102.704	14.762.184	17,2
70	0,0302	2,0058	0,1383	0,8617	793.257	109.744	3.637.686	10.659.480	13,4
75	0,0519	2,1127	0,2256	0,7744	683.513	154.222	2.972.277	7.021.794	10,3
80	0,0860	1,9431	0,3405	0,6595	529.290	180.235	2.095.489	4.049.517	7,7
85	0,1417	1,6207	0,4791	0,5209	349.055	167.230	1.180.160	1.954.028	5,6
90+	0,2350	3,9820	1,0000	0,0000	181.825	181.825	773.869	773.869	4,3

Note: For figures in columns L_x , d_x , p_x , q_x and m_x the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 17: Turkey Abridged Period Life Table, TR6, 2009.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0134		0,0134	0,9866	1.000.000	13.387	986.613	76.588.003	76,6
1	0,0007	1,1741	0,0026	0,9974	986.613	2.572	3.939.184	75.601.390	76,6
5	0,0004	1,8700	0,0020	0,9980	984.041	1.921	4.914.192	71.662.207	72,8
10	0,0003	2,0485	0,0017	0,9983	982.120	1.647	4.905.738	66.748.015	68,0
15	0,0006	2,1152	0,0029	0,9971	980.473	2.825	4.894.215	61.842.277	63,1
20	0,0006	2,0526	0,0031	0,9969	977.648	3.030	4.879.311	56.948.062	58,3
25	0,0007	2,0498	0,0036	0,9964	974.618	3.527	4.862.686	52.068.751	53,4
30	0,0007	2,0023	0,0037	0,9963	971.091	3.548	4.844.821	47.206.066	48,6
35	0,0010	2,0388	0,0049	0,9951	967.544	4.741	4.823.680	42.361.244	43,8
40	0,0016	2,3455	0,0079	0,9921	962.803	7.577	4.793.901	37.537.564	39,0
45	0,0025	2,1649	0,0126	0,9874	955.226	12.041	4.741.993	32.743.663	34,3
50	0,0043	2,2713	0,0210	0,9790	943.185	19.814	4.661.857	28.001.670	29,7
55	0,0067	2,1821	0,0330	0,9670	923.371	30.452	4.531.044	23.339.813	25,3
60	0,0103	2,0985	0,0499	0,9501	892.919	44.584	4.335.231	18.808.768	21,1
65	0,0184	2,1600	0,0876	0,9124	848.335	74.309	4.030.639	14.473.537	17,1
70	0,0303	1,9883	0,1387	0,8613	774.026	107.380	3.546.734	10.442.898	13,5
75	0,0517	1,9660	0,2233	0,7767	666.646	148.883	2.881.525	6.896.164	10,3
80	0,0877	1,9127	0,3452	0,6548	517.763	178.732	2.037.014	4.014.638	7,8
85	0,1424	1,6240	0,4809	0,5191	339.031	163.025	1.144.782	1.977.625	5,8
90+	0,2113	4,0160	1,0000	0,0000	176.006	176.006	832.842	832.842	4,7

Note: For figures in columns L_x , dx , px , qx and mx the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 18: Turkey Abridged Period Life Table, TR6, 2010.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0121		0,0121	0,9879	1.000.000	12.125	987.875	77.042.949	77,0
1	0,0006	1,1327	0,0023	0,9977	987.875	2.284	3.944.950	76.055.074	77,0
5	0,0003	1,7153	0,0016	0,9984	985.591	1.551	4.922.859	72.110.124	73,2
10	0,0003	2,0392	0,0015	0,9985	984.040	1.437	4.915.944	67.187.265	68,3
15	0,0006	2,0938	0,0029	0,9971	982.603	2.844	4.904.750	62.271.320	63,4
20	0,0006	2,0308	0,0030	0,9970	979.759	2.987	4.889.929	57.366.570	58,6
25	0,0006	2,1150	0,0032	0,9968	976.773	3.168	4.874.723	52.476.641	53,7
30	0,0007	1,9504	0,0036	0,9964	973.604	3.480	4.857.409	47.601.918	48,9
35	0,0009	2,1165	0,0047	0,9953	970.124	4.525	4.837.574	42.744.509	44,1
40	0,0015	2,1707	0,0075	0,9925	965.599	7.244	4.807.502	37.906.936	39,3
45	0,0024	2,0608	0,0120	0,9880	958.356	11.540	4.757.859	33.099.433	34,5
50	0,0043	2,1916	0,0211	0,9789	946.815	19.996	4.677.921	28.341.574	29,9
55	0,0063	1,9701	0,0308	0,9692	926.819	28.545	4.547.610	23.663.653	25,5
60	0,0110	1,9684	0,0531	0,9469	898.275	47.720	4.346.705	19.116.043	21,3
65	0,0176	2,0615	0,0836	0,9164	850.555	71.128	4.043.768	14.769.338	17,4
70	0,0294	2,0058	0,1352	0,8648	779.427	105.376	3.581.619	10.725.570	13,8
75	0,0492	2,1127	0,2155	0,7845	674.052	145.228	2.950.942	7.143.951	10,6
80	0,0847	1,9431	0,3364	0,6636	528.824	177.902	2.100.288	4.193.009	7,9
85	0,1403	1,6207	0,4759	0,5241	350.921	167.004	1.190.255	2.092.721	6,0
90+	0,2038	3,9820	1,0000	0,0000	183.918	183.918	902.466	902.466	4,9

Note: For figures in columns L_x , dx , px , qx and mx the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 19: Turkey Abridged Period Life Table, TR7, 2009.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0119		0,0119	0,9881	1.000.000	11.876	988.124	75.466.744	75,5
1	0,0008	1,1741	0,0031	0,9969	988.124	3.090	3.943.765	74.478.619	75,4
5	0,0003	1,8700	0,0017	0,9983	985.034	1.711	4.919.816	70.534.854	71,6
10	0,0003	2,0485	0,0014	0,9986	983.323	1.411	4.912.452	65.615.038	66,7
15	0,0006	2,1152	0,0028	0,9972	981.912	2.793	4.901.506	60.702.586	61,8
20	0,0006	2,0526	0,0029	0,9971	979.120	2.871	4.887.135	55.801.081	57,0
25	0,0007	2,0498	0,0035	0,9965	976.248	3.410	4.871.183	50.913.945	52,2
30	0,0008	2,0023	0,0041	0,9959	972.839	3.959	4.852.325	46.042.763	47,3
35	0,0012	2,0388	0,0061	0,9939	968.879	5.914	4.826.886	41.190.437	42,5
40	0,0017	2,3455	0,0087	0,9913	962.966	8.335	4.792.702	36.363.552	37,8
45	0,0030	2,1649	0,0146	0,9854	954.630	13.966	4.733.556	31.570.850	33,1
50	0,0047	2,2713	0,0232	0,9768	940.664	21.840	4.643.725	26.837.293	28,5
55	0,0083	2,1821	0,0404	0,9596	918.824	37.143	4.489.458	22.193.569	24,2
60	0,0122	2,0985	0,0591	0,9409	881.682	52.087	4.257.275	17.704.111	20,1
65	0,0209	2,1600	0,0988	0,9012	829.594	81.976	3.915.165	13.446.836	16,2
70	0,0332	1,9883	0,1510	0,8490	747.619	112.885	3.398.120	9.531.671	12,7
75	0,0529	1,9660	0,2281	0,7719	634.734	144.780	2.734.413	6.133.551	9,7
80	0,0973	1,9127	0,3742	0,6258	489.954	183.355	1.883.694	3.399.138	6,9
85	0,1648	1,6240	0,5294	0,4706	306.598	162.308	985.036	1.515.445	4,9
90+	0,2720	4,0160	1,0000	0,0000	144.290	144.290	530.408	530.408	3,7

Note: For figures in columns L_x , d_x , p_x , q_x and m_x the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 20: Turkey Abridged Period Life Table, TR7, 2010.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0107		0,0107	0,9893	1.000.000	10.668	989.332	76.258.930	76,3
1	0,0007	1,1327	0,0027	0,9973	989.332	2.653	3.949.723	75.269.597	76,1
5	0,0003	1,7153	0,0015	0,9985	986.680	1.460	4.928.604	71.319.874	72,3
10	0,0003	2,0392	0,0017	0,9983	985.220	1.634	4.921.261	66.391.271	67,4
15	0,0005	2,0938	0,0026	0,9974	983.586	2.598	4.910.378	61.470.009	62,5
20	0,0006	2,0308	0,0028	0,9972	980.988	2.719	4.896.864	56.559.632	57,7
25	0,0006	2,1150	0,0030	0,9970	978.268	2.967	4.882.780	51.662.768	52,8
30	0,0007	1,9504	0,0036	0,9964	975.301	3.522	4.865.763	46.779.987	48,0
35	0,0010	2,1165	0,0050	0,9950	971.778	4.847	4.844.916	41.914.225	43,1
40	0,0015	2,1707	0,0077	0,9923	966.931	7.454	4.813.568	37.069.308	38,3
45	0,0026	2,0608	0,0127	0,9873	959.477	12.219	4.761.473	32.255.740	33,6
50	0,0043	2,1916	0,0214	0,9786	947.259	20.229	4.679.482	27.494.267	29,0
55	0,0071	1,9701	0,0347	0,9653	927.029	32.122	4.537.819	22.814.785	24,6
60	0,0113	1,9684	0,0544	0,9456	894.907	48.727	4.326.810	18.276.966	20,4
65	0,0194	2,0615	0,0919	0,9081	846.180	77.785	4.002.329	13.950.156	16,5
70	0,0326	2,0058	0,1486	0,8514	768.395	114.206	3.500.018	9.947.827	12,9
75	0,0515	2,1127	0,2240	0,7760	654.189	146.557	2.847.793	6.447.809	9,9
80	0,0938	1,9431	0,3646	0,6354	507.632	185.085	1.972.376	3.600.016	7,1
85	0,1624	1,6207	0,5243	0,4757	322.548	169.110	1.041.271	1.627.640	5,0
90+	0,2617	3,9820	1,0000	0,0000	153.438	153.438	586.369	586.369	3,8

Note: For figures in columns L_x , d_x , p_x , q_x and m_x the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 21: Turkey Abridged Period Life Table, TR8, 2009.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0131		0,0131	0,9869	1.000.000	13.086	986.914	75.418.876	75,4
1	0,0007	1,1741	0,0030	0,9970	986.914	2.949	3.939.322	74.431.962	75,4
5	0,0003	1,8700	0,0017	0,9983	983.965	1.693	4.914.526	70.492.640	71,6
10	0,0003	2,0485	0,0014	0,9986	982.272	1.360	4.907.345	65.578.114	66,8
15	0,0005	2,1152	0,0026	0,9974	980.912	2.527	4.897.269	60.670.769	61,9
20	0,0006	2,0526	0,0031	0,9969	978.385	2.995	4.883.095	55.773.500	57,0
25	0,0008	2,0498	0,0038	0,9962	975.389	3.734	4.865.931	50.890.405	52,2
30	0,0010	2,0023	0,0051	0,9949	971.655	4.915	4.843.544	46.024.474	47,4
35	0,0012	2,0388	0,0058	0,9942	966.740	5.559	4.817.242	41.180.931	42,6
40	0,0017	2,3455	0,0084	0,9916	961.182	8.105	4.784.392	36.363.689	37,8
45	0,0030	2,1649	0,0148	0,9852	953.076	14.127	4.725.332	31.579.297	33,1
50	0,0047	2,2713	0,0234	0,9766	938.950	21.927	4.634.915	26.853.965	28,6
55	0,0075	2,1821	0,0366	0,9634	917.023	33.576	4.490.500	22.219.050	24,2
60	0,0125	2,0985	0,0604	0,9396	883.446	53.320	4.262.523	17.728.550	20,1
65	0,0202	2,1600	0,0956	0,9044	830.127	79.325	3.925.353	13.466.027	16,2
70	0,0330	1,9883	0,1501	0,8499	750.801	112.669	3.414.683	9.540.674	12,7
75	0,0508	1,9660	0,2200	0,7800	638.132	140.414	2.764.650	6.125.992	9,6
80	0,0942	1,9127	0,3647	0,6353	497.718	181.536	1.928.130	3.361.342	6,8
85	0,1781	1,6240	0,5561	0,4439	316.181	175.815	987.352	1.433.212	4,5
90+	0,3148	4,0160	1,0000	0,0000	140.366	140.366	445.859	445.859	3,2

Note: For figures in columns L_x , dx , px , qx and mx the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 22: Turkey Abridged Period Life Table, TR8, 2010.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0111		0,0111	0,9889	1.000.000	11.056	988.944	76.155.669	76,2
1	0,0006	1,1327	0,0026	0,9974	988.944	2.557	3.948.444	75.166.725	76,0
5	0,0003	1,7153	0,0016	0,9984	986.387	1.556	4.926.824	71.218.281	72,2
10	0,0003	2,0392	0,0013	0,9987	984.831	1.268	4.920.400	66.291.456	67,3
15	0,0005	2,0938	0,0024	0,9976	983.563	2.355	4.910.970	61.371.056	62,4
20	0,0005	2,0308	0,0026	0,9974	981.208	2.582	4.898.371	56.460.086	57,5
25	0,0007	2,1150	0,0033	0,9967	978.625	3.221	4.883.836	51.561.715	52,7
30	0,0008	1,9504	0,0039	0,9961	975.405	3.775	4.865.512	46.677.879	47,9
35	0,0010	2,1165	0,0051	0,9949	971.630	4.937	4.843.914	41.812.367	43,0
40	0,0016	2,1707	0,0078	0,9922	966.693	7.505	4.812.231	36.968.453	38,2
45	0,0028	2,0608	0,0137	0,9863	959.188	13.103	4.757.426	32.156.222	33,5
50	0,0045	2,1916	0,0223	0,9777	946.085	21.100	4.671.166	27.398.796	29,0
55	0,0067	1,9701	0,0326	0,9674	924.984	30.193	4.533.442	22.727.630	24,6
60	0,0114	1,9684	0,0552	0,9448	894.792	49.409	4.324.168	18.194.188	20,3
65	0,0189	2,0615	0,0895	0,9105	845.382	75.630	4.004.674	13.870.020	16,4
70	0,0318	2,0058	0,1451	0,8549	769.752	111.721	3.514.244	9.865.346	12,8
75	0,0493	2,1127	0,2157	0,7843	658.031	141.919	2.880.393	6.351.102	9,7
80	0,0926	1,9431	0,3608	0,6392	516.112	186.192	2.011.388	3.470.710	6,7
85	0,1870	1,6207	0,5729	0,4271	329.920	189.016	1.010.861	1.459.322	4,4
90+	0,3142	3,9820	1,0000	0,0000	140.904	140.904	448.461	448.461	3,2

Note: For figures in columns L_x , dx , px , qx and mx the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 23: Turkey Abridged Period Life Table, TR9, 2009.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0117		0,0117	0,9883	1.000.000	11.659	988.341	76.897.768	76,9
1	0,0006	1,1741	0,0025	0,9975	988.341	2.505	3.946.283	75.909.428	76,8
5	0,0004	1,8700	0,0022	0,9978	985.835	2.188	4.922.328	71.963.144	73,0
10	0,0004	2,0485	0,0018	0,9982	983.647	1.729	4.913.131	67.040.817	68,2
15	0,0004	2,1152	0,0021	0,9979	981.918	2.104	4.903.520	62.127.685	63,3
20	0,0006	2,0526	0,0032	0,9968	979.814	3.161	4.889.755	57.224.165	58,4
25	0,0008	2,0498	0,0041	0,9959	976.653	4.037	4.871.357	52.334.410	53,6
30	0,0009	2,0023	0,0043	0,9957	972.616	4.193	4.850.511	47.463.054	48,8
35	0,0011	2,0388	0,0054	0,9946	968.423	5.270	4.826.508	42.612.543	44,0
40	0,0018	2,3455	0,0088	0,9912	963.153	8.480	4.793.253	37.786.035	39,2
45	0,0025	2,1649	0,0126	0,9874	954.673	12.003	4.739.335	32.992.782	34,6
50	0,0045	2,2713	0,0222	0,9778	942.670	20.952	4.656.175	28.253.448	30,0
55	0,0071	2,1821	0,0347	0,9653	921.718	32.023	4.518.353	23.597.272	25,6
60	0,0110	2,0985	0,0535	0,9465	889.695	47.564	4.310.466	19.078.920	21,4
65	0,0187	2,1600	0,0886	0,9114	842.131	74.626	3.998.721	14.768.454	17,5
70	0,0280	1,9883	0,1291	0,8709	767.505	99.075	3.539.144	10.769.733	14,0
75	0,0461	1,9660	0,2022	0,7978	668.430	135.168	2.932.060	7.230.588	10,8
80	0,0795	1,9127	0,3190	0,6810	533.263	170.121	2.141.098	4.298.529	8,1
85	0,1426	1,6240	0,4812	0,5188	363.142	174.740	1.225.786	2.157.431	5,9
90+	0,2022	4,0160	1,0000	0,0000	188.402	188.402	931.644	931.644	4,9

Note: For figures in columns L_x , dx , px , qx and mx the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 24: Turkey Abridged Period Life Table, TR9, 2010.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0104		0,0104	0,9896	1.000.000	10.435	989.565	77.716.802	77,7
1	0,0007	1,1327	0,0026	0,9974	989.565	2.589	3.950.836	76.727.237	77,5
5	0,0003	1,7153	0,0013	0,9987	986.976	1.296	4.930.622	72.776.401	73,7
10	0,0004	2,0392	0,0018	0,9982	985.680	1.746	4.923.230	67.845.779	68,8
15	0,0005	2,0938	0,0025	0,9975	983.934	2.478	4.912.469	62.922.549	63,9
20	0,0006	2,0308	0,0029	0,9971	981.456	2.889	4.898.703	58.010.080	59,1
25	0,0006	2,1150	0,0028	0,9972	978.567	2.735	4.884.945	53.111.377	54,3
30	0,0007	1,9504	0,0036	0,9964	975.832	3.553	4.868.324	48.226.432	49,4
35	0,0011	2,1165	0,0056	0,9944	972.279	5.434	4.845.723	43.358.109	44,6
40	0,0015	2,1707	0,0076	0,9924	966.844	7.351	4.813.424	38.512.386	39,8
45	0,0025	2,0608	0,0125	0,9875	959.493	12.029	4.762.110	33.698.962	35,1
50	0,0045	2,1916	0,0224	0,9776	947.464	21.187	4.677.820	28.936.852	30,5
55	0,0060	1,9701	0,0294	0,9706	926.277	27.252	4.548.816	24.259.032	26,2
60	0,0104	1,9684	0,0505	0,9495	899.025	45.364	4.357.600	19.710.216	21,9
65	0,0173	2,0615	0,0824	0,9176	853.662	70.335	4.061.631	15.352.616	18,0
70	0,0274	2,0058	0,1266	0,8734	783.327	99.135	3.619.805	11.290.985	14,4
75	0,0430	2,1127	0,1914	0,8086	684.192	130.957	3.042.851	7.671.180	11,2
80	0,0735	1,9431	0,3000	0,7000	553.236	165.990	2.258.763	4.628.329	8,4
85	0,1402	1,6207	0,4755	0,5245	387.246	184.154	1.313.921	2.369.566	6,1
90+	0,1924	3,9820	1,0000	0,0000	203.092	203.092	1.055.646	1.055.646	5,2

Note: For figures in columns L_x , dx , px , qx and mx the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 25: Turkey Abridged Period Life Table, TRA, 2009.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0129		0,0129	0,9871	1.000.000	12.934	987.066	74.431.056	74,4
1	0,0017	1,1741	0,0069	0,9931	987.066	6.796	3.929.060	73.443.990	74,4
5	0,0009	1,8700	0,0043	0,9957	980.270	4.239	4.888.082	69.514.930	70,9
10	0,0006	2,0485	0,0031	0,9969	976.031	3.018	4.871.247	64.626.848	66,2
15	0,0007	2,1152	0,0035	0,9965	973.013	3.423	4.855.190	59.755.601	61,4
20	0,0006	2,0526	0,0030	0,9970	969.590	2.881	4.839.459	54.900.410	56,6
25	0,0008	2,0498	0,0038	0,9962	966.709	3.679	4.822.693	50.060.951	51,8
30	0,0008	2,0023	0,0040	0,9960	963.031	3.817	4.803.710	45.238.258	47,0
35	0,0015	2,0388	0,0073	0,9927	959.213	6.971	4.775.424	40.434.549	42,2
40	0,0020	2,3455	0,0098	0,9902	952.242	9.339	4.736.419	35.659.125	37,4
45	0,0031	2,1649	0,0154	0,9846	942.903	14.520	4.673.349	30.922.706	32,8
50	0,0052	2,2713	0,0257	0,9743	928.383	23.862	4.576.800	26.249.357	28,3
55	0,0085	2,1821	0,0417	0,9583	904.520	37.699	4.416.370	21.672.558	24,0
60	0,0132	2,0985	0,0634	0,9366	866.821	54.954	4.174.653	17.256.187	19,9
65	0,0220	2,1600	0,1033	0,8967	811.867	83.902	3.821.057	13.081.534	16,1
70	0,0347	1,9883	0,1570	0,8430	727.965	114.293	3.295.610	9.260.477	12,7
75	0,0547	1,9660	0,2345	0,7655	613.672	143.924	2.631.698	5.964.868	9,7
80	0,0980	1,9127	0,3762	0,6238	469.747	176.728	1.803.123	3.333.169	7,1
85	0,1381	1,6240	0,4710	0,5290	293.020	138.015	999.158	1.530.046	5,2
90+	0,2920	4,0160	1,0000	0,0000	155.005	155.005	530.888	530.888	3,4

Note: For figures in columns L_x , dx , px , qx and mx the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 26: Turkey Abridged Period Life Table, TRA, 2010.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0140		0,0140	0,9860	1.000.000	13.959	986.041	75.129.425	75,1
1	0,0014	1,1327	0,0056	0,9944	986.041	5.524	3.928.322	74.143.385	75,2
5	0,0008	1,7153	0,0041	0,9959	980.516	4.040	4.889.312	70.215.062	71,6
10	0,0006	2,0392	0,0029	0,9971	976.477	2.855	4.873.929	65.325.750	66,9
15	0,0006	2,0938	0,0030	0,9970	973.621	2.917	4.859.630	60.451.820	62,1
20	0,0006	2,0308	0,0029	0,9971	970.705	2.858	4.845.038	55.592.190	57,3
25	0,0007	2,1150	0,0036	0,9964	967.847	3.485	4.829.182	50.747.152	52,4
30	0,0009	1,9504	0,0044	0,9956	964.362	4.212	4.808.968	45.917.970	47,6
35	0,0013	2,1165	0,0067	0,9933	960.151	6.410	4.782.269	41.109.003	42,8
40	0,0018	2,1707	0,0090	0,9910	953.740	8.618	4.744.320	36.326.733	38,1
45	0,0028	2,0608	0,0141	0,9859	945.123	13.355	4.686.361	31.582.413	33,4
50	0,0051	2,1916	0,0250	0,9750	931.768	23.325	4.593.335	26.896.053	28,9
55	0,0075	1,9701	0,0367	0,9633	908.443	33.374	4.441.097	22.302.718	24,6
60	0,0124	1,9684	0,0596	0,9404	875.070	52.186	4.217.139	17.861.621	20,4
65	0,0207	2,0615	0,0976	0,9024	822.884	80.344	3.878.328	13.644.482	16,6
70	0,0351	2,0058	0,1590	0,8410	742.539	118.043	3.359.249	9.766.153	13,2
75	0,0524	2,1127	0,2276	0,7724	624.496	142.130	2.712.108	6.406.904	10,3
80	0,0898	1,9431	0,3524	0,6476	482.366	169.979	1.892.220	3.694.796	7,7
85	0,1247	1,6207	0,4387	0,5613	312.387	137.059	1.098.773	1.802.576	5,8
90+	0,2491	3,9820	1,0000	0,0000	175.327	175.327	703.804	703.804	4,0

Note: For figures in columns L_x , dx , px , qx and mx the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 27: Turkey Abridged Period Life Table, TRB, 2009.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0173		0,0173	0,9827	1.000.000	17.270	982.730	74.472.203	74,5
1	0,0020	1,1741	0,0078	0,9922	982.730	7.655	3.909.287	73.489.473	74,8
5	0,0016	1,8700	0,0078	0,9922	975.075	7.624	4.851.512	69.580.185	71,4
10	0,0009	2,0485	0,0043	0,9957	967.451	4.170	4.824.949	64.728.673	66,9
15	0,0009	2,1152	0,0043	0,9957	963.282	4.158	4.804.414	59.903.724	62,2
20	0,0007	2,0526	0,0035	0,9965	959.124	3.396	4.785.611	55.099.310	57,4
25	0,0009	2,0498	0,0044	0,9956	955.728	4.195	4.766.265	50.313.699	52,6
30	0,0010	2,0023	0,0050	0,9950	951.534	4.793	4.743.300	45.547.434	47,9
35	0,0015	2,0388	0,0073	0,9927	946.740	6.893	4.713.292	40.804.134	43,1
40	0,0020	2,3455	0,0100	0,9900	939.848	9.370	4.674.365	36.090.842	38,4
45	0,0028	2,1649	0,0140	0,9860	930.478	12.980	4.615.589	31.416.477	33,8
50	0,0050	2,2713	0,0246	0,9754	917.498	22.612	4.525.785	26.800.888	29,2
55	0,0073	2,1821	0,0357	0,9643	894.885	31.942	4.384.419	22.275.103	24,9
60	0,0114	2,0985	0,0552	0,9448	862.943	47.591	4.176.629	17.890.684	20,7
65	0,0205	2,1600	0,0967	0,9033	815.352	78.873	3.852.764	13.714.055	16,8
70	0,0332	1,9883	0,1510	0,8490	736.479	111.174	3.347.575	9.861.291	13,4
75	0,0555	1,9660	0,2374	0,7626	625.305	148.476	2.676.058	6.513.716	10,4
80	0,0935	1,9127	0,3627	0,6373	476.830	172.929	1.850.264	3.837.658	8,0
85	0,1216	1,6240	0,4312	0,5688	303.901	131.033	1.077.138	1.987.394	6,5
90+	0,1899	4,0160	1,0000	0,0000	172.868	172.868	910.256	910.256	5,3

Note: For figures in columns L_x , d_x , p_x , q_x and m_x the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 28: Turkey Abridged Period Life Table, TRB, 2010.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0143		0,0143	0,9857	1.000.000	14.302	985.698	75.421.658	75,4
1	0,0017	1,1327	0,0069	0,9931	985.698	6.815	3.923.251	74.435.960	75,5
5	0,0013	1,7153	0,0064	0,9936	978.883	6.312	4.873.680	70.512.708	72,0
10	0,0007	2,0392	0,0035	0,9965	972.571	3.361	4.852.902	65.639.028	67,5
15	0,0008	2,0938	0,0041	0,9959	969.210	4.004	4.834.414	60.786.125	62,7
20	0,0006	2,0308	0,0031	0,9969	965.206	3.004	4.817.111	55.951.712	58,0
25	0,0008	2,1150	0,0039	0,9961	962.202	3.724	4.800.264	51.134.601	53,1
30	0,0009	1,9504	0,0046	0,9954	958.477	4.389	4.779.004	46.334.337	48,3
35	0,0013	2,1165	0,0065	0,9935	954.089	6.178	4.752.630	41.555.333	43,6
40	0,0019	2,1707	0,0094	0,9906	947.911	8.894	4.714.390	36.802.703	38,8
45	0,0027	2,0608	0,0132	0,9868	939.017	12.435	4.658.533	32.088.313	34,2
50	0,0050	2,1916	0,0247	0,9753	926.581	22.908	4.568.571	27.429.781	29,6
55	0,0069	1,9701	0,0339	0,9661	903.673	30.666	4.425.449	22.861.209	25,3
60	0,0113	1,9684	0,0549	0,9451	873.007	47.892	4.219.840	18.435.760	21,1
65	0,0195	2,0615	0,0922	0,9078	825.114	76.108	3.901.930	14.215.920	17,2
70	0,0323	2,0058	0,1474	0,8526	749.007	110.375	3.414.547	10.313.990	13,8
75	0,0534	2,1127	0,2313	0,7687	638.632	147.711	2.766.675	6.899.442	10,8
80	0,0907	1,9431	0,3551	0,6449	490.921	174.326	1.921.709	4.132.767	8,4
85	0,1164	1,6207	0,4177	0,5823	316.596	132.257	1.136.044	2.211.059	7,0
90+	0,1715	3,9820	1,0000	0,0000	184.338	184.338	1.075.014	1.075.014	5,8

Note: For figures in columns L_x , d_x , p_x , q_x and m_x the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 29: Turkey Abridged Period Life Table, TRC, 2009.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0172		0,0172	0,9828	1.000.000	17.200	982.800	75.401.459	75,4
1	0,0017	1,1741	0,0069	0,9931	982.800	6.751	3.912.123	74.418.659	75,7
5	0,0010	1,8700	0,0052	0,9948	976.049	5.039	4.864.474	70.506.536	72,2
10	0,0006	2,0485	0,0031	0,9969	971.010	3.002	4.846.190	65.642.062	67,6
15	0,0008	2,1152	0,0037	0,9963	968.008	3.623	4.829.589	60.795.872	62,8
20	0,0007	2,0526	0,0035	0,9965	964.385	3.372	4.811.989	55.966.283	58,0
25	0,0008	2,0498	0,0041	0,9959	961.014	3.922	4.793.497	51.154.294	53,2
30	0,0009	2,0023	0,0044	0,9956	957.092	4.200	4.772.868	46.360.797	48,4
35	0,0012	2,0388	0,0060	0,9940	952.892	5.684	4.747.628	41.587.929	43,6
40	0,0018	2,3455	0,0092	0,9908	947.208	8.683	4.712.991	36.840.301	38,9
45	0,0027	2,1649	0,0136	0,9864	938.525	12.731	4.656.534	32.127.310	34,2
50	0,0046	2,2713	0,0226	0,9774	925.795	20.924	4.571.876	27.470.776	29,7
55	0,0073	2,1821	0,0357	0,9643	904.870	32.311	4.433.304	22.898.900	25,3
60	0,0112	2,0985	0,0544	0,9456	872.559	47.445	4.225.132	18.465.596	21,2
65	0,0194	2,1600	0,0917	0,9083	825.114	75.695	3.910.600	14.240.464	17,3
70	0,0315	1,9883	0,1440	0,8560	749.419	107.914	3.422.092	10.329.863	13,8
75	0,0532	1,9660	0,2289	0,7711	641.505	146.837	2.762.029	6.907.771	10,8
80	0,0918	1,9127	0,3576	0,6424	494.668	176.875	1.927.275	4.145.742	8,4
85	0,1278	1,6240	0,4463	0,5537	317.794	141.846	1.110.096	2.218.467	7,0
90+	0,1587	4,0160	1,0000	0,0000	175.948	175.948	1.108.371	1.108.371	6,3

Note: For figures in columns L_x , dx , px , qx and mx the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

Appendix 30: Turkey Abridged Period Life Table, TRC, 2010.

Age	$n m_x$	$n a_x$	$n q_x$	$n p_x$	l_x	$n d_x$	$n L_x$	T_x	e_x^0
0	0,0160		0,0160	0,9840	1.000.000	16.022	983.978	75.978.780	76,0
1	0,0016	1,1327	0,0064	0,9936	983.978	6.286	3.917.889	74.994.801	76,2
5	0,0009	1,7153	0,0044	0,9956	977.692	4.349	4.874.175	71.076.912	72,7
10	0,0005	2,0392	0,0026	0,9974	973.343	2.547	4.859.175	66.202.737	68,0
15	0,0007	2,0938	0,0037	0,9963	970.796	3.625	4.843.448	61.343.562	63,2
20	0,0007	2,0308	0,0034	0,9966	967.172	3.296	4.826.072	56.500.114	58,4
25	0,0007	2,1150	0,0036	0,9964	963.876	3.429	4.809.487	51.674.042	53,6
30	0,0009	1,9504	0,0044	0,9956	960.447	4.184	4.789.475	46.864.555	48,8
35	0,0011	2,1165	0,0054	0,9946	956.263	5.139	4.766.497	42.075.080	44,0
40	0,0017	2,1707	0,0085	0,9915	951.124	8.047	4.732.853	37.308.583	39,2
45	0,0025	2,0608	0,0123	0,9877	943.077	11.643	4.681.163	32.575.730	34,5
50	0,0044	2,1916	0,0219	0,9781	931.434	20.401	4.599.876	27.894.567	29,9
55	0,0067	1,9701	0,0330	0,9670	911.033	30.022	4.464.202	23.294.691	25,6
60	0,0106	1,9684	0,0512	0,9488	881.011	45.123	4.268.260	18.830.489	21,4
65	0,0189	2,0615	0,0897	0,9103	835.889	74.940	3.959.232	14.562.229	17,4
70	0,0315	2,0058	0,1438	0,8562	760.948	109.438	3.477.059	10.602.997	13,9
75	0,0525	2,1127	0,2280	0,7720	651.510	148.542	2.828.662	7.125.938	10,9
80	0,0902	1,9431	0,3536	0,6464	502.967	177.857	1.971.144	4.297.276	8,5
85	0,1291	1,6207	0,4495	0,5505	325.110	146.124	1.131.759	2.326.132	7,2
90+	0,1499	3,9820	1,0000	0,0000	178.987	178.987	1.194.374	1.194.374	6,7

Note: For figures in columns L_x , dx , px , qx and mx the age interval relates to a 5-year period except for: age 0 which relates to a 1-year period, age 1 which relates to a 4-year period, and age 90 which relates to remaining life span.

