Changes in Modal Age at Death and Mortality Compression in Turkey: 1920-2020

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Abstract
Life expectancy is the indicator most frequently used to describe the mean of the life table distribution of death. However, an alternative perspective is to study the age where most of the deaths are occurring, that is the modal age at death. Currently, mortality is concentrated at older ages in most countries. Studying the modal age at death provides an opportunity to have a different perspective of the changes in the distribution of deaths and to explain the change in mortality at older ages. Turkey is not exception experiencing the concentration of mortality at older ages. The objective of the study is to examine the changes in the model age at death and its linkage with the mortality compression in Turkey for the period of 1920-2020. The data are from the forecast using the secondary data for the past periods, and from the vital registration system for the recent periods. The preliminary results reveal that life expectancy has increased by 52 years from 26 years in 1920 to 78 years in 2020. In the same period, modal age at death has increased by 17 years from 67 years to 84 years. In this period, the standard deviation above modal age at death has decreased from 8.5 to 6.2 that also confirms the mortality compression at older ages over time in Turkey. Turkey, as a country at the onset of population aging process, should take necessary economic, social and health-related measures considering mortality compression that the country experiencing rapidly.

Key words: Modal age at death, mortality compression, mortality shift, Turkey

Introduction

Mortality pattern in Turkey has changed considerably in the period of 1920-2020. In this period, life expectancy has increased by 52 years from 26 years to 78 years. Concentration of deaths has shifted from childhood period to older period. In line with these changes, probability of surviving until exact age 80 has increased from 24 percent in 1920 to 62 percent in 2020. In Turkey, a country at the onset of population aging, percentage of population 65 and over has reached to almost 9 percent in 2018 and expected to be over 19 percent in 2050. For this reason, policies related to aging population, such as retirement ages, pensions, health and social care planning, carry great importance in Turkey on this point of time.

Since the pattern of the age at death has shifted, and deaths has concentrated at older ages, the life expectancy has become telling less about the longevity in Turkey. As a consequence, it is necessary to use a different measure for the recent changes in mortality patterns in Turkey. Within this context, the study constructs a series of life tables to calculate the modal age at death- the age which has the maximum number of deaths in a population- and standard deviations above the modal age death to understand the mortality compressions and shifts for the period of 1920-2020. The study asks three different but interrelated questions:

- How has the modal age at death changed in the period of 1920-2020 in Turkey?
- How has the standard deviations above the modal age at death as indicators of mortality shift changed over time in Turkey?
- Did Turkey enter into the compression of mortality period?

Literature Review

The modal age at death is one of the well-studied issues in demography. However, the study that we proposed is the unique study conducted so far in Turkey.

The first study on the modal age death is worked by Lexis (1878). In his work, he divided the distribution of deaths into 3 parts: decreasing number of deaths with age after infancy, deaths around the late modal age deaths, and premature deaths which are between the infancy and older ages (Lexis, 1878).

In his research, Kannisto (2001) emphasis the bi-modal distribution of length of life. One of the modal age is in infancy and the other one is in older ages. Furthermore, if there are two or more modes in the older ages, this means that there are some problems with data used. These problems may be insufficiency or age heaping errors in the data. He analyzed the modal age at death, standard deviation above the mode, life expectancy at mode and the ratio of standard deviation above the mode and life expectancy at mode. He concluded that the modal age at death and standard deviation above the mode are useful indicators for the length of older ages (Kannisto, 2001).

Thatcher et al. (2010) measured the modal age death at adult period, life expectancy and standard deviation above the modal age at death. They used shifting mortality model for England and Wales' official life tables and for the selected six countries' life tables from Human Mortality Database (HMD) for the age 70 and over. In the shifting mortality model, they combined Kannisto's approach with the logistic model. Study revealed that there had been mortality compression between the 1950-54 and 2000-2004. According to Thatcher et al. (2010) The compression that they observed was mainly due to the resistance because of death rates at higher ages did not decrease fast. One of the possible reasons this resistance may stem from better medical advances at lower old ages than at higher old ages (Thatcher et al, 2010).

Canudas-Romo (2008) analyzed the shifting mortality hypothesis by evaluating the late modal age at death for six countries: England and Wales, France, Italy, Japan, Sweden and the United States. In this study, Canudas-Romo used 4 mortality models: Gompertz model, logistic model to consider the over-estimation of older age deaths, Siler model to consider the effect of infant mortality on modal age at death and combined logistic and Siler models. This study shows that the phase of compression of mortality has stopped and modal age at death at old ages move toward to older ages.

In another study, Canudas-Romo (2010), have examined the life expectancy at birth, median and modal age at death for the years 1840-2005 for some countries. He also analyzed the trend of life expectancy at birth, median and modal age at death based on the record data of these countries. It was clarified in this study that the first increase in life expectancy and median age at death occurred when the infant and child mortality declined. Modal age at death has increased when the older age mortality has improved significantly. This pattern has shown that there has been a shifting mortality trend where mortality moved “from dominance of infant and child mortality reductions to dominance of adult mortality reductions” (Canudas-Romo, 2010).

Ouellette & Bourbeau (2011) analyzed the age at death distribution in Japan (1947-2209), Canada (1921-2007), USA (1945-2007), and France (1920-2009) for females and males. Ouellette & Bourbeau have used a nonparametric Poisson P-spline smoothing approach in this study. Results have shown that standard deviation above the mode has had little change since 1990s for women and 2000s for men in Japan. This means that compression of deaths above the modal age at death has stopped and mode of death has shifted towards higher ages. Shifting mortality at modal age at death is also valid for Canadian, French and US women, but it is not valid for their male counterparts. Compression of mortality phase continues for males in these countries.

Data and Methods

The data used in this study comes from the forecasted infant mortality rates for the 1920-1990 period. The forecasts of infant mortality rates are based on the secondary data mainly from the study conducted by Shorter & Macura (1983). For the period of 1990-2020, infant mortality rates are gathered from the vital registration system.

Based on infant mortality rates produced on the basis of sex, a series of abridged life tables were constructed with MORTPAK MATCH module for each 5-year for the above-mentioned period. Then, complete life tables were produced from the ${}_nq_x$ values of the abridged life tables by using MORTPAK UNABR module.

Once the complete life tables were constructed, modal age death is calculated for age 10 and above by using the number of deaths at each age (d_x). The reason for excluding the deaths at ages less than 10 is due to fact that Turkey had a bi-modal distribution of death, one at the childhood period and one at the older ages especially for the period of 1920-1990. Furthermore, focusing on age 10 and above provides benefits in removing the effects of infant and child mortality on the modal age at death. The modal age at death was calculated by using the equation given below (Kannisto, 2001; Canudas-Romo, 2010):

$$\mathrm{M(t)} = \mathrm{x} + \frac{\mathrm{d(x)} - \mathrm{d(x-1)}}{[\mathrm{d(x)} - \mathrm{d(x-1)}] + [(\mathrm{d(x)} - \mathrm{d(x+1)}]}$$

where x is the age with the highest death in the life table at time t. We then calculated the standard deviations above the modal age at death by using the following equation:

$$\mathrm{SD}(\mathrm{M}+) = \sqrt{\frac{\sum_{\mathrm{M}}^{\mathrm{w}}(\mathrm{x}-\mathrm{M})^2 * \mathrm{d}(\mathrm{x})}{\sum_{\mathrm{M}}^{\mathrm{w}}\mathrm{d}(\mathrm{x})}}$$

where M is modal age at death and w is the highest age at death in population.

Results

According to results, the modal age at death has increased from 67 to 82 years for males and from 68 to 87 for females in Turkey (**Figure 1**). On the other hand, a comparison on how the life expectancy at birth and modal age at death changes over time reveals that there exists an much steep increase for the life expectancy at birth while only a slight increase for the modal age at death. The life expectancy at birth and modal age at death converges over time, mainly originated from the declines the impact of early age mortality rates considerably on the life expectancy at birth and shift of mortality towards older ages **(Figure 2)**.

Figure 3 and **Figure 4** shows how the mortality shifts over time in Turkey. In the early periods, the number of deaths distributes almost evenly at each age, however the deaths set out concentrating at older ages for both sexes starting from 1980 and onwards. The shape of the curves become narrower over time, implying that deaths are compressed into a shorter age interval in Turkey.

The SD(M+) has decreased from 8.9 to 6.4 and from 7.7 to 6.0 for males and females respectively. The declining trend of the SD(M+) once more confirms that mortality above the modal age has compressed at older ages in Turkey (**Figure 5**).

Conclusion

As emphasized by United Nations (1983) and by Shorter and Macura (1982), Turkey had a unique mortality patterns characterized by high early age mortality and low adult mortality. This high childhood mortality is frequently defined as “Turkish Puzzle” by Tezcan (1992), Yüksel and Koc (2010) and Eryurt and Koc (2010) to describe the eclectic pattern of mortality in Turkey. The results of this study provide strong evidence that the puzzle has already been solved in Turkey together with the bi-modal mortality distribution has ended starting from 1990s. Therefore, Turkey has entered a new phase in its mortality transition that characterized by compression of the mortality at older ages effective from just three decades ago. Thereby, Turkey, as a country at the onset of population aging process, should take necessary economic, social and health-related measures considering mortality compression that the country experiencing rapidly.

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Figure 1. Changes in the modal age at death, 1920-2020

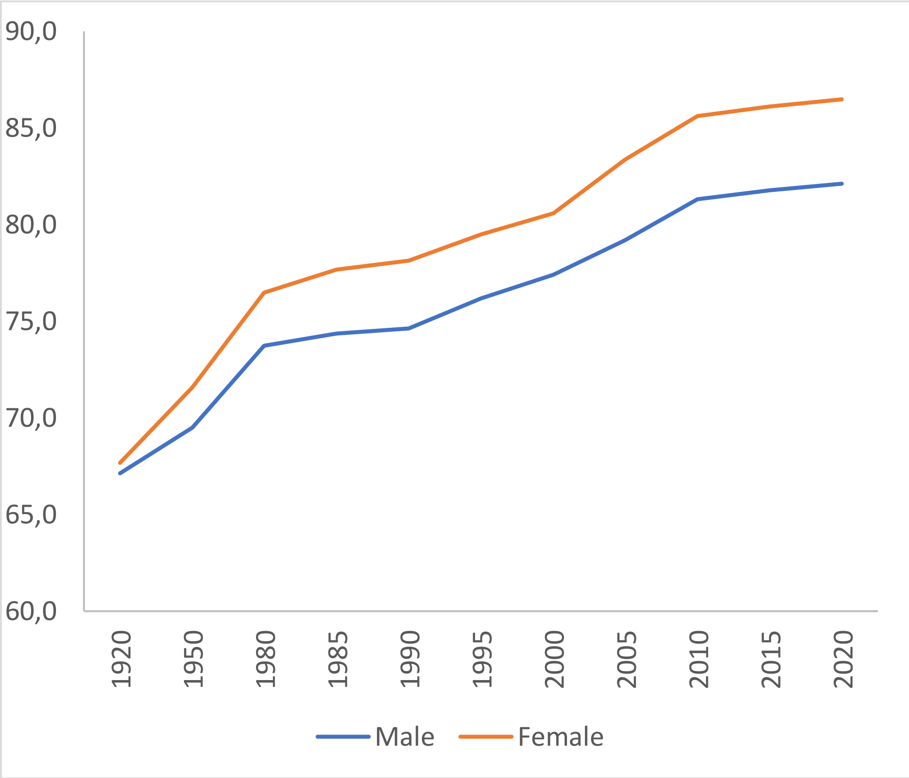

Figure 2. Historical trends of life expectancy and modal age at death, 1920-2020

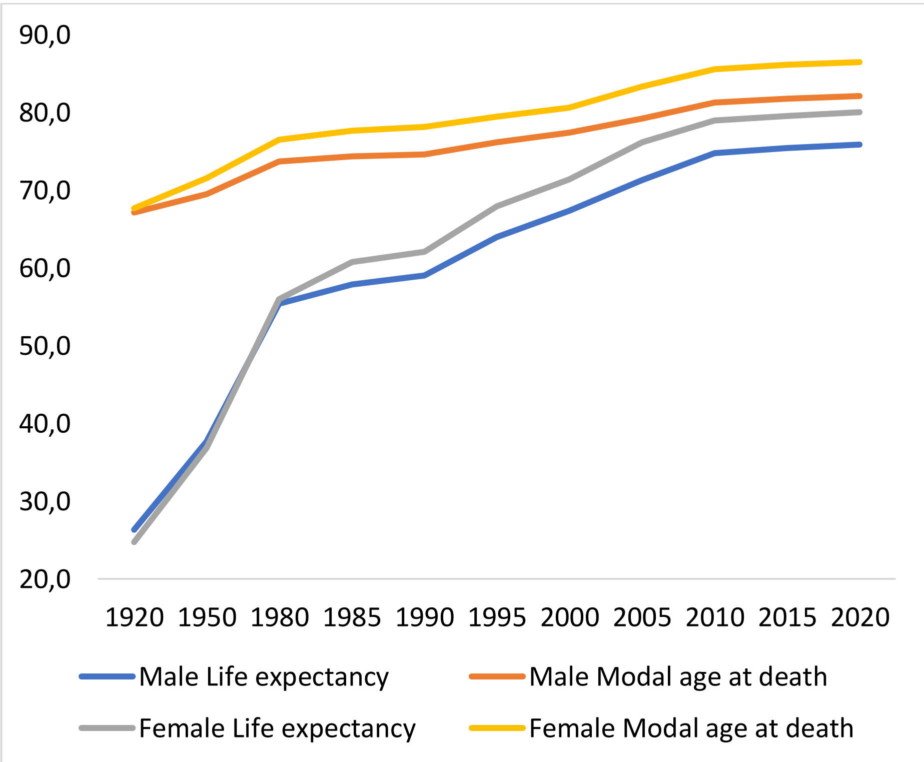

Figure 3. Distribution of life table deaths (d_x) by age and selected years, males

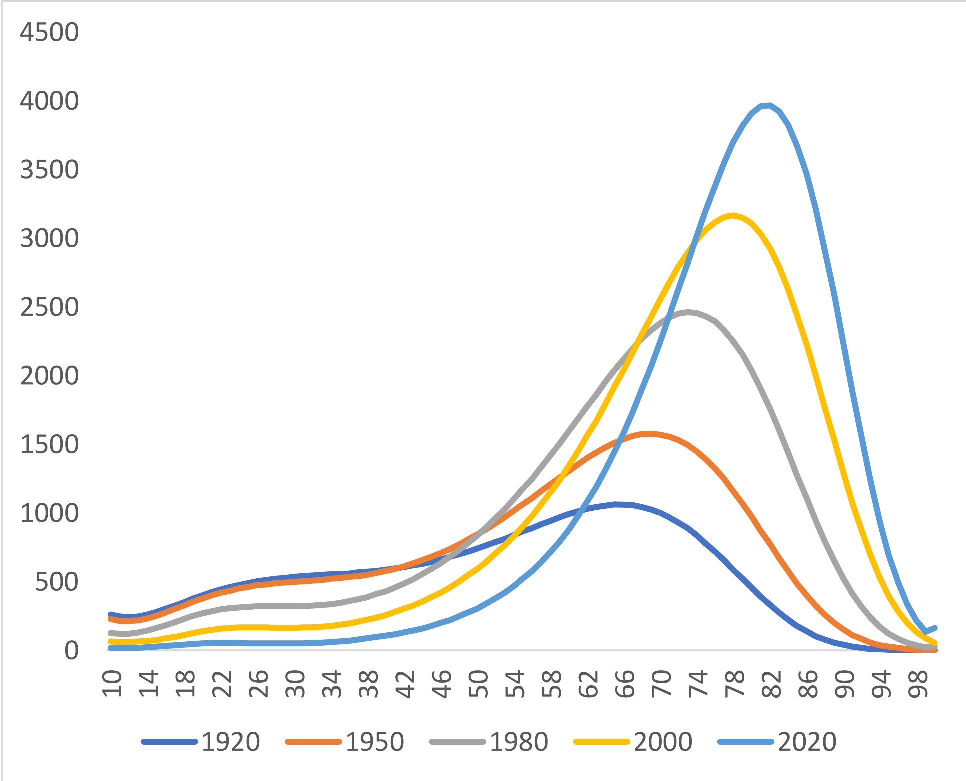

Figure 4. Distribution of life table deaths (d_x) by age and selected years, females

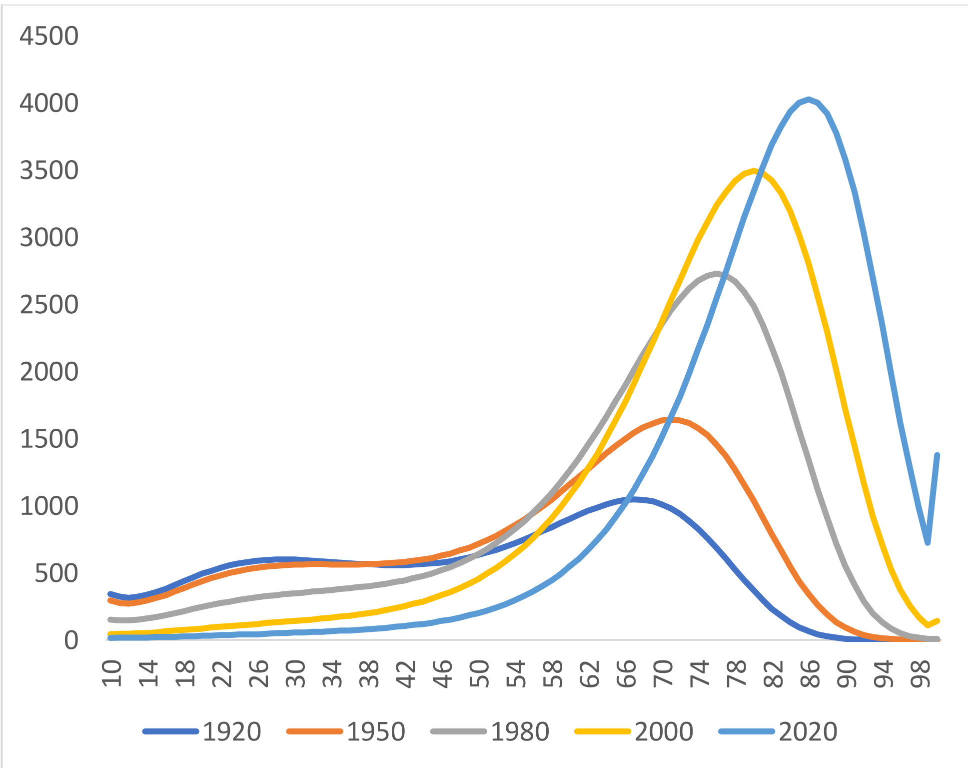

Figure 5. Standard deviation above the modal age at death, 1920-2020