THE IMPACT OF COMPETING RISKS OF DEATH ON GAINS AND LOSSES IN LIFE EXPECTANCY IN TURKEY

Dilek Torun, Hacettepe University - Ankara, Turkey

SUMMARY

Mortality measures used for analyzing the mortality level of a population fail to quantify the effects of premature deaths. For this reason, alternative measures are developed to explain the mortality trends of a population. Years of potential life lost (YPLL) and potential gains in life expectancy (PGLE) are two measures for analyzing the effect of premature deaths. These measures enable to examine the premature mortality patterns of a population in terms of causes of death. The main objective of this study is to calculate the YPLL and PGLE indicators for Turkey according to the major groups of causes of death for the years 2000-2008. For applying cause specific mortality analyses, single and multiple decrement life tables and then further associated single decrement life tables are constructed. The life tables are constructed by using the infant mortality rates derived from the results of Turkish Demographic and Health Survey 1998, 2003 and 2008. The results of the PGLE analyses are represented by complete and partial elimination of causes of death. YPLL results are estimated as lifetime YPLL and YPLL up to age 65 for each group of cause of death. The findings suggest that the overall effect of premature mortality shows a decreasing trend during the period 2000 – 2008 in Turkey. Cardiovascular diseases and cancers are the leading causes of death affecting premature mortality. It is observed that the impact of cancers and injuries on premature mortality are greater for the younger age groups in Turkey. The results of this study represent useful information for effective allocation of public health resources and improvement of research programs as well as setting up health goals.

1. INTRODUCTION

The effects of premature deaths cannot be quantified by using general mortality rates since they are dominated by chronic diseases among the elderly. Years of potential life lost (YPLL) and potential gains in life expectancy (PGLE) are two indicators for measuring the impact of premature deaths from different causes of death in a population. YPLL is presented as an index that focuses on the social and economic consequences of mortality (Gardner and Sanborn, 1990). YPLLs represent the total number of years that a person would have lived if he/she had not died from a particular cause of death. It is the weighted sum of number of deaths from a specific cause in the concerned period. This method fails to take into account competing risks and heavily influenced by population age structures. PGLEs represent the added years of life expectancy the population would receive if the deaths from a particular cause were reduced or eliminated (Lai and Hardy, 1999). They are based on the multiple decrement life table technique and competing risks of death are taken into consideration. Multiple decrement tables represent the change in life expectancies for two or more forms of exit. The life table concerning various causes of death is a method for estimating the role of causes of death in life expectancies. By eliminating one or more causes of death, the effect of corresponding causes on life expectancy can be analyzed. Since death is usually attributed to a single cause, the effect of competing causes of death is considered in the PGLE analysis.

The analysis of the level of mortality when a cause of death is eliminated originated when vaccination was discovered in the eighteenth century. Bernoulli, D'Alembert and Laplace derived different methods for determining the change in the level of mortality when smallpox is eliminated as a cause of death. The theory of decremental forces or multiple decrement forces are first formulated by Makeham and practical applications were explored (Chiang, 1968). The concept of potential years of life lost was first introduced by Dempsey in 1947 with a method of measuring premature mortality due to tuberculosis and comparing with heart diseases and cancer. For each death, she calculated the remaining years of life by subtracting the age at death from the life expectancy at birth. In 1948, Dickinson and Welker introduced the concepts “life years lost” and “working years lost” which is calculated by using life expectancy at different ages instead of life expectancy at birth (Romeder and McWhinnie, 1977).

In Turkey, a couple of studies were implemented for measuring the effect of premature deaths. The national burden of disease and cost effectiveness project for Turkey was applied as a part of global burden of disease (GBD) framework implemented by World Health Organization (WHO). GBD analysis measures mortality and loss of health due to diseases, injuries and risk factors for all regions of the world. The total burden of disease is measured by using disability-adjusted life year (DALY). DALY combines years of life lost due to premature mortality and years of life lost due to time lived in states of less than full health. The national project was applied by Refik Saydam Hygiene Center Presidency and Başkent University for the year 2000. The analysis of years life lost and disability-adjusted life year are implemented for national and regional level (Refik Saydam Hygiene Center Presidency, 2004). Burden of disease methods were applied to cause of death data by Akgün, Rao, et al. (2007) in order to derive national cause-specific mortality estimates. Their study examines the application of different methods to develop national mortality estimates in Turkey, and their implications for national health development policies. Another study about premature mortality was performed by Naci and Baker (2008). The total years of potential life lost and potentially productive years of life lost from mortality were calculated in order to estimate the cost of productivity losses from road traffic deaths in Turkey.

The aim of this study is to examine the gain and loss in life expectancy in Turkey according to the major groups of causes of death. PGLE and YPLL for the years 2000 and 2008 will be analyzed and compared. In order to analyze PGLE; first, the life table for Turkey for all causes of death will be constructed and then multiple decrement life tables and associated single decrement life tables will be constructed. The contribution of a specific cause of death to general mortality will be measured as the difference between the expectations of life before and after the elimination of that cause. YPLL will be analyzed by using the weighted sum of the number of deaths by age from a particular cause.

2. DATA SOURCES

The province and district death statistics derived by Turkish Statistical Institute (TURKSTAT) for the years 2000 and 2008, the results of 2000 population census and 2008 address based population registration system and the last three Turkish Demographic and Health Surveys (TDHS) conducted by Hacettepe University Institute of Population Studies in 1998, 2003 and 2008 are the data sources of this study.

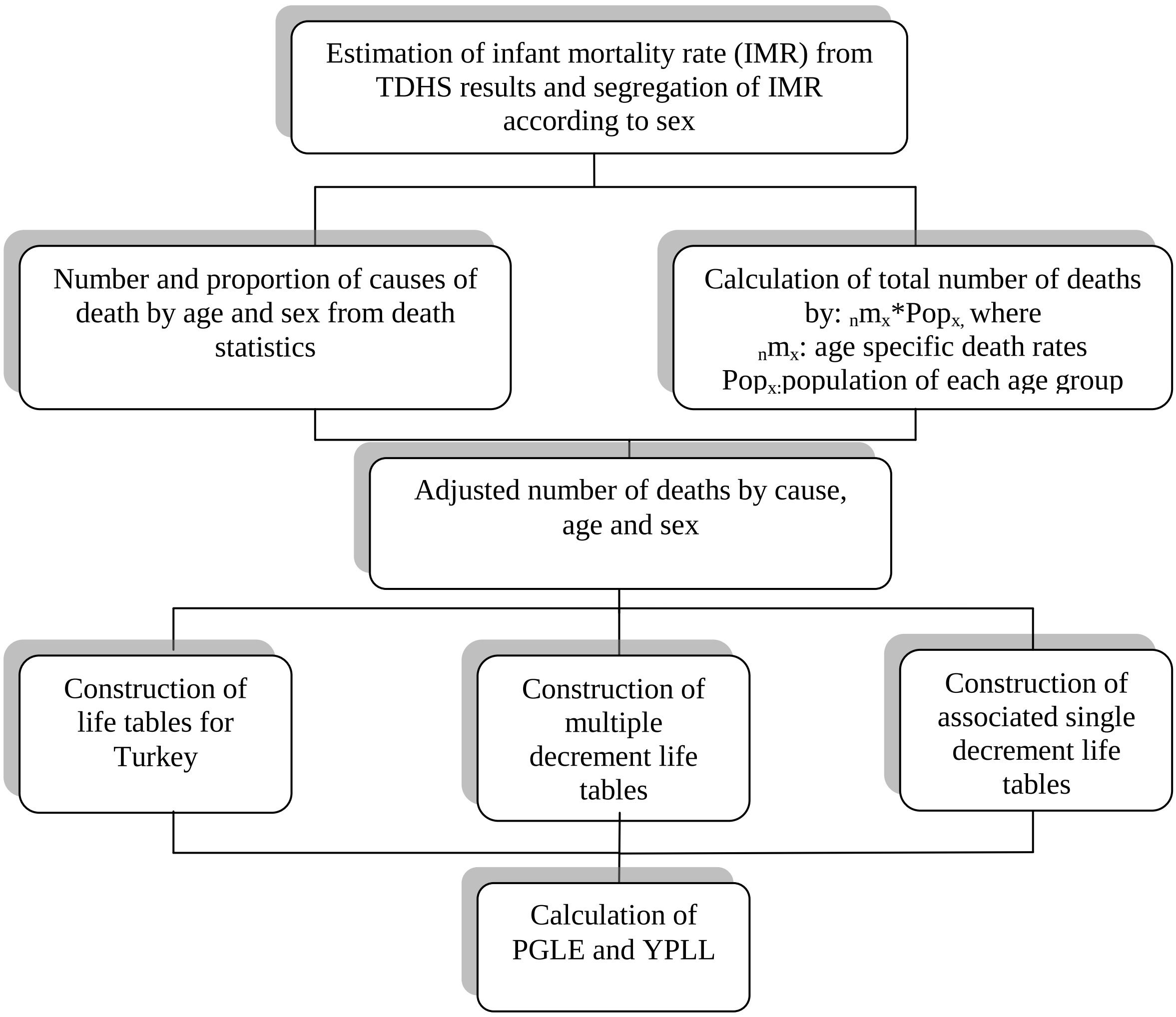
Death statistics of TURKSTAT are classified in compliance with the International Disease Categories (ICD-8) containing 50 and 150 diseases as required by World Health Organization until 2009. Since information on deaths are collected in the province and district level, geographic units smaller than districts are excluded in the mortality statistics of TURKSTAT. Deaths by 150 selected causes, sex and age group for province and district centers for the years 2000 and 2008 is used in this study. Causes of death are grouped according to the major causes of death concerning public health issues. Major groups are cardiovascular diseases, cancers, respiratory diseases, infectious diseases, injuries and other diseases.

In Turkey, the last population census was conducted in the year 2000. Address Based Population Registration System (ABPRS) was established in 2007 by registering all addresses within the boundaries of the country in the National Address Database and registering all Turkish Citizens living in these addresses linked to the Identification Number. Instead of population censuses conducted in every ten years, information on population size according to the place of usual residence is published annually by TURKSTAT. The results of 2000 population census and 2008 address based population registration system are used in this study.

TDHS 1998, TDHS 2003 and TDHS 2008 are the part of the series of quinquennial demographic surveys conducted by Hacettepe University Institute of Population Studies. The aim of these surveys is to provide information on trends and levels in fertility, infant and child mortality and contraceptive prevalence, as well as for the health indicators for Turkey (HUIPS, 2004). A weighted, multistage, stratified cluster sampling approach was used for the three surveys. For TDHS 1998, the estimates of population and health indicators for Turkey as whole, urban and rural areas and major five regions of the country (West, South, Central, North and East) were provided by the sample design. In TDHS 2003, survey results were also presented for 12 geographical regions (NUTS 1) which were adopted as part of Turkey's process of adaptation to the European Union. In TDHS-2008, beside the four domains in TDHS-2003, the seven metropolitan cities which are larger than one million population (İstanbul, Ankara, İzmir, Bursa, Adana, Konya, Gaziantep) was added in the sample design. In this study, probability of dying between ages 0-1 $({}_1q_0)$ - infant mortality rate (IMR) - is derived by using TDHS 1998, TDHS 2003 and TDHS 2008 results.

3. METHODOLOGY

The following steps are applied in the analysis of gains and losses in life expectancy:



3.1. Computational Procedure

The following steps are applied through the process of construction of life tables.

Step 1: Segregation of IMR

In Turkish Demographic and Health Surveys, the estimates of infant mortality rate (IMR) are provided for both sexes combined for five years preceding the survey. In order to calculate $({}_1q_0)$ separately for males and females on annual basis, segregation of IMR procedure developed by Toros (2000) is used. The procedure requires sex ratio at birth, which is taken to be 1.064 and sex specific IMR for ten-year period preceding the survey is used in the calculations.

Step 2: MORTPAK Match Procedure

MORTPAK is the software package developed by United Nations for demographic measurement in developing countries. In this study, MATCH application of MORTPAK is employed to construct life tables for Turkey. The MATCH procedure constructs model life tables and compares empirical data with respect to a model life table. According to the mortality and age pattern of Turkey, Coale and Demeny's West model life table family is chosen as a demographic model in this study. Model selection is made by considering the demographic and geographical characteristics of the country. The mortality pattern varies by different geographic regions and among urban and rural areas in Turkey. In addition, the effect of the mortality transitions makes it difficult to choose the exact model of life tables. Since the West model is intermediate between other models of Coale and Demeny regional model life tables and reflects a general pattern of mortality, it is regarded as the most appropriate model. The West model is usually recommended as a first choice when the mortality characteristics of a country prevent a more suitable choice of model (UN, 1983).

Step 3: Estimation of Number of Deaths

The age, sex and cause specific death structure of the population for the years 2000 and 2008 is estimated by using the data on deaths by selected causes, sex and age group and population by sex and age group.

The following steps are applied for adjustment:

- Age specific death rates provided from life tables are multiplied by the population of the corresponding age group and the number of deaths for each age group according to sex is estimated.
- Proportion of deaths due to each cause is calculated from death statistics by dividing the number of deaths due to each cause in an age group to all deaths in the corresponding age group.
- Proportion of deaths are multiplied by the adjusted total number of deaths and adjusted number of deaths according to cause of death, age group and sex is achieved.

3.2. Multiple Decrement Process

In cause specific mortality analysis "competing risks" is a critical issue. In the competing risks framework, death is attributed to a single cause since it is not a repetitive event. Here, the underlying assumption is that the different causes of death act independently. Chiang (1991) gives the example of a study about cancer as a risk of death. In the case, some persons may die from other causes during the study period so they will no longer die from cancer but also they would not survive to the end of the study period. So the question is what would be the contribution of their survival to the study or what adjustment would have to be made for the competing effect of other causes in the study? If cancer was eliminated as a cause of death, what would be a person's chance of surviving or how many years in life expectancy was lost because of cancer? By applying multiple decrement process in cause specific mortality analysis, these questions are trying to be answered.

Commonly used methodology regarding causes of death as competing risks are given by Chiang (1968). According to Chiang's methodology, the net probability of dying from cause R_δ if cause R_δ is eliminated as a competing risk is:

$\hat{q}_{i,\delta} = 1 - \hat{p}_i^{(D_i - D_{i\delta})/D_i}$, where

$\hat{p}_i$:probability of surviving in age interval $(x_i + x_{i+1})$
D_i :total number of deaths in age interval $(x_i + x_{i+1})$
$D_{i\delta}$:number of deaths from cause R_δ in age interval $(x_i + x_{i+1})$

3.3. Multiple Decrement Life Tables

Cause of death life tables, a type of the multiple decrement life tables, are constructed by subdividing a conventional life table into component tables for the causes of death. The total number of deaths is subdivided into different causes or groups of causes of death. The multiple decrement life tables may be constructed by using the age specific probabilities of the occurrence of death. For constructing cause of death life table, first a conventional life table is constructed for age specific probabilities of dying for all causes combined. Then, the proportion of deaths from each cause is computed and the number of deaths for each age group is separated into subcategories. The component tables related to a particular cause or groups of causes of death and other table relating all other causes of death are mutually exclusive and additive. The sum of life table deaths through all age groups and component tables indicates the life table deaths for all causes combined. The life table deaths for each cause and age group are used to calculate the probabilities of death from specified causes and represent the probability that an individual will die of that cause in the corresponding age group (Siegel and Swanson, 2004).

The basic life table functions - l_x , ${}_nd_x$, ${}_nq_x$, ${}_nL_x$, T_x , e_x - are used in constructing cause of death life tables. New columns which refer to particular causes of death are added to the multiple decrement tables. The functions in these columns are represented in Table 1.

Table 1. Multiple decrement life table functions

Life table function	Explanation	Formula
$\boldsymbol{{}_nd_x^i}$	The number of persons dying from cause *i* between ages *x* and *x+n*	${}_nd_x^i = {}_nq_x^i * l_x$
$\boldsymbol{{}_nq_x^i}$	The probability of dying from cause *i* between exact ages *x* and *x+n*	${}_nq_x^i = {}_nq_x * \frac{{}_nD_x^i}{{}_nD_x}$
$\boldsymbol{l_x^i}$	The number of persons surviving at age *x* who will eventually succumb to cause *i*	$l_x^i = \sum_{a=x}^{\infty} {}_nd_a^i$
$\boldsymbol{{}_nm_x^i}$	The rate of decrement from cause *i* between ages *x* and *x+n*	${}_nm_x^i = {}_nd_x^i / {}_nL_x$

3.4. Associated Single Decrement Life Tables

Associated single decrement - or cause deleted - life tables are constructed for computing the potential gains after the elimination of a cause. Cause elimination life tables are usually constructed in association with cause of death tables. For each of the causes of decrement in a multiple decrement life table, a single decrement table can be constructed. The gain in life expectancy from eliminating a specific cause of death is the difference in life expectancy calculated from the cause elimination life table and the life table for all causes combined (Siegel and Swanson, 2004).

The formulas of basic life table functions are adapted for some of the functions of the cause elimination life tables. Three types of functions used in associated single decrement life tables are explained in Table 2.

Table 2. Associated single decrement life table functions

Life table function	Explanation	Formula
$\boldsymbol{{}_np_x^{-i}}$	The probability of surviving between exact ages x and $x+n$ assuming that cause i is eliminated	${}_np_x^{-i} = [{}_np_x]^{R^{-i}}$, where $R^{-i} = (({}_nD_x - {}_nD_x^{i}) / {}_nD_x)$
$\boldsymbol{l_x^{-i}}$	The number of persons surviving at age x assuming that cause i is eliminated	$l_{x+n}^{-i} = l_x^{-i} * {}_np_x^{-i}$
$\boldsymbol{{}_na_x^{-i}}$	The average person years lived in the interval between ages x and $x+n$ for persons dying in the interval assuming that cause i is eliminated	${}_na_x^{-i} = n + R^{-i} \frac{{}_nq_x}{{}_nq_x^{-i}} ({}_na_x - \text{n})$ for x = 0, 1, 5, 75 ${}_5a_x^{-i} = \frac{\frac{-5}{24}\,{}_5d_{x-5}^{-i} + 2.5\,{}_5d_x^{-i} + \frac{5}{24}\,{}_5d_{x+5}^{-i}}{{}_5d_x^{-i}}$ for x = 10 to 70 ${}_\infty a_{80}^{-i} = e_{80}^{-i} = \frac{e_{80}^{0}}{R^{-i}}$

3.5. Potential Gains in Life Expectancy

The gain in life expectancy from eliminating a specific cause of death is the difference of life expectancy of cause elimination life table and the table for all causes combined:

$g_x^{-i} = e_x^{-i} - e_x$, where

e_x^{-i} : The expectation of life for a person who survives at age x assuming that cause i is eliminated as a cause of death

e_x : The expectation of life for a person who survives at age x

A slight modification to the formula of net probability of dying is made to allow the partial elimination in a cause of death (Tsai et al, 1978). The modified net probability is given by the formula:

$\hat{q}_{i,\delta}\ (\pi_{i\delta}) = 1 - \hat{p}_i^{(D_i - \pi_{i\delta}\ D_{i\delta})/D_i}$, where

$\hat{p}_i$: probability of surviving in age interval $(x_i + x_{i+1})$
D_i : total number of deaths in age interval $(x_i + x_{i+1})$
$D_{i\delta}$: number of deaths from cause R_δ in age interval $(x_i + x_{i+1})$
$\pi_{i\delta}$: improvement factor

The results of per cent elimination by 5 year age group are weighted by L_x , the total number of person-years lived between ages x and $x+n$, and added years of life for the corresponding age groups are achieved. The gain in life expectancy for age groups 0-14, 15-64 and 65+ are calculated by the following formulas:

$$g_{(0-14)}^{-i} = \sum_{X=0}^{10}(g_x^{-i} * L_x) / \sum_{X=0}^{10} L_x$$

$$g_{(15-64)}^{-i} = \sum_{X=15}^{60}(g_x^{-i} * L_x) / \sum_{X=15}^{60} L_x$$

$$g_{(65+)}^{-i} = \sum_{X=65}^{80}(g_x^{-i} * L_x) / \sum_{X=65}^{80} L_x$$

3.6. Years of Potential Life Lost

YPLL is calculated by multiplying the number of deaths at each age group by the remaining life expectancy for that age group.

- Lifetime YPLL and YPLL up to age 65 for all causes are calculated by using the formulas:

YPLL: $\sum_{X=0}^{80}({}_nD_x \ * \ e_x)$

$YPLL_{65}$: $\sum_{X=0}^{60}[(65 - 1 - x) + \ (n - {}_na_x)] \ * \ {}_nD_x$, where

${}_nD_x$: Number of deaths from all causes combined from adjusted number of deaths
e_x : The expectation of life for a person who survives at age x
${}_na_x$: The average person years lived in the interval between ages x and $x+n$ for persons dying in the interval

- Lifetime YPLL and YPLL up to age 65 for cause i are calculated by using:

$YPLL_i$: $\sum_{X=0}^{80}({}_nD_x^i * \ e_x^{-i})$

$YPLL_{(65,\ i)}$: $\sum_{X=0}^{60}[(65 - 1 - x) + \ (n - {}_na_x^{-i})] \ * \ {}_nD_x^i$, where

${}_nD_x^i$: Number of deaths from cause i from adjusted number of deaths
e_x^{-i} : The expectation of life for a person who survives at age x assuming that cause i is eliminated as a cause of death
${}_na_x^{-i}$: The average person years lived in the interval between ages x and $x+n$ for persons dying in the interval assuming that cause i is eliminated

3.7. Assumptions and Limitations of the Method

The major assumption related to multiple decrement methodology is the assumption of independence of causes of death. The various causes of death are assumed to act independently in the "competing risks" approach. The force of mortality – or failure rate – is assumed to be zero for an eliminated cause of death and also force of mortality is assumed to remain unchanged for all other causes. In other words, eliminating one cause of death has no effect on the risk of dying from the remaining causes (Siegel and Swanson, 2004).

The quality of death statistics is an important limitation for this study. Because of the lack of vital registration system data, the death statistics for province and district centers by 150 selected causes, sex and age group for the years 2000 and 2008 published by TURKSTAT is used. Since country wide and reliable data on death events for the corresponding years are not available, the age specific death rates are calculated and used in the analysis instead of actual number of deaths. The total number of deaths is estimated by multiplying the age specific death rates by the population of each age group.

In this study, the first assumption is the independence of causes of death assumption as explained above. The mortality pattern of province and district centers is assumed to reflect the mortality pattern of whole Turkey including rural areas as a second assumption. The third assumption is related to the age distribution of data; the age pattern of the population and death statistics are assumed to be distributed in the way that reflects the actual situation of the population. The last assumption is related to the model life tables; the age pattern of mortality of the selected model life table is assumed to be consistent with the age pattern of the actual population under concern.

4. RESULTS

Potential gains in life expectancy for males and females when cardiovascular diseases, cancers, respiratory diseases, infectious diseases, injuries and other diseases are eliminated are shown in Table 3 and Table 4. In the year 2000, potential gains in life expectancy by elimination of cardiovascular diseases are 9,68 years and 10,89 years for males and females respectively. The gains in male life expectancy by elimination of cardiovascular diseases are 9,29 years in 2008 and the average length of life for females would increase 11,68 years if cardiovascular diseases are totally eliminated. If cancers are eliminated, the gains in life expectancy are 2,16 years for males and 1,74 years for females in 2000; 2,26 years for males and 1,45 years for females in 2008.

If cardiovascular diseases are reduced by 50 per cent, the gains for males and females are nearly one third the years gained by total elimination. For cancers, respiratory diseases, infectious diseases, injuries and other diseases; 50 per cent elimination provides a gain of approximately one half the years gained by 100 per cent elimination. The increase in life expectancy for the causes of death other than cardiovascular diseases have an almost linear relationship with the proportion eliminated. This linearity holds for the causes of death with relatively small mortality rates; however when the magnitude of a cause of death is larger, no linear relationship is expected (Tsai et al, 1978).

In 2000, the gains are greater for females when cardiovascular diseases and other diseases are eliminated; for cancers, respiratory diseases, infectious diseases and injuries, males are estimated to gain more added years of life than females. In 2008, the gains in life expectancy for females are larger than the gains for males when cardiovascular diseases are eliminated or reduced. The exact opposite situation is observed for cancers, respiratory diseases and injuries. For infectious diseases, there is no significant difference in added years of life among sex groups.

Table 3. Added years of life at birth by reducing causes of death, 2000 and 2008

PGLE	2000		2008	
	Per cent of elimination			
	100	50	100	50
Cardiovascular Diseases				
Males	9,68	3,54	9,29	3,33
Females	10,89	3,85	11,68	3,77
Total Population	10,29	3,70	10,49	3,55
Cancers				
Males	2,16	1,04	2,26	1,07
Females	1,74	0,85	1,45	0,71
Total Population	1,95	0,94	1,85	0,89
Respiratory Diseases				
Males	1,08	0,53	1,43	0,68
Females	0,96	0,47	1,09	0,53
Total Population	1,02	0,50	1,26	0,60
Infectious Diseases				
Males	0,70	0,35	0,27	0,13
Females	0,67	0,34	0,25	0,12
Total Population	0,68	0,34	0,26	0,12
Injuries				
Males	1,17	0,58	0,45	0,23
Females	0,71	0,35	0,21	0,11
Total Population	0,94	0,46	0,33	0,17
Other				
Males	4,24	1,98	2,75	1,29
Females	4,72	2,14	2,87	1,31
Total Population	4,48	2,06	2,81	1,30

The gains in the absence of cardiovascular diseases are greater for females in 2000 and 2008. The gains in life expectancy increased for females in the 8 year period; however a descending pattern is observed for males except older ages. It can be suggested that cardiovascular diseases have an expanding impact on female mortality in the period 2000-2008. Cancers make greater contribution to male mortality in both years. The impact of cancer on female mortality increased at older ages between 2000 and 2008.

The years of life gained from elimination of injuries are greater for males at younger ages. The potential gains decreased between 2000 and 2008 for both sexes. At older ages, the age pattern of gains shows little difference for both sexes. The impact of other diseases on added years of life decreased between 2000 and 2008 at the age group 0-1. The decrease may be due to the decline in the infant mortality rates.

Table 4. Added years of life at birth for the age groups, 2000 and 2008

	2000				2008			
	Males		Females		Males		Females	
	Per cent of elimination				Per cent of elimination			
	100	50	100	50	100	50	100	50
Cardiovascular Diseases								
0-14	9,89	3,60	11,09	3,90	9,19	3,27	11,62	3,72
15-64	9,59	3,43	10,72	3,70	8,97	3,15	11,47	3,63
65+	7,65	2,52	8,68	2,77	7,86	2,57	10,46	3,11
Cancers								
0-14	2,21	1,06	1,76	0,86	2,27	1,08	1,45	0,71
15-64	2,00	0,96	1,45	0,71	2,15	1,02	1,31	0,64
65+	0,94	0,45	0,50	0,24	1,17	0,55	0,62	0,30
Respiratory Diseases								
0-14	0,92	0,45	0,77	0,38	1,31	0,62	1,00	0,48
15-64	0,83	0,40	0,65	0,32	1,26	0,60	0,95	0,46
65+	0,61	0,29	0,47	0,23	1,10	0,51	0,81	0,38
Infectious Diseases								
0-14	0,28	0,14	0,27	0,14	0,15	0,08	0,16	0,08
15-64	0,15	0,07	0,14	0,07	0,12	0,06	0,14	0,07
65+	0,06	0,03	0,05	0,02	0,08	0,04	0,08	0,04
Injuries								
0-14	1,13	0,56	0,66	0,33	0,43	0,22	0,20	0,10
15-64	0,51	0,25	0,30	0,15	0,23	0,11	0,12	0,06
65+	0,09	0,04	0,07	0,03	0,06	0,03	0,04	0,02
Other								
0-14	2,60	1,18	3,21	1,40	2,22	1,03	2,48	1,12
15-64	2,15	0,95	2,81	1,20	1,97	0,90	2,33	1,04
65+	2,08	0,88	2,78	1,14	1,67	0,75	2,09	0,92

Table 5. Years of potential life lost for all causes of death

	2000			2008		
	Males	Females	Total Population	Males	Females	Total Population
Lifetime	5.648.363	5.245.092	5.453.281	3.666.872	3.145.819	3.420.318
0-64	3.480.498	2.971.505	3.225.076	1.495.251	967.857	1.230.190
15-64	1.506.175	1.242.931	1.373.792	814.221	524.427	668.186
Percentage (0-64)	0,62	0,57	0,59	0,41	0,31	0,36
Percentage (15-64)	0,27	0,24	0,25	0,22	0,17	0,20

Years of potential life lost for all causes of death are represented in Table 5. In Turkey, the burden of premature mortality is estimated as a total of 5.648.363 YPLL for males and 5.245.092 YPLL for females in 2000. In 2008, premature deaths led to 3.666.872 YPLL for males and 3.145.819 YPLL for females. The relative percentage of YPLL up to age 65 decreased significantly in the period 2000-2008. In 2000, the proportion of YPLL up to age 65 to overall YPLL is 0,62 for males and 0,57 for females; in 2008, the corresponding values are 0,41 and 0,31, respectively. YPLL in productive years (15-64) shows a decreasing trend in the 8-year period, especially for females.

Years of potential life lost by causes of death and percentage distribution of YPLL are shown in Table 6 and Table 7.

Table 6. Years of potential life lost by causes of death

YPLL	2000		2008	
	Males	Females	Males	Females
Cardiovascular Diseases				
Lifetime	2.525.602	2.774.395	2.197.763	2.601.868
Ages 15-64	504.019	470.854	295.934	209.182
Cancers				
Lifetime	697.367	626.233	640.905	457.349
Ages 15-64	229.470	240.127	147.217	123.166
Respiratory Diseases				
Lifetime	395.756	371.657	391.880	301.509
Ages 15-64	66.474	62.748	49.747	35.328
Infectious Diseases				
Lifetime	418.762	386.403	123.403	100.364
Ages 15-64	42.034	39.668	14.277	11.396
Injuries				
Lifetime	696.243	402.326	243.055	102.420
Ages 15-64	401.333	215.388	136.009	46.615
Other Diseases				
Lifetime	1.952.712	1.880.449	958.972	838.428
Ages 15-64	262.703	214.297	170.608	98.554

Cardiovascular diseases are the major causes of premature mortality, responsible for 2.525.602 YPLL for males and 2.774.395 YPLL for females in 2000. Other diseases rank as the second cause of premature mortality for males and females, followed by cancers and injuries. The infectious diseases and respiratory diseases rank fifth and sixth in the year 2000. In the productive years (15-64), the leading causes of premature mortality are cardiovascular diseases and injuries for males and cardiovascular diseases and cancers for females, respectively.

In 2008, the major contribution is made by cardiovascular diseases for males (2.197.763 YPLL) and females (2.601.868 YPLL). Other diseases are the second cause of years life lost followed by cancers, respiratory diseases, injuries and infectious diseases. In the age group (15-64), the leading causes of premature mortality are cardiovascular diseases, cancers and other diseases for males and cardiovascular diseases and cancers for females, respectively.

The impact of cardiovascular diseases shows an increasing pattern for both sexes, but especially for females. The sharp increase can be explained by the age pattern of female population in the older ages. When working ages are considered, the relative percentage of YPLL from cardiovascular diseases decreases considerably for both sexes. It should also be pointed out that; the contribution of cancers and injuries to premature mortality significantly increases in the working ages and this contribution increases for cancers between 2000 and 2008 but the exact opposite situation is observed for injuries.

Table 7. Percentage distribution of YPLL by causes of death (%), 2000 and 2008

	2000			2008		
	Males	Females	Total Population	Males	Females	Total Population
Cardiovascular Diseases						
Lifetime	37,8	43,1	40,5	48,2	59,1	53,9
Ages 15-64	33,5	37,9	35,6	36,4	39,9	37,7
Cancers						
Lifetime	10,4	9,7	10,0	14,1	10,4	12,1
Ages 15-64	15,2	19,3	17,1	18,1	23,5	20,2
Respiratory Diseases						
Lifetime	5,9	5,7	5,8	8,6	6,8	7,6
Ages 15-64	4,4	5,1	4,7	6,1	6,7	6,4
Infectious Diseases						
Lifetime	6,3	6,0	6,1	2,7	2,3	2,5
Ages 15-64	2,8	3,2	2,9	1,8	2,2	1,9
Injuries						
Lifetime	10,4	6,3	8,3	5,3	2,3	3,8
Ages 15-64	26,7	17,3	22,4	16,7	8,9	13,6
Other Diseases						
Lifetime	29,2	29,2	29,2	21,1	19,1	20,0
Ages 15-64	17,4	17,2	17,3	20,9	18,8	20,1

5. CONCLUSION

When the results of PGLE analyses are considered; total gains in life expectancy decreased nearly 2 years during the period 2000 – 2008. Life expectancy is getting longer in Turkey; it can be suggested that the reduction in mortality from specified diseases play a part in this improvement. The most significant contribution to the gains in life expectancy was made by elimination of cardiovascular diseases. Nearly one half of the contribution to the total gain was made by elimination of cardiovascular diseases as a cause of death. Elimination of cancers and respiratory diseases make a remarkable contribution to the potential gains in life expectancy. When the results of partial reduction in mortality according to age groups are considered; more added years of life expectancy is observed in younger ages. With a 50 percent reduction; cancer related mortality have a considerable impact on the gains in working ages as well as younger age groups when compared with the results of complete elimination. Injuries have a more significant effect on the added years of life expectancy for younger ages. Under the hypothesis of partial reduction; the relative impact of cardiovascular disease related mortality shifted from working ages to older ages in the period 2000-2008.

According to the results of YPLL analyses; a decline of nearly 2.000.000 YPLL is observed in the estimates of premature mortality in the 8 year period. Also relative impact of total YPLL in working ages shows a decreasing trend in the same period. When causes of death are considered; cardiovascular diseases are the leading causes of years life lost and the relative impact of cardiovascular disease related mortality remarkably increases during the period 2000-2008. Cancers are the secondary causes of premature mortality according to the YPLL analyses. The relative impact of years life lost due to cancers and injuries significantly increases in the working ages for both years.

When the relative ratios of PGLE and YPLL results are considered; YPLL underestimated the impact of cardiovascular diseases when compared to PGLE. A slight difference is observed in the relative impact of cancers, respiratory diseases and other diseases with YPLL and PGLE analyses. On the other hand, YPLL overestimated the impact of infectious diseases and injuries when compared to PGLE. However, the overall pattern of the results obtained from two methods has sufficient consistency to draw a conclusion about premature mortality trends in Turkey.

The results of this study represent useful information for effective allocation of public health resources and improvement of research programs as well as setting up health goals. The analyses of gains and losses in life expectancies indicate that cardiovascular diseases and cancers are the leading causes of death affecting premature mortality in Turkey. The potential decrease in mortality due to cardiovascular diseases and cancers may be possible by improving treatment and prevention programs. As well as primary prevention actions such as modification of lifestyle behaviours associated with these specific causes of death, secondary preventive measures like screening programs should be implemented. Additionally, improvement in medical therapies is an essential measure for achieving a reduction in mortality due to cardiovascular diseases and cancers.

Deaths occurring in the early ages and working ages require a particular consideration in terms of economic and social consequences. The analyses of premature mortality for the corresponding ages provide the opportunity to determine the economic burden of diseases. On the basis of the results of this study, the relative impact of cancers and injuries are greater for the corresponding age groups in Turkey. It should be pointed out that males are exposed to risk of dying more than females for causes of death related to lifestyle factors. Therefore, programs against preventable causes of death should be taken into consideration as well as the treatment and prevention programs previously stated.

The results of the health transformation program should also be considered when analyzing the health status in Turkey. The health transformation program is implemented since 2003 and one of the main components of this program is to strengthen the preventive health services. New programmes are developed related to the maternal and child health, communicable diseases, mental health, non-communicable diseases and so on. Chronic diseases control programs are developed and cancer early diagnosis, screening and training centers are established as a part of the program. When the evaluation of the program in the period 2003-2010 is considered, the most significant improvement is observed in tobacco control; the rate of smokers decreased substantially in this period (Ministry of Health, 2011). The consequences of these prevention programs and their effect on the improvements in the health status may be evaluated by observing the long term outcomes of the programs.

In conclusion, a range of preventive actions and improvement of treatment programs will provide the opportunity to improve life expectancy in Turkey. The public health areas such as tobacco control, prevention of chronic diseases and injuries, early diagnosis of cancers, obesity control or road traffic safety should be supported to improve the health status. Further analyses that will support the efforts in planning the prevention and intervention programs will be possible by improving the health information system and obtaining accurate cause of death statistics at the national level.

REFERENCES

Akgün S, Rao C, Yardim N, Basara B.B, Aydın Ö, Mollahaliloglu S, Lopez A.D. (2007), *Estimating mortality and causes of death in Turkey: methods, results and policy implications*, European Journal of Public Health, Vol. 17, No. 6, 593–599.

Chiang, C.L. (1968): *Introduction to Stochastic Processes in Biostatistics*, John Wiley and Sons Inc., New York.

Chiang, C.L. (1991), *Competing Risks in Mortality Analysis*, Annual Review of Public Health, 12:281-307.

Dickinson F.G., Welker E.L. (1948), *What is the Leading Cause of Death? Two New Measures*, Chicago: American Medical Association, Bulletin 64.

Gardner J.W., Sanborn J.S. (1990), *Years of Potential Life Lost (YPLL)? What Does it Measure?*, Epidemiology, Vol. 1, No. 4, pp. 322-329.

Institute of Population Studies (1999), *Turkish Demographic and Health Survey* 1998, Hacettepe University, Institute of Population Studies, Ankara, Turkey.

Institute of Population Studies (2004), *Turkish Demographic and Health Survey* 2003, Hacettepe University, Institute of Population Studies, Ankara, Turkey.

Institute of Population Studies (2009), *Turkish Demographic and Health Survey* 2008, Hacettepe University, Institute of Population Studies, Ankara, Turkey.

Lai D, Hardy RJ. (1999), *Potential gains in life expectancy (PGLE) and years of potential life lost (YPLL): impact of competing risks of death*, International Journal of Epidemiology, Oct;28(5):894-8.

Ministry of Health (2011), *Turkey Health Transformation Program Evaluation Report (2003-2010)*, Ankara.

Naci H., Baker T.D. (2008), *Productivity losses from road traffic deaths in Turkey*, International Journal of Injury Control and Safety Promotion, 15:1, 19-24.

Refik Saydam Hygiene Center Presidency (2004), *Burden of Disease Final Report*, Ministry of Health Refik Saydam Hygiene Center Presidency, Ankara, Turkey.

Romeder J.M., McWhinnie J.R. (1977), *Potential Years of Life Lost Between Ages 1 and 70: An Indicator of Premature Mortality for Health Planning*, International Journal of Epidemiology, Oxford University Press, Vol. 6. No. 2.

Swanson D.A., Siegel J.S. (2004), *The Methods and Materials of Demography, 2nd Edition* Elsevier Academic Press, San Diego.

Toros A. (2000), *Life Tables for the Last Decade of XX. Century in Turkey*, the Turkish Journal of Population Studies, 22, 57-110.

Tsai S.P., Lee E.S., Hardy R.J. (1978), T*he Effect of a Reduction in Leading Causes of Death: Potential Gains in Life Expectancy*, American Journal of Public Health, Oct;68(10):966-71.

Turkish Statistical Institute (TURKSTAT), (2003), *Death Statistics Province and District Centers 2000*, Turkish Statistical Institute, Ankara, Turkey.

Turkish Statistical Institute (TURKSTAT), (2009), *Death Statistics Province and District Centers 2008*, Turkish Statistical Institute, Ankara, Turkey.

United Nations (UN), (1983), *Manual X Indirect Techniques for Demographic Estimation*, New York: United Nations.