ARAŞTIRMA MAKALESİ / RESEARCH ARTICLE

A CENTURY OF TRANSITION IN TÜRKİYE'S MORTALITY - UNRAVELING TRENDS THROUGH MODAL AGE AT DEATH (1920-2020)

TÜRKİYE'NİN ÖLÜM ORANINDAKİ YÜZYILLIK DEĞİŞİM - MODAL ÖLÜM YAŞI TRENDİ (1920-2020)

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ABSTRACT

This article explores the demographic landscape of Türkiye from 1920 to 2020 using life tables, focusing on adult mortality trends and employing the modal age at death as a key metric. It emphasizes the shifts in mortality patterns, particularly in relation to life expectancy, and addresses the historical and contextual factors influencing Türkiye's demographic transition. The literature review underlines the significance of the modal age at death as an indicator for assessing mortality dynamics, offering insights into compression and delay in mortality. The study utilizes a comprehensive methodology, including the acquisition of infant mortality rates, life table construction, and the calculation of modal age at death and standard deviation. The results highlight a remarkable increase in life expectancy over the century, driven by improvements in healthcare and reductions in infant and child mortality. The analysis of the modal age at death reveals trends of mortality delay and compression, with the decline in the standard deviation calculated for the modal age at death indicating a gradual shift of mortality to older ages. The findings align with Türkiye's demographic transition stages, emphasizing the evolving health landscape and the importance of considering modal age at death alongside life expectancy for a nuanced understanding of the trends of adult mortality. This study bridges a significant gap in the existing research on Türkiye by utilizing the modal age at death to assess older age mortality trends.

KEYWORDS: Modal age death, mortality transition, life table applications, longevity, life expectancy at birth

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ÖZET

Bu makale, 1920'den 2020'ye Türkiye'nin demografik görünümünü, yetişkin ölümlülük eğilimlerine odaklanarak ve temel bir ölçüt olarak modal ölüm yaşını kullanarak incelemektedir. Özellikle yaşam beklentisiyle ilişkili olarak ölümlülük örüntülerindeki değişimleri vurgulamakta ve Türkiye'nin demografik geçişini etkileyen tarihsel ve bağlamsal faktörleri ele almaktadır. Literatür taraması, ölümlülük dinamiklerinin değerlendirilmesinde bir gösterge olarak modal ölüm yaşının öneminin altını çizmekte ve ölümlülükteki sıkışma ve gecikmeye ilişkin içgörüler sunmaktadır. Çalışmada, bebek ölüm oranlarının elde edilmesi, yaşam tablosunun oluşturulması ve modal ölüm yaşı ile standart sapmanın hesaplanmasını içeren kapsamlı bir metodoloji kullanılmıştır. Sonuçlar, sağlık hizmetlerindeki gelişmeler ile bebek ve çocuk ölümlerindeki azalmaların etkisiyle yüzyıl boyunca yaşam beklentisinde kayda değer bir artış olduğunu vurgulamaktadır. Modal ölüm yaşı analizi, mortalite gecikmesi ve sıkışması eğilimlerini ortaya koymakta, modal ölüm yaşı için hesaplanan standart sapmadaki düşüş ise, ileri yaş ölümlülüğünün giderek daha ileri yaşlara kaydığına işaret etmektedir. Bulgular, Türkiye'nin demografik geçiş aşamalarıyla uyumlu olup, değişen sağlık ortamını ve yetişkin ölümlülüğündeki eğilimlerin daha iyi anlaşılması için yaşam beklentisinin yanı sıra modal ölüm yaşını da dikkate almanın önemini vurgulamaktadır. Bu çalışma, ileri yaş ölümlülük eğilimlerini değerlendirmek için modal ölüm yaşını kullanarak Türkiye üzerine yapılan mevcut araştırmalardaki önemli bir boşluğu doldurmaktadır.

ANAHTAR KELİMELER: Modal ölüm yaşı, ölümlülük dönüşümü, hayat tablosu uygulamaları, doğumda yaşam beklentisi, uzun ömürlülük

INTRODUCTION

The remarkable increase in life expectancy over the last two centuries is a noteworthy achievement in modern society (Basellini & Camarda, 2019). The subject of longevity is captivating and crucial, consistently sparking interest, especially when examining variations in mortality rates across different age groups. While there has been comprehensive exploration of child and infant mortality in Türkiye considering the Turkish puzzle (Gürsoy-Tezcan, 1992; Yüksel & Koç, 2010; Aktar & Palloni, 2022), our focus now shifts to adult mortality. We aim to uncover patterns that extend beyond conventional metrics like life expectancy as we navigate through Türkiye's demographic landscape from 1920 to 2020. Our goal is to meticulously analyze the complexities of mortality trends, placing particular emphasis on the modal age at death as a pivotal metric.

Over the past century, Türkiye's demographic landscape has undergone profound transformations, characterized by dynamic shifts in mortality patterns and a remarkable demographic transition. From the aftermath of World War I in the early 1920s to the present day, the nation has experienced substantial alterations in its population structure, healthcare systems, and socio-economic conditions. This article delves into the intricate interplay of these factors, with a particular focus on the modal age at death as a pivotal metric for comprehending mortality trends in Türkiye spanning from 1920 to 2020. A crucial aspect of this demographic transition lies in the noticeable evolution of death rates. The analysis within this article delves into the subtleties of mortality patterns in Türkiye, carefully examining the changes in age-specific mortality rates and their implications for the overall health of the population. As the country progressed through significant historical milestones, including periods of industrialization and urbanization, these factors played a fundamental role in shaping the distribution of deaths across various age groups.

There exists a significant gap in the existing studies that utilize the modal age of mortality to assess older age mortality in Türkiye. This article aims to fill this void by delving into long-term trends for both women and men, offering an illustrative depiction of a century of transition in Türkiye's mortality patterns. Our approach involves the creation of unabridged life tables for every 5th year from 1920 to 2020. Utilizing these life tables, we calculated life expectancy and the modal age at death. Our primary objective is to present the trends and underscore the disparities between life expectancy and the modal age, providing valuable insights into the explanation of mortality trends. Given our emphasis on the century-long trend in adult mortality, we specifically focus on modal age death rather than life expectancy, which is notably influenced by infant and child mortality.

The subsequent sections of the article delve into a literature review, providing a foundation for the exploration. Following this, the context of Türkiye is examined, offering a historical backdrop for understanding the demographic nuances. The methodology employed in the study is elucidated, detailing the steps taken to construct unabridged life tables and extract meaningful insights. The results section presents a meticulous analysis of compression of mortality, life expectancy, modal age at death, standard deviation, and the observed trends. Finally, the conclusion synthesizes key findings, highlights their implications, and contributes to the broader discourse on mortality dynamics of the century.

LITERATURE REVIEW

The exploration of mortality dynamics beyond life expectancy has become increasingly prominent in demography, prompting the consideration of alternative indicators such as the modal age at death. Scholars, notably Kannisto (2000), advocate for a nuanced approach to measuring the compression of mortality, emphasizing the necessity of examining specific age groups. This perspective is substantiated by studies from Wilmoth and Horiuchi (1999), which recognize constant age-at-death variability since the 1950s but highlight significant compression occurring later, with ongoing variations between countries. The exploration of mortality dynamics beyond life expectancy has become increasingly prominent in demography, prompting the consideration of alternative indicators such as the modal age at death. Scholars, notably Kannisto (2000), advocate for a nuanced approach to measuring the compression of mortality, emphasizing the necessity of examining specific age groups. This perspective is substantiated by studies from Wilmoth and Horiuchi (1999), which recognize constant age-at-death variability since the 1950s but highlight significant compression occurring later, with ongoing variations between countries.

Life expectancy, a widely used composite metric responsive to child mortality, is grounded in age-specific mortality rates. It is inherently influenced by the contribution of age-specific characteristics to mortality measures. Although life expectancy, as outlined by Preston, Heuveline, and Guillot (2001), is a key indicator of both health and mortality, relying solely on it provides an incomplete view of a population's mortality profile. This limitation arises from the average age at death, potentially obscuring vital heterogeneity in the overall age pattern of mortality, as noted by Martin et al. (2023).

To address these limitations, scholars propose the utilization of the adult modal age at death, representing the age beyond infancy at which the highest number of deaths occurs. This indicator is suggested for analyzing mortality disparities at older ages. Denoted as "M" within a specific mortality regime, it signifies the most common or "typical" length of life among adults. In comparison to traditional measures like life expectancy, M possesses desirable properties, including freedom from an arbitrary selection of an "old" age threshold and sole determination by mortality at older ages (Diaconu et al., 2022). Additionally, modal age at death is introduced alongside other measures, leveraging percentile-based approaches in survivorship. This approach ensures that the percentage level is not arbitrarily chosen, is easily understandable for the general population, and remains insensitive to changes in the definition of premature mortality (Diaconu et al., 2022).

Extensively used as an indicator for assessing the shifting mortality period, the modal age at death, when shifted toward older ages, results in the corresponding movement of deaths around this age (Bergeron-Boucher et al., 2015). This indicator offers several advantages in investigating survival at old ages, being insensitive to mortality changes at younger ages and reflecting the most common lifespan. A change in the modal age can only occur with pulling forces, indicating mortality improvement at ages older than the mode (Kannisto 2000; Canudas-Romo 2010, Bergeron-Boucher et al., 2015). Notably, the modal age at death has shown an accelerated increase since the onset of the old-age mortality decline, gaining prominence as a key indicator of lifespan, particularly since longevity extension has become determined by adult and old-age mortality in the 21st century (Kannisto 2000 2001; Bongaarts 2005; Cheung and Robine 2007; Canudas-Romo 2008, 2010; Ouellette and Bourbeau 2011; Horiuchi et al. 2013, Bergeron-Boucher et al., 2015).

Changes in mortality across different age groups have played a significant role in altering overall mortality rates and life expectancy. De Beer and Janssen (2016) distinguish between two types of changes: compression, resulting from variations in the decrease of rate across ages, which alters the age pattern of mortality (Fries, 1980), and delay, involving a decrease in mortality across all ages without changing the age pattern of mortality (Vaupel, 2010). If only mortality compression occurs, we would be approaching a limit to life expectancy. Conversely, if there is a delay in aging, a limit to life expectancy is unlikely in the near future. Additionally, the roles of delay versus compression provide insights into the main determinants of the increase in life expectancy (de Beer & Janssen, 2016).

The primary determinants of mortality delay, indicated by an increase in the modal age at death, include increased prosperity and advancements in medicine (Vaupel, 2010). Improved living and working conditions contribute to better health, while enhancements in public health and medical treatment prevent and mitigate illnesses. Changes in the age-at-death distribution's shape have various causes, with compression occurring if mortality at young ages decreases more sharply than at ages around the modal age at death, and if mortality at the oldest ages decreases less sharply than around the modal ages. Both types of compression are driven by different developments (de Beer & Janssen, 2016).

In consideration of these viewpoints, the collective body of literature implies that the modal age at death offers valuable insights into mortality patterns, particularly within the context of aging or onset of aging populations. Its emphasis on older age groups renders it a pertinent indicator for monitoring trends in longevity, complementing traditional metrics such as

life expectancy. Additionally, age-at-death distributions offer crucial insights into longevity and lifespan variability that cannot be directly gleaned from mortality rates (Basellini & Camarda, 2019). Consequently, this article will predominantly focus on the compression of mortality, life expectancy at birth (to facilitate a comparison with M), the modal age at death, and its associated standard deviation.

CONTEXT OF TURKIYE

Over the course of the last century, Türkiye's demographic landscape has undergone profound and dynamic transformations, marked by significant shifts in mortality patterns and an extraordinary demographic transition. Providing a comprehensive framework for understanding this evolution, Koç et al. (2010) delineate Türkiye's demographic transition into three distinct phases in their study, "Demographic Transition of Türkiye." The beginning period, spanning from 1923 to 1955, coincided with the foundation of the Republic of Türkiye and witnessed the onset of early modernization and pro-natalist policies. This phase was characterized by high mortality rates and elevated fertility levels. The subsequent period, from 1955 to 1980, saw a shift in governmental policies towards anti-natalist measures, resulting in lower mortality rates but continued high fertility. Finally, the third period, commencing in 1980, is emblematic of a demographic landscape characterized by both low mortality and low fertility rates (Koç et al., 2010).

Delving into the intricacies of the Turkish context, Gürsoy-Tezcan (1992) identifies infant mortality as a historical puzzle, attributing its complexities to cultural codes and health literacy. Later, Yüksel and Koç (2010) and Aktar and Palloni (2022) also tried to reveal the solution to this puzzle. This highlights the imperative need to scrutinize age-specific mortality trends, especially among older populations, in order to gain a more nuanced and accurate understanding of the broader mortality landscape in Türkiye. This dual focus on both historical transitions and contextual nuances underscores the multifaceted nature of demographic shifts in the country over the past century. Given the intricacies of the Turkish puzzle, it is advisable to concentrate on adult mortality, excluding the influence of infant and child mortality. This focused approach, employing the modal age at death, will enable us to delve into the specific dynamics of adult mortality, disentangling them from the broader demographic landscape. By utilizing the modal age at death using life tables as our analytical tool, we aim to capture a clearer and more nuanced picture of the mortality trends among the adult population in Türkiye. This methodological choice aligns with our objective to uncover unique patterns and factors shaping adult mortality, offering a targeted and insightful exploration into this aspect of Türkiye's demographic dynamics.

In Türkiye, research on life tables has a history, with the first significant study dating back to 1951 by Wiesler. Wiesler's work involved calculating mortality rates for ages 10 and below using two years of data specific to Türkiye, leading to the creation of life tables (Kırkbeşoğlu, 2006). Subsequent studies in this area have covered various aspects. Oral (1969), for instance, based calculations on mortality data from Ankara's population to determine death probabilities by age, constructing life tables as a result. Alpay (1969) used both rural and urban population data to derive life tables for Türkiye. Özsoy (1970) focused on the Ordu Aid Institution, utilizing mortality data from the T.C. Retirement Fund for the years 1950-1957. Öcal (1974) extended the scope to nine provinces in Türkiye, leveraging the 1960 population data to obtain life tables. Demirci (1987) conducted a study to identify the most suitable model for Türkiye among Coale-Demeny and United Nations tables, both of which are model life tables based on population data from 1966-1967. Hoşgör (1992, 1997) delved into age and gender data from 1930-1990, generating life tables for the post-childhood period. Furthermore, calculations for death levels and life expectancies were made for provinces and regions using the Preston-Bennett method, incorporating age, gender, and population growth rate data for the years 1985-1990.

Coşkun (2002) employed the orphanhood technique with Türkiye Population and Health Surveys (TDHS) data from 1993-1998. Initially calculating adult female mortality, Coşkun then determined adult male mortality using the same technique. Eryurt and Koç (2006) utilized the synthetic orphanhood technique with TDHS data for 1998 and 2003 to ascertain the level of adult mortality. Life tables for both women and men were subsequently developed for the years 1998-2003. Kırkbeşoğlu (2006) contributed by calculating adult mortality in Türkiye. The Coale-Demeny West model and the synthetic orphanhood method were applied, incorporating infant mortality rates from 1998 and 2003 TDHS data. The outcome was the creation of mortality and commutation tables specifically tailored for life insurance companies operating in Türkiye.

When we look at the more recent studies, Enfiyeci and Koç (2019) calculated the ${}_{n}a_{x}$ values for the life tables of Türkiye for the time between 2010-2018 through utilizing data provided by the vital registration systems. In their study (Enfiyeci and Koç, 2019), after they compared the values from vital registration with the values produced by model life tables, they showed that while it is possible to generate reliable ${}_{n}a_{x}$ values from vital registration data, those values are higher than the ${}_{n}a_{x}$ values produced from the model life tables.

Last but not least, Erkan (2020) also constructed 42 life tables of five-year periods, for males and females separately, for the years between 1920-2020 by

basing on the infant mortality rates, as it is done in this study. Erkan's study (2020) aimed to calculate the confidence interval of the life expectancies for each age groups. Her calculations showed that there was no difference between sexes regarding the confidence interval of the life expectancies up to the year 1960, and after 1960, females became advantageous in their value of life expectancies (Erkan, 2020). Overall, Erkan (2020) showed that, for both males and females, the confidence intervals of life expectancies were observed to decrease which means the estimations gradually became more reliable over the years, as expected.

DATA AND METHOD

To compute modal age at death, life expectancy at birth, and death compression for the period between 1920 and 2020 in Türkiye, we have undertaken a series of steps outlined as follows:

Step 1: Acquisition of Infant Mortality Rates (IMR) for Both Sexes

In the initial phase, our aim was to obtain IMR values for the five-year intervals spanning from 1920 to 2020. Our primary focus was to acquire all available IMR values and estimations, and calculate the missing ones with an interpolation method. In this phase IMR values obtained were mostly not disaggregated by sex.

TURKSTAT serves only as a contemporary data source, offering IMR values starting from 2009. For the early period (1935-1975), the most reliable estimations were from Shorter and Macura's (1982) influential work, "Trends in Fertility and Mortality in Turkey, 1935-1975". Their study utilizes the survival estimate technique for infant mortality rates. Additionally, Shorter's (1996) IMR calculations are integrated into our dataset. Given the absence of data from the first census in 1927, Bakar's (2020) comprehensive study on constructing life tables using IMRs from 1920 to 2020 was beneficial. Covering the time span from 1975 to the early 2000s, insights from Tüzün's (2021) article on factors influencing infant and child mortality were also incorporated. It is important to note that all IMR values considered in this step encompass both sexes. In cases where data was unavailable for certain time periods, the interpolation feature of Excel was strategically employed to calculate missing values, ensuring a thorough dataset construction.

Step 2: Calculation of Missing IMR values and Sex Segregation

In the second step, we addressed the periods where sex disaggregated IMR values are not available by employing the Toros method. This method requires the sex ratio of death, involving data on the number of female and male deaths, along with the IMR values from the preceding 10 years

of the targeted time period. Toros (2000) introduced this method, offering a systematic approach to segregate the Infant Mortality Rate for each sex. Through the Toros method, we calculated the missing infant mortality rates for both sexes, ensuring a comprehensive and sex-disaggregated dataset.

To compute sex-specific Infant Mortality Rates (IMR), the following formulas were applied:

$$1qo_{\text{females}} = \frac{\text{Female deaths}}{\text{Size of birth cohort}}$$

$$1qo_{\text{males}} = \frac{\text{Male deaths}}{\text{Size of birth cohort}}$$

The sex ratio of deaths was calculated using the formula:

$$\text{Sex Ratio of Deaths} = \frac{(\text{IMR}_{\text{males}} \times \text{Cohort size}_{\text{males}})}{(\text{IMR}_{\text{females}} \times \text{Cohort size}_{\text{females}})}$$

Given cohort sizes:

- Cohort size males = 106.4
- Cohort size females = 100

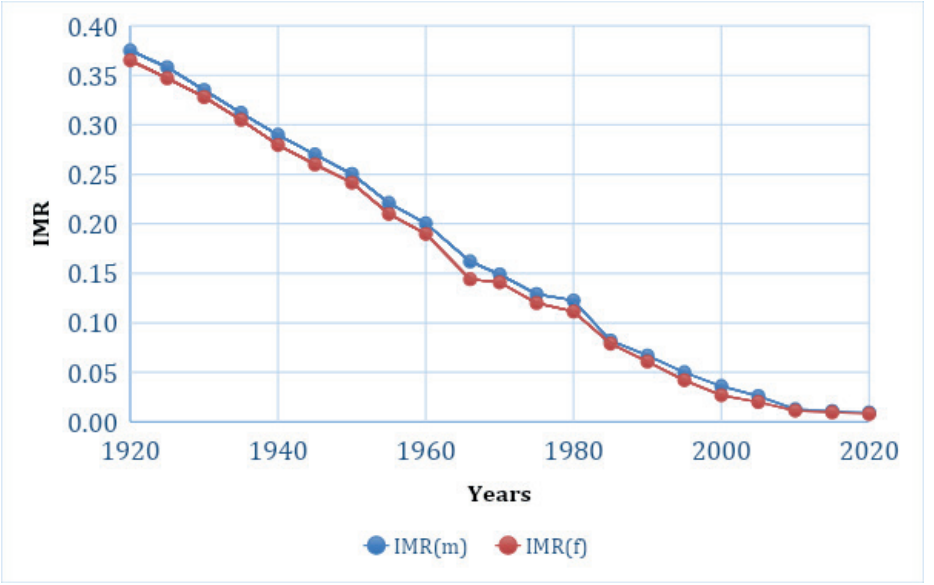
Further calculations were carried out:

$$\text{Female deaths} = \text{Total infant deaths} \times \text{Share of female deaths}$$

$$\text{Male deaths} = \text{Total infant deaths} - \text{Female deaths}$$

The sex segregation method proposed by Toros (2000) proved instrumental in obtaining sex-specific infant mortality rates for a defined period. Subsequently, interpolation techniques were applied to address any missing data in the dataset. Figure 1 presents the Infant Mortality Rates for both sexes spanning the period from 1920 to 2020 in Türkiye.

Figure 1. Infant Mortality Rates for both sexes between 1920-2020, Türkiye



STEP 3: Construction of Life Tables through MORTPAK Applications

In this phase, life tables were meticulously constructed through the integration of various applications within MORTPAK. The MATCH application is pivotal, enabling the generation of country-specific model life tables based on Coale-Demeny models, relying solely on IMR values. Adapting to the unique demographic structure and developmental processes in Türkiye, the East model was applied for the period between 1920 to 1950, followed by a transition to the West model from 1955 to 2020.

Following this, the UNABR application was engaged to estimate unabridged life tables by incorporating age-specific probabilities of dying ($_nq_x$). The probabilities of dying, acquired from the MATCH application, play a crucial role in this process. The outcome was the creation of 42 unabridged life tables (21 for males and 21 for females), offering a detailed and comprehensive representation of mortality patterns for each 5-year interval from 1920 to 2020.

This thorough process provided valuable insights into the dynamics of mortality in Türkiye over the specified century-long timeframe. Additionally, the resulting values of the life expectancy at birth offered a quantitative measure to further understand the overarching trends and shifts in the population's life expectancy over the course of a century at this step.

STEP 5: Calculation of Modal Age at Death and Standard Deviation

In this phase, we proceeded to calculate the modal age at death and its standard deviation. These metrics provided valuable insights into the central tendency and variability of age at death within the studied population. The modal age at death represents the most common age at which individuals pass away, offering a key indicator of mortality patterns. Simultaneously, the standard deviation provides a measure of the dispersion or in another words, spread of ages at death, allowing for a nuanced understanding of the variability around the modal age. This comprehensive analysis contributed to a deeper comprehension of mortality dynamics within the specified context.

Modal Age at Death

As mentioned before modal age at death refers to the age in which maximum number of deaths occur. To identify this age, the UNABR application in MORTPAK provides the number of deaths for singular ages, facilitating the detection of the mode age through visual inspection or using Excel sheet formulas or any other suitable method. The ${}_nD_x$ column of each life table (provided in the appendices) was specifically utilized to discern the mode age at death, providing a rough estimate of the predominant age. The calculation of the modal age involves the use of the formula below (Kannisto, 2001).

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

In the numerator, we subtracted the number of deaths at the mode age at death from the number of deaths at the previous age. In the first part of the addition in the denominator, we used the result of the operation in the numerator. We added this result to the number of deaths at the mode age at death minus the number of deaths at the age after the mode age at death.

After obtaining the modal age at death for each time period, we calculated the standard deviation of the modal age at death. This step provided a measure of the variability or spread around the identified modal age, offering insights into the distribution of ages at which the maximum number of deaths occur over different time periods.

Standard Deviation

The standard deviation of the modal age at death can be calculated using the following formula:

$$\text{Standard Deviation} = \sqrt{\frac{\sum_i (x_i - M)^2 \cdot d(x_i)}{N}}$$

Where:

- x_i is the modal age at death for each age group.
- M is the mean (average) modal age at death.
- $d(x_i)$ is the number of deaths for each age group.
- N is the total number of deaths.

This is actually a classic standard deviation calculation. We used the modal age at death as a constant value. This is the formula that we applied from the age with the modal age at death to the 100th age. First, we subtracted the modal age at death from each age and squared the difference obtained for each age. Then, we multiplied each squared difference by the number of deaths at the respective age. The denominator is the sum of deaths at each age starting from the modal age at death to age 100. Then for the normalization, we divided the sum of the weighted squared differences by the total sum of deaths. Finally sum all the normalized values and took the square root.

This standard deviation calculation was applied to all ages from the modal age at death to the 100th age. The process took into account the distribution of deaths across different ages, providing a measure of the variability or spread around the modal age at death. Over time, a standard deviation was expected to be narrowed, reflecting mortality compression toward older ages. This observation aligns with the trend of decreasing standard deviation as mortality compresses. The comparison with e_0 values further highlighted the relationship between the modal age at death and life expectancy trends over time.

RESULTS

We will commence with an insightful depiction of a population's mortality experience, elucidating the century-long trends in death compression for both males (Figure 2) and females (Figure 3). The spread of the distribution serves as an indicator of lifespan variability, and over time, there is a discernible decrease in this variability for both genders. The distribution becomes progressively taller and more compressed as time advances.

Figure 2 illustrates that for males, the peak of the distribution, where it reaches its highest point, was around the 60s in 1920 and has extended to

the early 80s in 2020. Similarly, Figure 3 indicates that for females, the peak of the distribution was around the late 60s in 1920 and has advanced to the mid-80s in 2020.

The figures vividly demonstrate that as we progress from 1920 to 2020, the distribution of deaths between ages becomes increasingly compressed. This phenomenon can be elucidated as follows. According to de Beer & Janssen (2016), changes in the shape of the age-at-death distribution can be attributed to various causes. Compression occurs when mortality at young ages decreases more sharply than at ages around the modal age at death, and if mortality at the oldest ages decreases less sharply than around the modal ages. This explanation aligns with the observed trends in the Turkish case here, as well.

Figure 2. Compression of Mortality among Males Throughout the Century (1920-2020) in Türkiye

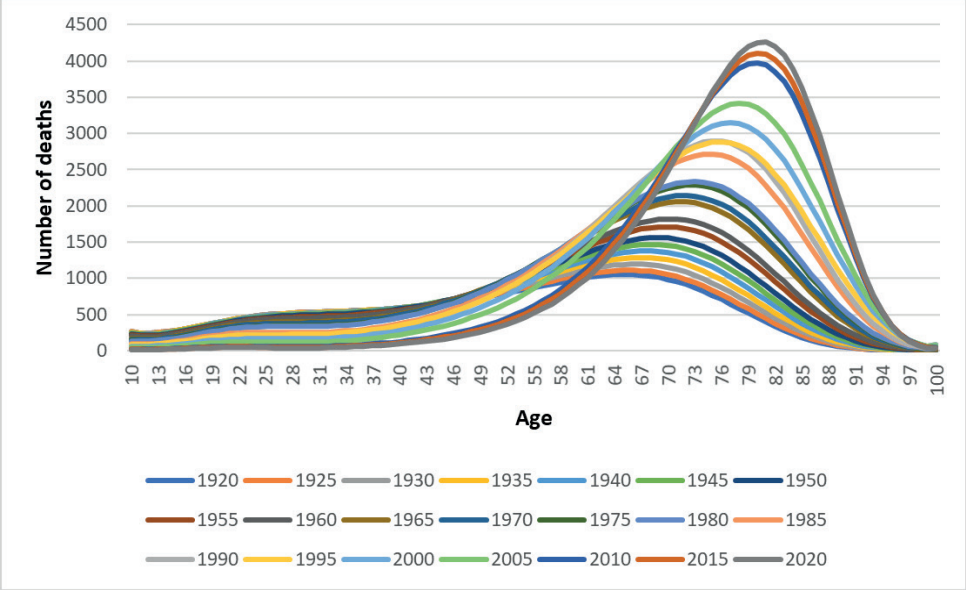


Figure 3. Compression of Mortality among Females Throughout the Century (1920-2020) in Türkiye

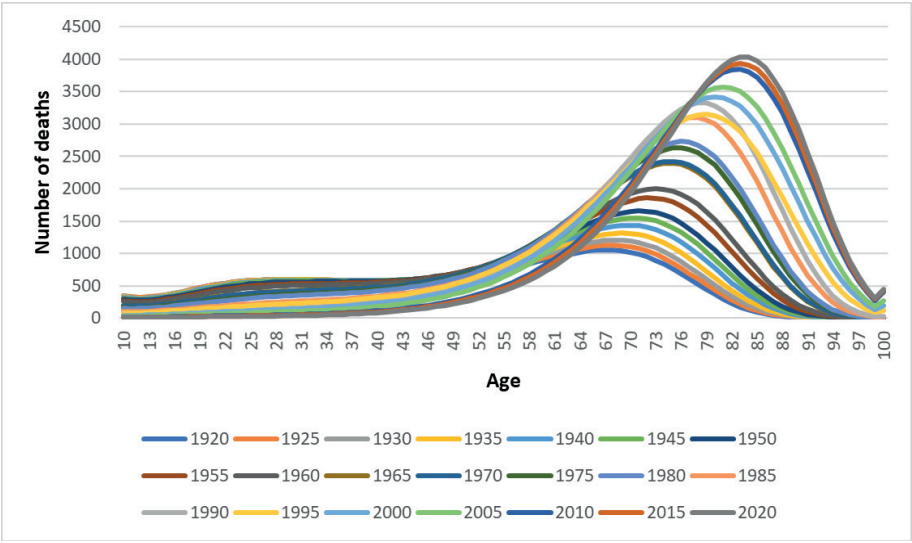


Figure 4 illustrates the trajectory of life expectancy at birth, the modal age at death, and the standard deviation for males in Türkiye from 1920 to 2020. Over the course of the century, life expectancy has witnessed a remarkable increase of nearly 50 years (1920: 26.32, 2020: 75.11). Concurrently, the modal age at death has steadily risen by approximately 16 years in comparison (1920: 65.74, 2020: 81.06). This surge in life expectancy is primarily attributed to advancements in the healthcare system, resulting in a substantial reduction in infant and child mortality rates over the years.

However, it is crucial to note that while life expectancy captures improvements in overall mortality, it may overlook advancements in old-age mortality, being very sensitive to infant and child mortality. Focusing on adult mortality, the modal age at death, on the other hand, serves as a vital indicator of mortality delay. The key determinants of mortality delay, signified by an increase in the modal age at death, include heightened prosperity and advancements in medicine. Improved living and working conditions play a pivotal role in enhancing overall health, while advancements in public health and medical treatment effectively prevent and mitigate illnesses.

Turning our attention to the standard deviation for males, as anticipated, the reduction in mortality rates at early ages and the delay in mortality, coupled with compression in old ages, contribute to a lower standard deviation. This pattern holds true for Türkiye's demographic landscape over the century, reflecting the positive impact of mortality improvements, particularly at older ages.

Figure 4. Evolution of Life Expectancy at Birth, Modal Age at Death and Standard Deviation in Males Over the Century (1920-2020) in Türkiye

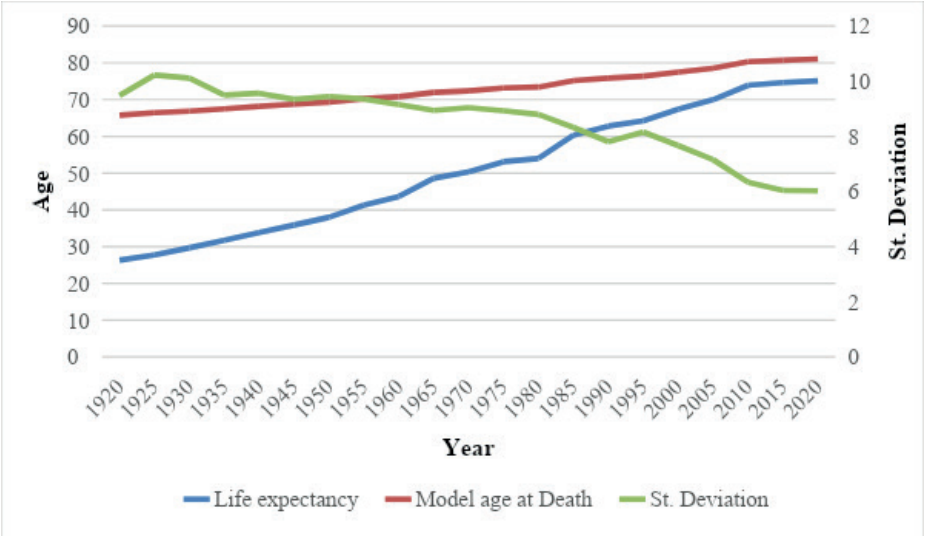
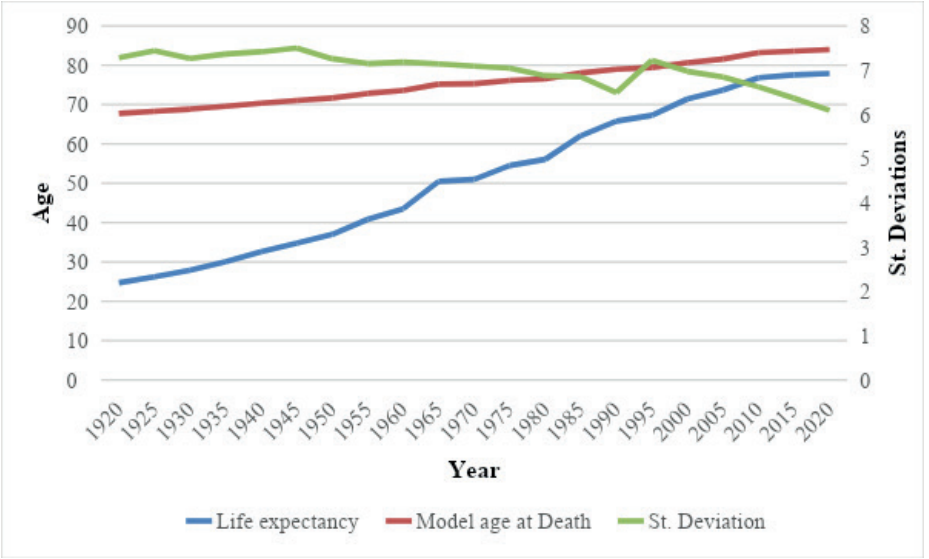


Figure 5 illustrates the trajectory of life expectancy at birth, the modal age at death, and the standard deviation for females in Türkiye from 1920 to 2020. As for the males, there is a striking increase in life expectancy with more than 50 years (1920: 24.72, 2020: 77.90). Modal age at death is also observed to have risen 16 years for the same period (1920: 65.75, 2020: 81.083.956). Similar factors mentioned above (i.e. improvements in the healthcare system, reduction in mortality of early ages) were considered to be effective in such an increase. When the standard deviation of the modal age at death for females is examined, we see a slightly less reduction over the century, when compared with men. Still, the decline of standard deviation is visible as it gets to the 20th century.

Figure 5. Evolution of Life Expectancy at Birth, Modal Age at Death and Standard Deviation in Females Over the Century (1920-2020) in Türkiye



In summary, our analysis reveals a marginal decline in the standard deviation for men and a slightly more substantial decrease for women in Türkiye. A nuanced assessment of Türkiye's mortality trend underlines the importance of considering modal age at death alongside life expectancy at birth. While life expectancy demonstrates a notable improvement, primarily attributed to the decrease in child and infant mortality, modal age at death provides a more focused perspective on adult mortality trends by excluding the impact of infant mortality rates.

The substantial improvement observed in modal age at death values suggests enhanced living conditions and improved medical services, particularly for the older population. This underscores the significance of modal age at death as an indicator that mitigates the influence of child and infant mortality when evaluating adult mortality trends. Our findings align with the demographic transition outlined by Koç et al. (2010), reflecting a progression through distinct demographic periods, each marked by specific changes in mortality dynamics. The discernible decline in infant and child mortality, coupled with an apparent mortality delay, emphasizes Türkiye's evolving health landscape from the mid-20th century to the present day. The nation transitions from one demographic period to the next, notably commencing with the second period in 1955, marked by a discernible decline in infant and child mortality. This reduction becomes increasingly evident in life expectancy trends. Moving into the third period, initiated in 1980, the decline in infant and child mortality persists, accompanied by a more

pronounced mortality delay, as evident in the trend of modal age at death, and a decrease in the standard deviation.

CONCLUSION

In conclusion, our analysis of Türkiye's mortality trends spanning from 1920 to 2020 unravels a captivating narrative of demographic transitions and health advancements. The century-long evolution is characterized by profound shifts in mortality patterns, prominently reflected in the compression of death distributions for both males and females. The decreasing variability in lifespan over time signifies a noteworthy trend towards a more uniformly distributed age-at-death pattern.

Our analysis kicked off by compiling IMR values and estimates spanning the period from 1920 to 2020. To fill in the gaps in IMR values, we used interpolation techniques, and for sex-specific infant mortality rates, we applied Toros' sex segregation method. With the sex-disaggregated IMR values in hand, we employed MORTPAK's MATCH and UNABR applications to construct life tables for each gender from 1920 to 1940. These life tables were then fine-tuned for singular ages (unabridged). To calculate the modal age at death, we applied Kannisto's (2001) formula, factoring in the number of deaths (starting from age 10 and above) derived from unabridged life tables generated through MORTPAK. Following the modal age calculations, we computed the standard deviation of these ages and showcased visual representations of the results in the results section.

Examining the male population, our analysis illustrates a remarkable surge in life expectancy at birth, emphasizing the positive impact of healthcare improvements, specifically the decline in infant and child mortality rates. Concurrently, the steady rise in the modal age at death indicates a pronounced mortality delay, attributable to increased prosperity and advancements in medicine. The observed reduction in the standard deviation for males echoes the compression in mortality rates, particularly in older age groups, reinforcing the positive influence of mortality improvements over the century. Similarly, the trajectory for females reveals a substantial increase in life expectancy and modal age at death, suggesting significant improvements in overall health and medical services. Although the decline in the standard deviation for females is slightly less pronounced as a result of earlier shifts of mortality to older ages than for males, it remains indicative of a positive shift in mortality patterns. The nuanced assessment, considering both life expectancy and modal age at death, underscores Türkiye's successful navigation through distinct demographic periods, as outlined by Koç et al. (2010). From the mid-20th century, marked by a decline in infant and child mortality, to the

subsequent period initiating in 1980, characterized by a more pronounced mortality delay and reduced standard deviation, Türkiye exhibits a dynamic demographic landscape.

Our findings emphasize the importance of scrutinizing adult mortality beyond conventional metrics like life expectancy. While the latter primarily reflects improvements related to child and infant mortality, modal age at death provides a more targeted perspective on advancements in adult mortality, offering insights into improved living conditions and healthcare services for the older population.

In essence, Türkiye's demographic journey reflects a convergence of factors—historical, socio-economic, and medical—that have collectively shaped a century of mortality trends. Considering our unique situation of the Turkish puzzle (Gürsoy-Tezcan, 1992) gets closer to being solved, it can be inferred that when the mortality trend is examined through excluding the impact of IMR, which can be accepted as a measure that relatively more resistant to decrease, it is possible to see this compression of adult mortality to older ages as a result of enhancements in health services provided to the regarding age groups. Hence, the continual decline in variability, coupled with an increase in modal age at death, paints a portrait of a nation steadily advancing towards a healthier and more age-diverse population.

Appendix A1. Number of male deaths between 1920 - 2020

	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965
10	263	261	257	252	245	238	228	213	202	173
11	247	245	241	237	231	224	215	202	191	164
12	243	242	238	234	228	221	213	200	190	165
13	250	248	245	241	235	228	220	207	198	172
14	263	262	259	255	249	242	234	222	212	186
15	282	281	278	275	269	262	254	241	232	206
16	304	304	301	298	292	285	277	265	256	229
17	329	329	327	323	317	310	303	290	281	254
18	354	354	352	349	344	337	329	316	307	280
19	379	380	378	375	369	362	355	342	332	304
20	403	404	402	399	394	387	379	365	355	326
21	425	426	425	422	416	409	402	386	376	345
22	446	446	445	442	436	429	421	405	394	361
23	463	465	464	460	454	446	438	421	409	374
24	479	480	479	475	469	461	452	434	421	383
25	492	493	492	488	481	473	464	444	430	390
26	503	504	503	498	491	483	472	453	437	394
27	513	513	512	507	500	491	480	459	442	397
28	521	521	519	514	507	497	486	464	446	399
29	527	527	526	521	513	502	490	468	450	401
30	532	533	531	526	518	507	494	472	452	402
31	537	537	535	530	522	511	498	475	456	405
32	540	541	540	535	526	516	502	479	459	408
33	544	545	544	539	531	520	507	484	464	413
34	548	549	548	544	536	525	512	489	470	419
35	552	554	553	549	541	531	518	496	477	428
36	557	559	559	555	549	539	526	505	486	439
37	562	565	565	563	556	547	536	515	498	453
38	569	572	573	572	566	558	547	527	511	468
39	576	580	582	582	577	570	560	541	527	487
40	584	589	593	593	590	584	575	559	546	508
41	594	600	605	607	605	600	592	577	567	533
42	605	612	618	622	621	618	612	599	590	559
43	618	625	633	639	640	639	634	623	616	589
44	632	641	650	658	661	661	658	650	645	622
45	647	658	669	679	684	686	685	679	677	658
46	664	676	690	702	709	713	714	711	711	697
47	683	697	713	727	736	742	746	745	749	739
48	703	718	737	754	766	774	780	782	789	785
49	724	741	762	783	797	808	816	822	832	832
50	747	766	790	813	829	843	855	864	877	884
51	770	792	819	844	864	881	895	909	925	937
52	795	818	848	878	901	921	938	956	976	994
53	820	846	880	912	939	961	982	1005	1028	1054

54	846	874	911	947	977	1004	1027	1056	1083	1116
55	872	903	943	983	1017	1047	1075	1108	1139	1180
56	898	932	976	1019	1057	1091	1122	1162	1197	1246
57	923	960	1007	1055	1097	1135	1170	1216	1256	1313
58	948	987	1039	1091	1137	1179	1219	1271	1316	1382
59	971	1013	1069	1125	1176	1222	1266	1326	1375	1452
60	992	1037	1097	1158	1213	1264	1313	1380	1434	1522
61	1011	1059	1123	1188	1249	1304	1358	1433	1492	1591
62	1027	1077	1146	1216	1281	1341	1400	1483	1548	1659
63	1039	1093	1166	1240	1311	1375	1439	1531	1601	1725
64	1048	1104	1181	1260	1336	1405	1475	1575	1651	1788
65	1052	1110	1192	1275	1356	1430	1505	1615	1697	1847
66	1050	1111	1197	1285	1370	1450	1530	1649	1737	1901
67	1043	1107	1196	1288	1379	1463	1548	1677	1770	1949
68	1031	1096	1189	1285	1380	1469	1559	1697	1796	1990
69	1012	1079	1174	1274	1373	1467	1562	1709	1813	2022
70	986	1055	1153	1255	1359	1456	1556	1712	1821	2044
71	954	1024	1124	1229	1336	1437	1541	1705	1819	2055
72	916	986	1088	1194	1304	1408	1516	1687	1805	2054
73	872	942	1044	1152	1264	1370	1481	1659	1780	2041
74	822	892	993	1101	1214	1323	1436	1619	1743	2014
75	767	836	936	1044	1157	1267	1382	1568	1694	1973
76	708	776	874	980	1093	1202	1317	1505	1633	1918
77	647	711	807	910	1021	1129	1245	1433	1561	1849
78	583	645	737	836	945	1051	1164	1351	1478	1767
79	519	577	664	759	864	967	1077	1260	1385	1672
80	455	510	591	681	781	879	986	1163	1284	1566
81	394	444	519	602	696	789	891	1061	1177	1450
82	335	380	449	525	612	699	795	955	1066	1327
83	280	320	382	451	531	611	700	849	953	1200
84	230	265	320	381	453	526	607	744	840	1070
85	185	216	263	317	380	445	518	642	729	941
86	147	172	212	258	313	370	435	545	623	814
87	113	134	167	206	253	303	359	454	524	693
88	86	102	130	162	201	242	290	372	433	580
89	63	76	98	124	156	191	231	299	350	477
90	45	56	72	93	118	146	179	236	278	384
91	32	39	52	68	88	110	136	182	216	303
92	21	27	36	48	64	81	101	137	164	234
93	14	18	25	34	45	57	73	100	122	176
94	9	12	17	23	31	40	52	72	88	130
95	6	8	11	15	21	27	35	50	62	93
96	4	4	7	9	13	18	24	34	42	65
97	2	3	4	6	8	11	15	22	28	44
98	1	1	2	4	5	7	10	14	18	29
99	1	1	1	2	3	4	6	9	11	18
100	1	1	1	2	3	5	7	12	16	26

Appendix A2. Number of male deaths between 1920 - 2020 (continue)

	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2020
10	162	144	138	94	75	85	62	44	21	18	14
11	155	138	133	92	74	84	61	43	21	18	14
12	155	138	133	94	78	86	63	44	22	18	15
13	162	146	141	101	86	93	67	48	23	20	16
14	177	159	154	114	98	103	75	54	27	22	18
15	196	178	172	130	113	117	86	63	31	27	22
16	219	200	193	149	131	132	100	73	37	32	27
17	243	224	217	169	149	149	113	84	44	37	32
18	269	247	241	189	168	165	127	95	51	44	37
19	293	270	263	208	184	181	140	106	57	49	40
20	314	291	283	223	197	193	150	113	62	53	44
21	332	307	299	236	208	204	157	119	64	55	45
22	348	321	312	245	215	211	163	123	65	56	46
23	359	331	322	251	220	217	166	123	65	55	45
24	367	339	329	255	222	221	167	123	64	54	44
25	373	343	333	256	222	223	167	122	62	52	42
26	377	346	335	256	221	223	165	120	60	50	41
27	379	347	336	254	220	223	165	119	59	49	40
28	380	347	336	253	219	225	164	118	58	48	39
29	381	348	337	254	218	225	164	118	58	48	39
30	383	349	338	254	220	227	166	119	58	49	40
31	385	351	341	256	222	230	168	121	60	51	41
32	388	354	344	260	226	235	174	126	63	54	44
33	393	359	349	266	231	241	180	131	67	57	47
34	400	367	357	273	239	250	188	139	72	62	51
35	409	376	366	283	249	260	198	147	78	66	55
36	421	389	378	296	261	273	210	158	84	73	61
37	435	403	393	312	276	288	224	170	93	80	68
38	451	420	411	329	293	305	241	185	103	89	74
39	471	440	431	350	314	325	259	200	113	98	83
40	492	463	454	373	336	347	280	218	126	109	93
41	518	489	480	399	362	372	304	239	139	121	103
42	545	518	508	428	390	400	330	261	154	135	115
43	576	550	540	460	421	430	358	286	171	151	130
44	611	585	576	495	455	464	390	314	191	168	145
45	648	623	614	534	493	501	424	344	213	188	162
46	688	664	656	575	533	541	462	378	236	210	182
47	731	709	701	621	578	584	503	414	263	235	204
48	777	756	749	669	626	632	547	454	293	262	229
49	827	808	800	722	679	683	596	498	326	293	257
50	879	862	855	779	735	738	649	546	364	328	289
51	935	919	913	840	796	797	705	599	405	366	325
52	994	981	975	904	860	861	767	656	451	409	364
53	1055	1045	1040	973	930	928	833	718	502	457	409

54	1119	1112	1108	1046	1004	1000	904	786	559	511	458
55	1186	1182	1179	1124	1083	1077	980	859	621	570	515
56	1254	1255	1253	1205	1167	1158	1063	938	690	636	576
57	1325	1331	1330	1291	1255	1244	1150	1024	766	709	646
58	1397	1408	1409	1380	1348	1335	1242	1116	850	790	723
59	1471	1487	1490	1474	1446	1429	1341	1215	942	879	809
60	1544	1567	1572	1569	1548	1527	1445	1321	1043	977	903
61	1618	1648	1655	1669	1654	1630	1554	1432	1153	1085	1008
62	1690	1728	1738	1770	1763	1735	1667	1551	1272	1203	1123
63	1761	1807	1820	1873	1874	1843	1786	1677	1401	1331	1250
64	1829	1885	1900	1976	1987	1953	1908	1809	1541	1471	1389
65	1894	1959	1978	2078	2101	2064	2033	1946	1691	1621	1539
66	1954	2029	2051	2179	2213	2174	2159	2087	1851	1783	1702
67	2007	2094	2119	2276	2325	2283	2287	2233	2021	1956	1878
68	2053	2151	2181	2368	2432	2389	2415	2380	2199	2139	2066
69	2091	2201	2234	2454	2533	2489	2539	2528	2384	2332	2265
70	2120	2241	2278	2531	2627	2584	2658	2674	2577	2533	2474
71	2137	2270	2310	2598	2710	2669	2771	2817	2772	2739	2690
72	2142	2286	2330	2652	2781	2743	2874	2951	2968	2947	2913
73	2134	2288	2337	2690	2838	2804	2965	3076	3160	3155	3137
74	2112	2276	2327	2713	2876	2850	3040	3187	3345	3357	3358
75	2075	2248	2302	2716	2895	2877	3098	3281	3518	3549	3571
76	2023	2203	2260	2699	2892	2885	3134	3353	3672	3723	3769
77	1956	2141	2200	2660	2865	2870	3146	3399	3801	3874	3945
78	1875	2064	2124	2599	2813	2833	3131	3417	3899	3994	4090
79	1780	1970	2031	2515	2735	2771	3089	3403	3959	4075	4197
80	1673	1861	1922	2409	2631	2684	3016	3353	3976	4110	4256
81	1555	1739	1799	2282	2503	2573	2914	3267	3942	4093	4259
82	1429	1607	1665	2135	2352	2439	2782	3144	3856	4019	4201
83	1296	1466	1521	1972	2180	2284	2622	2985	3714	3884	4078
84	1160	1319	1371	1797	1992	2110	2438	2793	3518	3689	3886
85	1023	1171	1219	1612	1792	1922	2232	2571	3271	3438	3631
86	889	1023	1066	1424	1585	1725	2011	2327	2980	3136	3319
87	760	879	918	1236	1378	1523	1781	2066	2655	2795	2960
88	639	742	776	1053	1174	1320	1547	1797	2308	2428	2571
89	527	615	644	879	980	1123	1317	1529	1954	2051	2167
90	426	500	524	719	800	937	1097	1270	1606	1681	1770
91	338	398	418	574	638	764	892	1028	1279	1332	1395
92	261	310	325	448	496	609	708	809	985	1018	1058
93	198	235	247	341	375	474	547	618	730	748	770
94	146	174	184	252	275	359	410	458	520	527	536
95	105	126	132	181	196	264	298	327	355	355	355
96	74	88	93	126	135	189	210	226	231	227	223
97	50	60	63	85	90	131	143	150	143	139	133
98	33	40	42	55	58	88	94	95	85	80	75
99	21	25	27	35	36	57	59	58	47	43	40
100	30	36	38	47	46	82	80	71	46	40	34

Appendix B1. Number of female deaths between 1920 - 2020

	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965
10	345	347	338	331	319	308	296	272	253	197
11	323	325	317	310	300	290	279	256	240	190
12	317	318	310	304	295	285	274	253	237	189
13	322	324	316	310	300	291	280	258	243	195
14	336	338	330	324	314	304	293	271	254	205
15	357	359	351	344	334	324	312	288	271	219
16	382	383	376	368	358	347	334	310	291	236
17	409	410	403	395	384	372	359	333	312	254
18	437	438	431	423	411	399	385	357	335	272
19	465	465	458	450	438	425	410	380	357	291
20	491	491	485	477	463	450	435	404	380	309
21	515	514	508	501	487	474	457	425	400	327
22	536	535	530	522	509	495	478	445	419	343
23	554	553	548	541	528	514	497	463	436	358
24	568	568	564	557	544	530	513	478	451	371
25	580	579	576	569	557	543	527	492	464	383
26	589	589	586	580	568	554	538	503	475	394
27	595	595	593	587	576	562	546	512	485	403
28	598	599	598	592	581	569	553	519	492	412
29	599	601	600	595	585	573	558	525	498	418
30	598	600	600	596	587	575	561	529	503	425
31	596	599	599	596	587	577	563	532	507	430
32	593	596	597	595	587	577	564	534	510	435
33	589	592	594	592	586	577	564	536	512	440
34	584	588	591	590	584	576	564	537	514	444
35	579	584	587	587	582	575	564	538	516	448
36	574	579	583	584	581	574	564	539	518	454
37	569	575	580	582	579	573	564	542	521	459
38	565	572	577	580	578	573	565	544	524	465
39	562	569	575	579	578	575	567	547	529	472
40	559	568	574	579	580	576	570	552	534	481
41	558	567	575	580	582	580	575	558	541	491
42	559	568	576	583	587	585	581	565	550	503
43	560	571	580	588	592	592	589	575	560	516
44	564	576	585	595	600	601	599	587	573	531
45	570	582	593	603	610	612	611	600	588	550
46	577	590	602	614	623	626	625	617	605	570
47	587	601	614	627	637	642	643	636	625	594
48	598	614	628	643	655	661	663	658	648	620
49	613	629	645	662	675	683	686	683	675	650
50	629	646	664	683	698	707	712	711	705	683
51	647	667	686	707	724	735	741	743	738	721
52	668	689	711	733	753	766	774	779	775	762
53	692	714	738	763	786	800	810	818	816	808

54	717	741	767	795	821	837	850	861	861	859
55	745	771	799	830	859	878	893	908	910	914
56	774	802	833	867	900	922	939	959	964	975
57	805	835	869	907	943	968	989	1013	1021	1040
58	836	870	907	948	989	1018	1042	1071	1083	1110
59	869	905	946	991	1036	1069	1097	1133	1149	1186
60	901	940	985	1035	1085	1123	1155	1197	1218	1266
61	932	975	1024	1079	1135	1177	1214	1265	1290	1351
62	962	1009	1061	1122	1185	1232	1274	1334	1365	1440
63	990	1040	1097	1163	1233	1287	1334	1404	1441	1533
64	1013	1068	1130	1203	1280	1339	1393	1474	1519	1629
65	1032	1092	1159	1238	1323	1389	1450	1543	1596	1727
66	1046	1110	1181	1267	1361	1435	1504	1609	1672	1825
67	1052	1121	1198	1291	1393	1475	1551	1672	1744	1922
68	1050	1123	1205	1306	1418	1508	1593	1728	1812	2017
69	1039	1117	1204	1312	1433	1531	1625	1777	1872	2106
70	1018	1100	1192	1307	1437	1544	1647	1816	1924	2188
71	986	1072	1168	1290	1429	1544	1656	1843	1964	2261
72	944	1033	1133	1260	1407	1531	1652	1856	1990	2321
73	892	983	1085	1218	1372	1502	1632	1853	2000	2365
74	830	922	1026	1162	1322	1458	1595	1832	1992	2390
75	760	852	956	1093	1257	1399	1542	1793	1965	2394
76	684	774	876	1014	1179	1324	1471	1734	1916	2375
77	603	690	789	924	1089	1235	1385	1656	1847	2330
78	521	603	698	828	989	1134	1284	1559	1757	2259
79	440	515	604	727	882	1023	1171	1446	1646	2161
80	362	430	511	625	771	905	1049	1319	1519	2038
81	290	350	422	525	659	785	921	1181	1377	1891
82	226	277	340	431	551	666	792	1037	1225	1725
83	170	212	265	344	449	551	665	892	1068	1544
84	124	158	201	266	356	445	545	749	911	1353
85	87	113	147	200	274	349	435	613	758	1160
86	59	78	104	145	204	266	337	489	615	971
87	39	52	71	102	148	196	253	378	484	792
88	24	33	47	69	102	139	184	284	371	627
89	14	20	29	44	69	95	129	206	274	482
90	8	12	17	28	44	63	87	144	196	359
91	4	7	10	16	27	40	56	97	135	258
92	2	3	6	9	16	24	35	63	90	178
93	1	2	3	5	9	14	21	39	57	118
94	1	1	1	3	5	8	12	23	35	75
95	0	1	1	1	2	4	6	13	20	46
96	0	0	0	1	1	2	3	7	11	27
97	0	0	0	0	1	1	2	4	6	15
98	0	0	0	0	0	1	1	2	3	8
99	0	0	0	0	0	0	0	1	1	4
100	0	0	0	0	0	0	0	1	1	3

Appendix B2. Number of female deaths between 1920 – 2020 (continue)

	1970	1975	1980	1985	1990	1995	2000	2005	2010	2015	2020
10	193	164	151	102	76	75	42	29	14	11	9
11	185	159	146	100	74	77	43	29	14	11	9
12	186	159	147	102	75	80	45	30	14	12	9
13	191	165	153	106	79	85	48	32	15	12	10
14	201	173	161	113	83	93	52	35	17	14	11
15	215	186	172	122	90	100	56	39	19	15	12
16	231	199	186	131	96	109	62	42	21	17	13
17	249	215	199	141	104	119	67	47	23	19	15
18	267	231	215	152	112	129	73	51	26	21	17
19	285	247	230	163	120	138	79	55	29	23	19
20	303	262	244	174	128	148	84	59	31	26	21
21	321	278	258	184	136	157	90	64	33	28	22
22	337	292	272	194	144	166	97	68	35	30	24
23	351	305	284	203	152	175	102	73	37	31	25
24	365	317	296	212	159	183	107	76	39	33	27
25	376	329	307	221	167	190	113	80	41	34	28
26	387	338	316	229	173	198	118	84	43	35	29
27	396	348	325	237	180	205	124	88	45	37	31
28	405	356	333	244	186	211	128	92	48	39	32
29	412	363	340	251	192	217	134	96	50	41	34
30	418	370	347	257	197	224	139	100	53	43	36
31	424	376	354	264	203	231	145	105	55	46	37
32	429	381	359	270	209	238	151	110	59	49	40
33	433	387	365	276	216	245	158	115	63	52	43
34	438	393	371	283	222	253	164	121	67	56	46
35	443	399	377	290	229	260	172	127	71	61	50
36	448	405	384	297	237	269	180	135	77	66	55
37	454	412	391	305	245	278	189	143	84	72	61
38	461	419	399	315	254	289	200	153	91	78	67
39	468	428	408	325	264	300	212	163	99	86	74
40	476	438	419	336	275	313	224	175	109	95	81
41	487	449	430	349	288	327	239	188	120	105	91
42	498	462	443	363	303	344	254	203	131	116	101
43	512	477	458	379	319	362	271	218	144	129	113
44	527	493	476	397	337	381	292	237	160	143	125
45	546	513	496	417	357	404	313	258	177	158	140
46	566	534	518	440	381	429	338	280	196	177	156
47	590	559	543	466	406	456	365	306	217	196	174
48	617	587	571	495	435	487	395	333	240	218	194
49	647	618	603	527	468	520	427	365	266	243	217
50	681	653	638	562	503	557	464	398	295	270	243
51	718	692	677	603	543	599	505	437	328	300	271
52	760	735	720	647	588	644	549	479	364	335	303
53	806	783	769	696	637	693	598	525	404	372	338

54	857	836	822	750	691	747	652	576	447	414	378
55	913	893	881	809	751	806	710	632	497	460	421
56	973	956	944	874	817	871	775	693	550	512	469
57	1039	1024	1014	947	890	940	844	760	609	568	523
58	1110	1099	1089	1024	969	1016	921	833	675	630	583
59	1186	1179	1170	1109	1055	1098	1002	913	746	699	648
60	1267	1264	1257	1200	1148	1186	1091	999	824	775	721
61	1353	1355	1350	1299	1249	1280	1187	1093	910	858	801
62	1443	1451	1449	1405	1358	1380	1290	1194	1004	949	889
63	1537	1552	1553	1518	1475	1487	1401	1303	1106	1049	986
64	1634	1658	1662	1637	1599	1600	1518	1418	1216	1157	1092
65	1733	1766	1774	1762	1730	1717	1642	1543	1335	1274	1207
66	1832	1877	1889	1893	1868	1841	1772	1675	1464	1402	1332
67	1932	1988	2006	2028	2012	1968	1909	1813	1602	1538	1467
68	2028	2098	2122	2166	2160	2098	2051	1959	1749	1685	1614
69	2120	2206	2236	2305	2312	2231	2197	2110	1904	1841	1770
70	2204	2307	2345	2443	2464	2364	2346	2266	2067	2006	1937
71	2279	2401	2447	2576	2615	2495	2496	2426	2238	2179	2113
72	2341	2482	2538	2703	2762	2622	2645	2586	2415	2360	2298
73	2388	2550	2615	2819	2900	2742	2790	2745	2596	2546	2490
74	2417	2599	2675	2921	3027	2853	2929	2902	2778	2735	2687
75	2424	2627	2714	3004	3137	2951	3057	3050	2959	2925	2887
76	2407	2631	2728	3064	3227	3033	3173	3189	3136	3113	3085
77	2364	2608	2715	3097	3291	3095	3271	3313	3305	3293	3280
78	2295	2556	2672	3098	3324	3134	3348	3418	3459	3462	3464
79	2198	2473	2598	3065	3323	3146	3398	3499	3596	3614	3634
80	2076	2361	2492	2995	3283	3128	3419	3552	3708	3743	3782
81	1930	2220	2355	2887	3204	3079	3407	3573	3791	3844	3903
82	1763	2053	2190	2741	3082	2996	3359	3557	3839	3910	3989
83	1581	1865	2001	2560	2919	2879	3273	3501	3845	3935	4034
84	1389	1661	1793	2349	2719	2730	3148	3405	3807	3914	4031
85	1193	1448	1573	2112	2486	2551	2986	3267	3721	3843	3977
86	1000	1233	1349	1860	2227	2345	2790	3088	3585	3719	3866
87	818	1024	1128	1599	1952	2119	2563	2873	3401	3544	3699
88	649	827	919	1340	1670	1879	2312	2626	3171	3318	3478
89	500	649	726	1093	1391	1632	2045	2354	2901	3049	3208
90	373	493	557	864	1126	1386	1770	2067	2601	2743	2896
91	269	362	412	662	885	1149	1498	1775	2279	2413	2554
92	187	256	295	490	672	929	1236	1487	1948	2070	2196
93	124	175	202	349	492	730	992	1213	1622	1728	1837
94	79	114	133	239	347	557	774	961	1312	1401	1490
95	49	71	84	157	235	411	585	739	1028	1100	1169
96	28	42	51	98	152	293	427	549	779	834	886
97	16	24	29	58	94	202	301	394	570	610	646
98	8	13	16	33	55	134	204	272	400	428	452
99	4	7	8	18	31	85	133	180	269	288	302
100	3	6	7	17	31	114	190	268	411	434	446

Appendix C. The calculated modal age at death and life expectancy at birth values for men and women between 1920-2020

	Males		Females	
Years	**e0**	**M**	**e0**	**M**
1920	26.32	65.74	24.72	67.75
1925	27.71	66.42	26.23	68.28
1930	29.68	66.87	27.93	68.84
1935	31.75	67.48	30.10	69.54
1940	33.86	68.16	32.63	70.34
1945	35.88	68.75	34.80	71.02
1950	37.98	69.34	36.99	71.67
1955	41.27	70.28	40.83	72.82
1960	43.64	70.78	43.52	73.56
1965	48.59	71.95	50.51	75.18
1970	50.32	72.39	50.99	75.29
1975	53.12	73.17	54.51	76.13
1980	53.99	73.40	56.08	76.52
1985	60.29	75.16	62.07	78.04
1990	62.79	75.87	65.78	78.96
1995	64.25	76.35	67.26	79.41
2000	67.36	77.45	71.42	80.63
2005	69.96	78.55	73.64	81.57
2010	73.92	80.33	76.83	83.15
2015	74.65	80.67	77.55	83.54
2020	75.11	81.06	77.90	83.95

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