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CAUSES OF DEATH IN TURKEY: HOW THE INCREASE IN THE BURDEN OF COMMUNICABLE DISEASES VARY BY SEX AND AGE?

Türkiye'de ölüm nedenleri: Bulaşıcı hastalık yükündeki artış cinsiyete ve yaşa göre nasıl değişmektedir?

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Abstract

Causes of death statistics are essential tools for public health, but Turkey lags in the number of studies on causes and trends of death. This study measures causes and trends of death in Turkey for the 2013-2019 period, with special emphasis on the increase in communicable diseases (CDs). This study has a representative research design based on the national population and cause of death registration systems. Causes of death with International Classification of Diseases, Tenth Revision (ICD-10) codes were grouped and garbage codes were determined and redistributed. To understand how the increase in the burden of CDs vary by sex and age, modal age at death, age-specific death rates, probability of eventual death, years of life lost (YLL) due to three main causes of death were calculated by using discrete absorbing Markov chain model. According to results, modal age at death among male population shifted to older ages, the share of respiratory infectious diseases and other infectious and parasitic diseases increased rapidly between 2013 and 2019, just before the onset of COVID-19 pandemic. Overall, our results suggest that burden of CDs increased for both sexes, and elderly male population was among the most effected group. Since non-communicable diseases were still the leading causes of death, increasing rate of CDs may create an extra burden on health system.

Keywords: Causes of death, communicable diseases, Markov chain, modal age at death, Turkey.

Özet

Ölüm nedeni istatistikleri, halk sağlığı için çok önemli araçlardır, ancak Türkiye ölüm nedenleri ve eğilimlerine ilişkin yapılan çalışmalarda geride kalmaktadır. Bu çalışma, bulaşıcı hastalıklardaki (BH'lerdeki) artışa özel bir vurgu yaparak, 2013-2019 döneminde Türkiye'deki ölüm nedenlerini ve eğilimlerini değerlendirmektedir. Çalışma, ulusal nüfus ve ölüm nedeni kayıt sistemlerine dayalı temsili araştırma tasarımına sahiptir. Uluslararası Hastalık Sınıflandırması Onuncu Revizyon (UHS-10) kodlarına sahip tüm ölüm nedenleri gruplandırılmış ve çöp kodlar belirlenerek ölüm nedenleri içinde yeniden dağıtılmıştır. BH yükündeki artışın cinsiyete ve yaşa göre nasıl değiştiğini anlamak için ayrık Markov zinciri modellemesi kullanılmış ve en fazla ölümün meydana geldiği yaş, üç ana ölüm nedenine göre yaşa özel ölüm oranları, ölüm olasılıkları ve kaybedilen yaşam yılları hesaplanmıştır. Çalışmanın sonuçlarına göre, erkek nüfusta en fazla ölümün meydana geldiği yaş daha ileri yaşlara kaymış; her iki cinsiyette de 2013-2019 yılları arasında- COVID-19 pandemisinin başlamasından hemen önce- solunum yolu enfeksiyon hastalıkları ile diğer bulaşıcı ve parazit hastalıkların payı hızla artmıştır. Genel olarak, sonuçlarımız her iki cinsiyet için de BH yükünün arttığını ve yaşlı erkek nüfusunun en çok etkilenen grup arasında olduğunu göstermektedir. Bulaşıcı olmayan hastalıklar hala önde gelen ölüm nedenleri olduğundan, artan BH oranları sağlık sistemi üzerinde fazladan bir yük oluşturabilir.

Anahtar kelimeler: Ölüm nedenleri, bulaşıcı hastalıklar, Markov zinciri, ölümdeki mod yaş, Türkiye.

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Introduction

Since the foundation of the Republic in 1923, Turkey followed an epidemiologic transition in parallel with its demographic transition process (1–3). Struggling with infectious diseases and epidemics early on, the country commenced vaccination programs against tuberculosis, smallpox and polio (4, 5), and expanded child and maternal services (3, 4). As a results of the improvements in health system and medicine, life expectancy at birth increased from 30 years in 1923 to 78.6 years in 2019 (6) and infant mortality rates decreased from 306 (7) to 11 per thousand (8). Furthermore, communicable diseases gave way to non-communicable diseases as leading causes of death.

In addition to the disease burden arising from non-communicable diseases (NCDs), communicable diseases (CDs) have increased in many parts of the world, especially in poor countries, in the late 20th century (9,10). Malaria, cholera and HIV/AIDS have increased the burden of disease for developing nations (9). In 1996, the WHO warned against the dangerous rise of both old and new infectious diseases (11). Alongside the world-wide re-emergence of infectious diseases (12), the north-eastern United States, western Europe, Japan and south-eastern Australia have been identified as “hotspots” for emerging diseases due to population density, antibiotic drug resistance, and other environmental factors (13). According to a European study (14), the key drivers of infectious diseases for the 2008-2013 period were travel and tourism, food and water quality, the natural environment, global trade, and climate (14).

This article examines the causes and trends of death in Turkey for the study period 2013-2019, highlights the increasing share of communicable diseases, and examines whether there are any sex and age differences in causes and trends of death. The 2013-2019 period is significant because Turkey implemented an electronic death notification system in 2013, so mortality data is more complete compared to the registration practices of previous year (15–17). Since the most recent available data on causes of death is for 2019, we selected the period as 2013-2019. Furthermore, focusing on pre-2020 data has also helped to avoid any fluctuation that may arise due to the COVID-19 pandemic.

There are lots of studies for Turkey handling the non-communicable diseases (NCDs) or chronic diseases (18–20). Since communicable diseases have a small share among the causes of death, studies on communicable diseases are very few. In order to implement sustainable, accurate and timely health policies, first of all, it is necessary to understand the trends and patterns of diseases, to identify vulnerable groups and to define the risk factors of diseases correctly. This study shows that communicable diseases were already on the rise before the time of COVID-19 pandemic and reveals the most affected groups on the basis of age and sex. Considering the current burden of non-communicable diseases and the burden created by COVID-19 pandemic, it is of great importance to include measures related to communicable diseases in health policies. In this study, we addressed the following inter-related research questions: (1) How do recent gains in life expectancy and modal age at death vary by sex and age? (2) How do causes of death change recently? (3) Are there different trends in the pattern of causes of death in terms of sex and age? Regarding these questions, we first measured life expectancy and modal age at death to reveal the age pattern at death, and then disclosed trends in causes of death by sex.

Material and Method

Data sources

The primary data sources of this study are TURKSTAT registration statistics for causes of death, and population by sex and age for the 2013-2019 period. In the causes of death datasets, each row corresponded to one death and provided data on age, sex, place of residence, and ICD-10 coded cause of death for each death.

Data preparation

Cause of death data

Prior to data analysis, four important data preparation steps have been applied; the first is the converting the ICD-10 codes to broad cause categories, the second is the redistribution of unknown sex, the third is the redistribution of unknown ages, and the fourth is redistribution of garbage (ill-defined) codes.

To begin the analysis, four-digit ICD-10 codes were converted to the broad cause categories. This process is applied according to the cause categories listed in Annex Table A of the WHO technical paper for Global Health Estimates (GHE) (21). Total number of deaths by cause, age and sex were extracted according to the GHE cause list, and some ICD-10 codes were mapped as garbage codes. Garbage codes are causes that do not provide information for underlying cause of death (22,23). Before causes of death analysis is done, these codes should be redistributed for a valid analysis result (22). According to the GHE cause list, there are four types of garbage codes. Garbage code-1 (R00-R94, R96-R99) includes “symptoms, signs and ill-defined conditions”. Garbage code-2 (Y10-Y34, Y872) includes injuries where intent is not determined. Garbage code-3 (C76, C80, and C97) covers neoplasms of other and unspecified sites. Garbage code-4 (I472, I490, I46, I50, I514, I515, I516, I519 and I709) includes heart failure, ventricular dysrhythmias, generalized atherosclerosis and ill-defined complications of heart diseases. We then grouped the four-digit ICD-10 codes in broader categories (Appendix 2) and determined the garbage codes.

In the second step, deaths of unknown sexes are redistributed proportionally within cause-age groups of known sexes. Then, deaths of unknown ages are redistributed proportionally within cause-sex groups of known ages.

In the final step, Garbage code-1 (GC-1) was redistributed proportionally by age and sex to all non-injury causes of death (21,23). Garbage code-2 (GC-2) was redistributed proportionally by age and sex to all injury causes of death. Garbage code-3 (GC-3) was redistributed proportionally by age and sex to all sites excluding liver, pancreas, ovary and lung cancers. Garbage code-4 (GC-4) was then redistributed by age and sex to target causes according to the specific proportions suggested by WHO for Eastern European and central Asian countries (21,24).

Percent distribution of garbage codes are presented in Figure 1. GC-4 constitutes the major portion of the garbage codes and includes ill-defined cardiovascular diseases. This portion is higher among females at 9% compared to 7% among males in 2019. GC-1 remains at the level of 1.6% among females and 1.5% among males in 2019. GC-3, which defines ill-defined neoplasm, is stable over the years and remains at 0.5% for both sexes. For the 2013-2019 period, the total percentage of garbage codes has increased from 7.9% to 9.4% among males and from 10.6% to 11.4% among females.

Population data

In the population dataset, we included only citizens of the Republic of Turkey. Because while majority of legally residing foreigners are registered in population registration system in Turkey, negligible number of this group are included in the death registration system (17). To provide the correspondence between event (death) and exposure population, we excluded legally residing population from population dataset. On the other hand, immigrants other than legal residing foreigners are not registered in both the cause of death and population registration systems anyway. Therefore, other immigrants did not pose a problem for our analysis. In the next step, we calculated the mid-year population for each

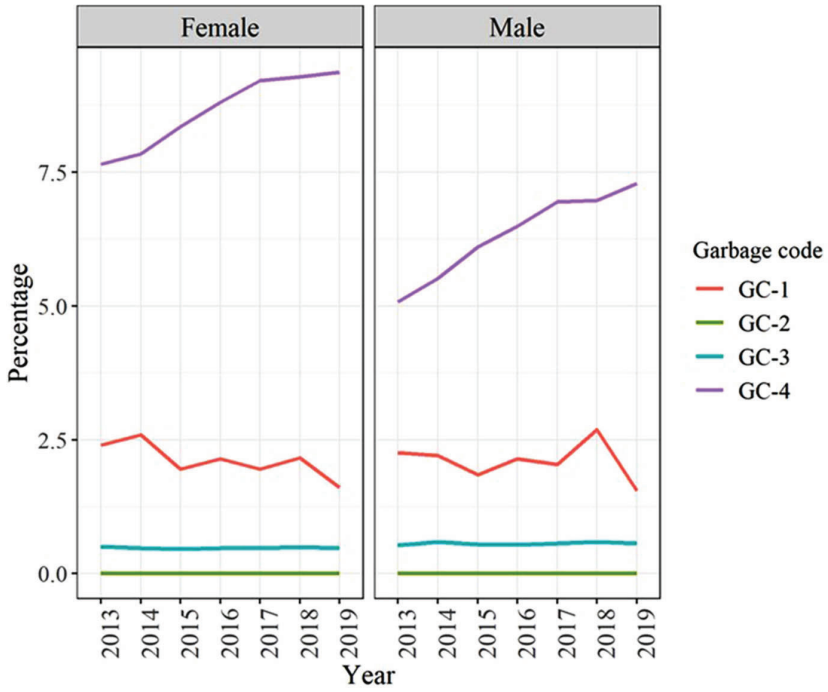

Figure 1: Percent distribution of garbage codes: 2013-2019.

year between 2013 and 2019. Total number of deaths and mid-year population were presented in Appendix 1.

Data analysis

In this study, we applied Markov chain matrix approach to analyse the trend and pattern of causes of death. Markov chain is a stochastic process, which provides the probabilities of transition among states. Markov chain also satisfies the property of memorylessness, that is, probability of next state depends on the current states, not past states (25). Markov chain is very suitable for human life cycle, because, as Caswell (26) states:

"The movement of an individual through its life cycle is a random process, and although the eventual destination (death) is certain, the pathways taken to that destination are stochastic and will differ even between identical individuals; this is individual stochasticity" and "…, because it accounts for all the possible pathways, and their probabilities, that an individual can follow through its life" (26).

In this paper, we used the discrete-time absorbing Markov chain model. In this model, causes of death are included as absorbing states. Figure 2 shows the figure of an age-classified life cycle with (0,1,…, ω) age classes and (D1, D2,…Di) causes of death. In this figure, qk, sk and vk where k = 0,1,…, ω define the death probabilities of causes D1, D2, and Di, respectively.

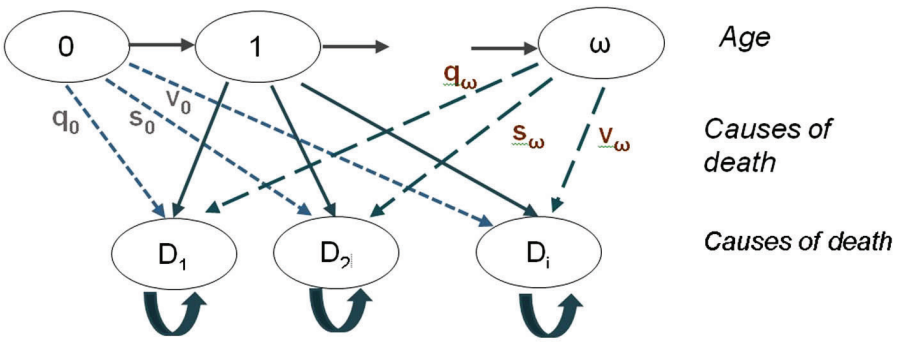

Figure 2: Markov chain model used in this study.

Then we get the transition matrix corresponding to Figure 2:

$$P = \begin{pmatrix} U & 0 \\ M & I_i \end{pmatrix}$$

Here, all capital letters are matrix. Therefore, P matrix consists of 4 matrices; U, M, 0 and I_i. U shows the transitions among the transient states. Since transient states refer to ages, U includes the survival probabilities on the sub diagonal and zeros elsewhere (ω×ω). Matrix M refers to absorbing states with the dimension of i×ω. This matrix shows the death rates for each cause of death. I_i corresponds to the identity matrix with the dimension of i×i . I_i provides the remaining number of dead individuals in their absorbing states (27). All matrices in the P matrix are constructed by calculating the age and cause-specific hazards. Formulas (1) and (2) defines the sex-specific hazards of causes of death:

$$h_{female} = \frac{\text{Age and cause specific female deaths in year t}}{\text{Age specific mid-year female population in year t}} \quad (1)$$

$$h_{male} = \frac{\text{Age and cause specific male deaths in year t}}{\text{Age specific mid-year male population in year t}} \quad (2)$$

After this calculation, hazard matrices took the form of

$$\mathbf{H} = \begin{pmatrix} h_{11} & h_{12} & \cdot & \cdot & h_{1i} \\ h_{21} & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ h_{\omega 1} & h_{\omega 2} & \cdot & \cdot & h_{\omega i} \end{pmatrix}$$

Cause of death →

Starting age ↓

where h_{ij} is the hazard due to cause j at age i. In the next steps, we calculated the longevity statistics (life expectancy, variance, and standard deviation), rates and probability of dying from each cause, years of life lost by causes.

Statistics of longevity

If we define the longevity of an individual in age class ω as the remaining time until an absorption by a state, then we constitute the fundamental matrix, N:

$$N = (I_\omega - U)^{-1} \quad (1)$$

Matrix N provides the statistics of longevity, where the $(i, j)^{th}$ entry of matrix N is the mean time spent in state i, conditional on survival to state j (26, 28–30). The first two moments are:

$$\eta_1^T = 1_\omega^T N \quad (2)$$

$$\eta_2^T = \eta_1^T (2N - I_\omega) \quad (3)$$

where 1_ω^T is the transpose of the column vector of ones with ω x 1 dimension and I_ω is the identity matrix with ω x ω dimension. Calculated statistics of longevity from these moments are:

$$E(\eta) = \eta_1 \quad (4)$$

$$V(\eta) = \eta_2 - \eta_1 \circ \eta_1 \quad (5)$$

$$SD(\eta) = \sqrt{V(\eta)} \quad (6)$$

$$CV(\eta) = \text{diag}(\eta_1)^{-1} SD(\eta) \quad (7)$$

where ∘ denotes element by element multiplication, E(η) gives the life expectancy at each age; V(η), SD(η) and CV(η) are variance, standard deviation and coefficient of variation of longevity, respectively.

Probability distribution of eventual death due to each cause

Assuming that bij is the probability of dying from cause i at the current age j, then

$$B = MN \quad (8)$$

columns of B give the probability distribution of eventual cause of death for each age. Rows of B give the probability of dying from a cause for each age (26, 28).

Life lost due to causes of death

If we define Z_1 as the matrix of mean life lost due to causes; that is,

$$Z_1 = (E(\text{life lost} \mid \text{cause} = 1, \text{starting age} = j))$$

$$Z_1 = (\eta_1^T I_a)B \quad (9)$$

and column sums of Z_1 give the total life lost for each cause.

Modal age at death

The modal age at death indicates the age at which the higher proportion of deaths occurred. In this study, modal age at death was calculated using the P-spline smoothing procedure. P-spline is a flexible nonparametric approach, and it is assumed as highly effective for fitting mortality rates to obtain smoothed forces of mortality (31, 32). Since we wanted to show the modal age among adults, infant and child mortality data excluded and so, P-spline smoothing method was applied to mortality data for age 10 and over. This procedure was performed by using "MortalitySmooth" package in R programming version 4.1.0.

Results

In this part, we first evaluated the longevity statistics for both sexes and then further analyzes on causes of death.

Life expectancy at birth for female population increased 1.02 years between 2013 and 2019 (Appendix 3). Variance and standard deviation in age at death provide information about inequality in death and progression in mortality. Higher variation or standard deviation indicates higher uncertainty about age at death. Results show that variation decreases with increasing age, as expected. Between 2013 and 2019, variation has decreased at all ages among women. Male life expectancy increased 1.5 years in seven years. As in females, the variation in life expectancy has decreased at all ages among males in 2013-2019 period (Appendix 4). When we compare by sex, we see a similar pattern in 2013 and 2019: male variances in life expectancy are higher up to age of 60, after which female variances become higher.

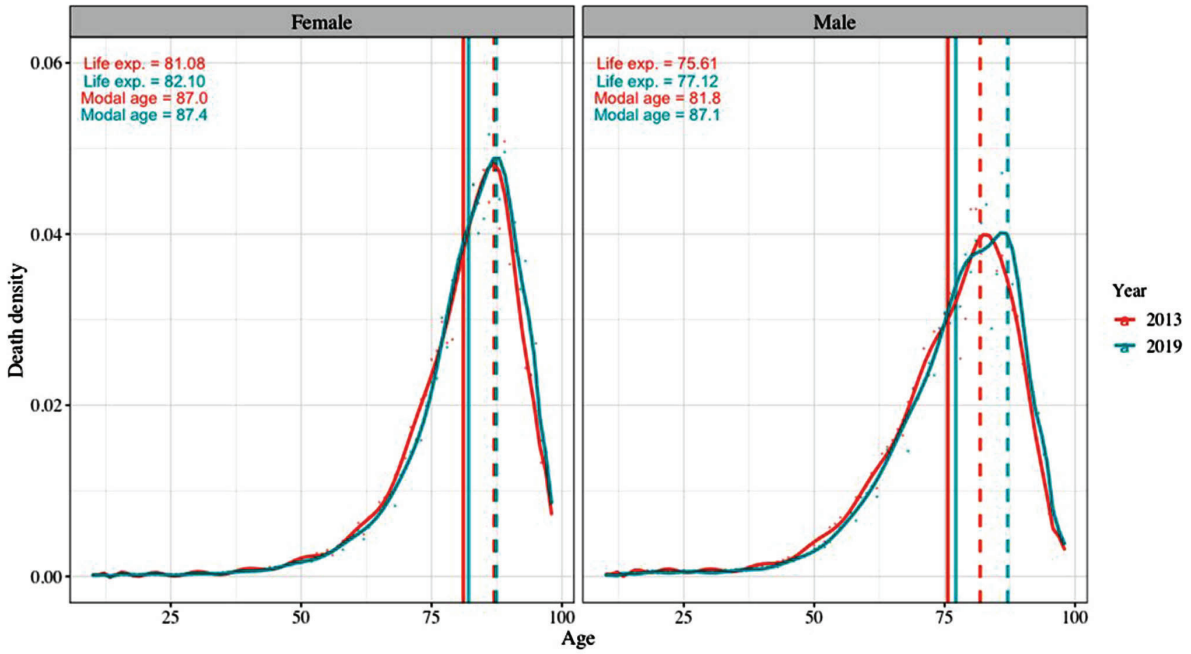

Figure 3: Distribution of death density in 2013 and 2019 by sex (solid vertical lines show life expectancy and dashed lines show modal age at death).

Note: Figure shows density curves for age 10 and over.

Figure 3 shows the death density curves, life expectancy and modal age at death in 2013 and 2019 for each sex. According to figure, death density rised sharply after age 50 and reached peaks at ages 80s for both sexes. The life expectancy

of females increased by almost a year, while that of males increased by 1.5 years. Modal ages increased 0.4 and 5.3 years among females and males, respectively.

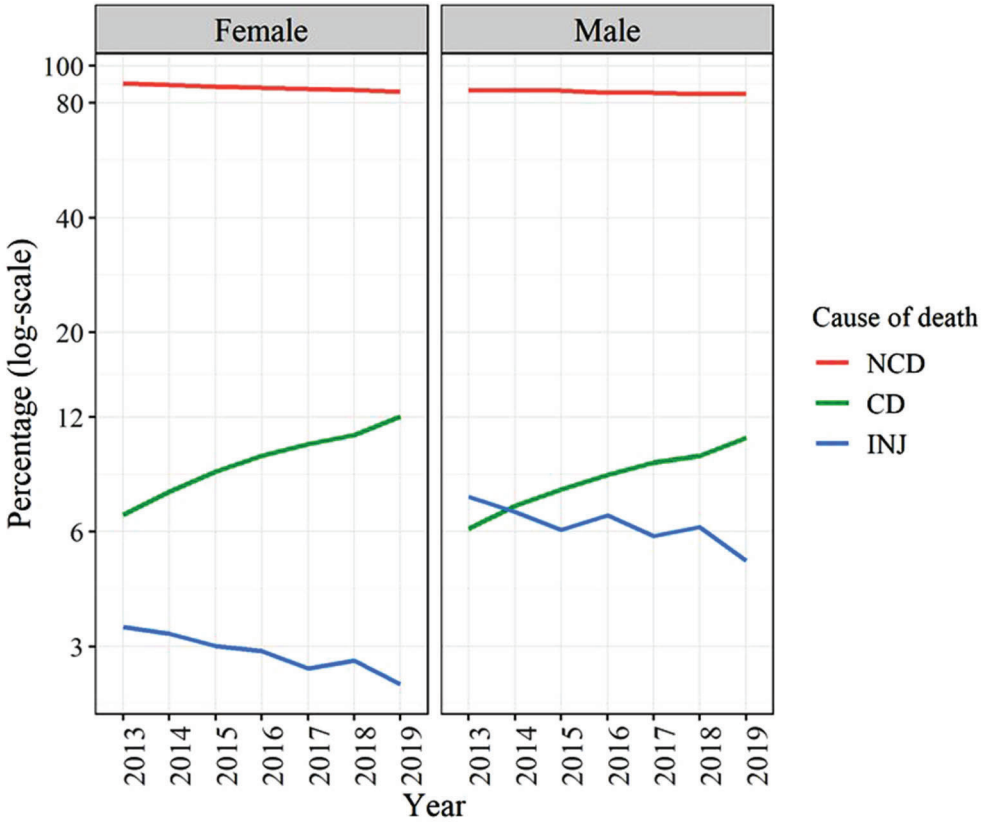

Figure 4: Percent distribution of cause of death: 2013-2019.

Figure 4 shows the percent distribution of three main causes of death. According to this figure, the share of non-communicable diseases (NCDs) and injuries are decreasing over the years, but percent decline of NCDs is very slow. NCDs still constitute the major causes of death, which stands at 86% and 84% in 2019 among females and males, respectively. Injuries (INJs) have a decreasing trend for both sexes but are higher among males than females.

By contrast, percentages of communicable, maternal, perinatal and nutritional conditions (CDs) are rising rapidly. CDs percentages almost double for both sexes, rising from 6.7% to 12% among females and from 6.1% to 11% among males between 2013 and 2019.

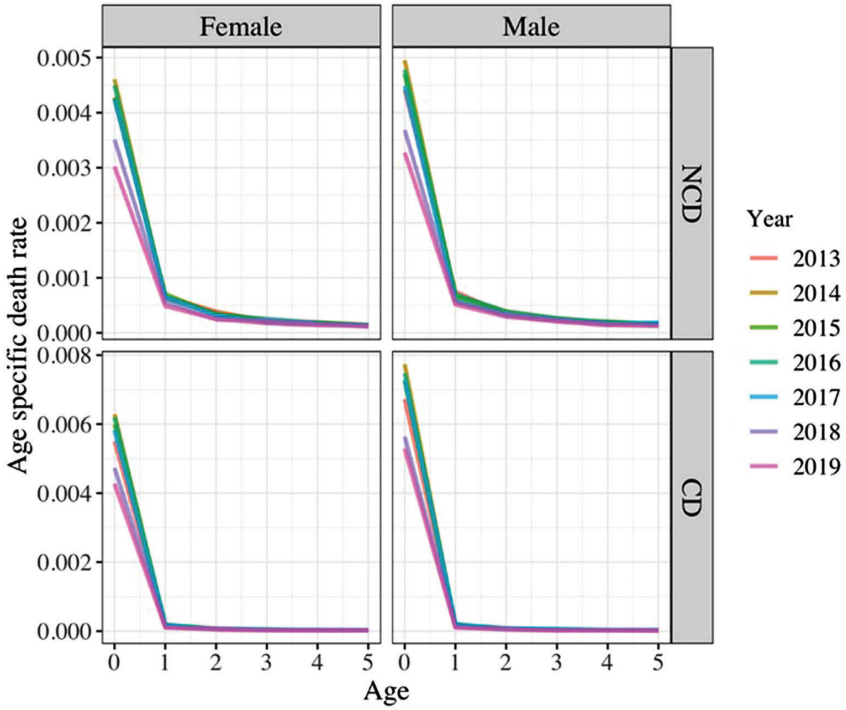

Figure 5(a): Age-specific death rates for children under five.

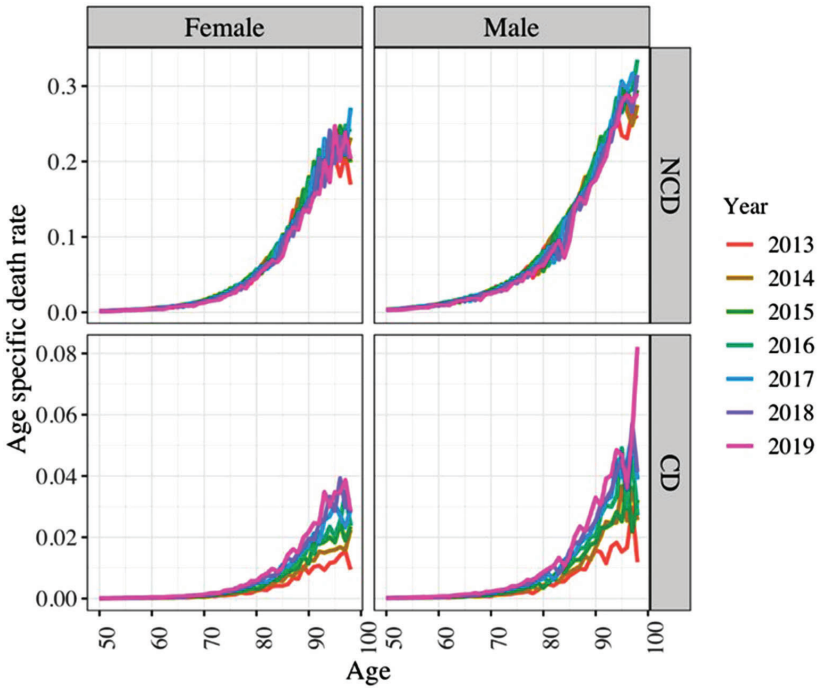

Figure 5 (b) Age-specific death rates among individuals aged 50 and older.

Figure 5(a) and Figure 5(b) shows the age specific death rates (ASDRs) of NCDs and CDs for under age 5 and age 50 and over, respectively. For the under 5, rates of NCDs and CDs are highest at age 0 and there is rapid decline until age 1. Infancy period ASDRs are decreasing for NCDs and CDs over the years.

For the age 50 and over group, while NCDs death rates are decreasing over the years, rates are higher at older ages and among males. Figure 5(b) also shows that CDs' death rates have an increasing trend from 2013 to 2019 and rates are higher among males.

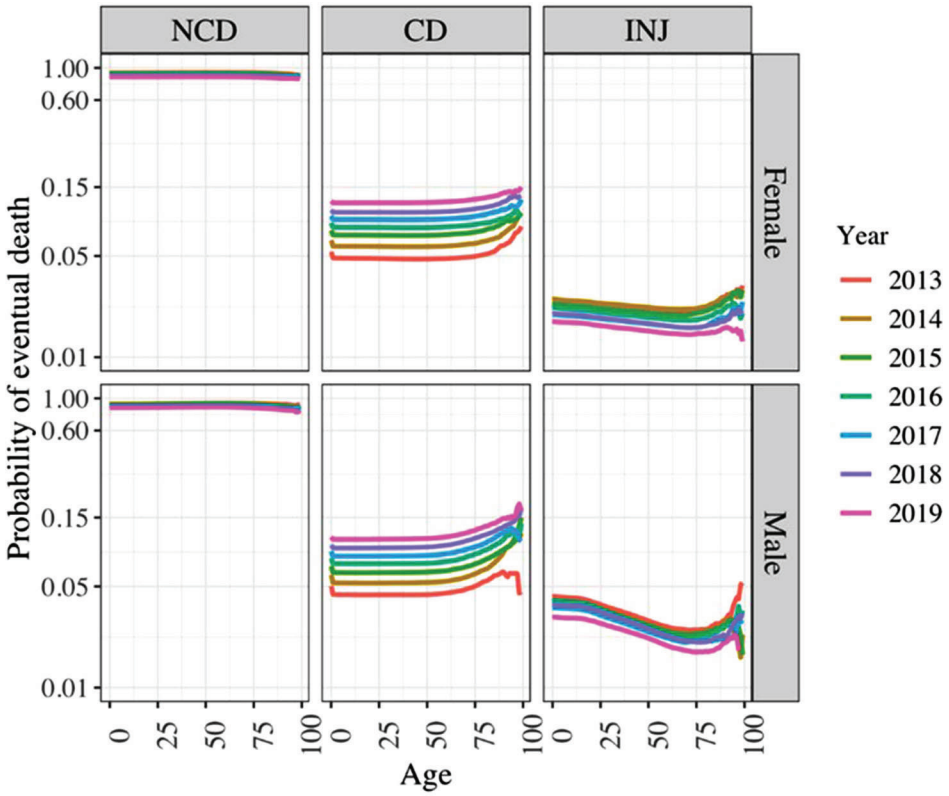

Figure 6: Probability of dying from NCDs, CDs and INJs by age and sex.

Figure 6 presents the change of death probabilities (in logarithmic scale) among three main causes of death by age and sex over the years. Although the probability of dying from NCDs has the highest category for all ages, average NCDs probabilities have declined slowly between 2013 and 2019, falling from 0.92 to 0.87 among males and from 0.93 to 0.87 among females. There are, however, rapid rises for CDs probabilities, which increased from an average of 0.05 to 0.12 for both sexes. Up to the age of 75, females are more likely to die from CD, while after this age it is higher for males. Meanwhile, probabilities of INJs have decreased from 0.03 to 0.02 for males, and from 0.02 to 0.015 among females.

To understand the contribution of different causes of death related to the increasing trend in death probabilities of CDs, we examined the sub-categories of CDs and split them into five parts (24) (WHO 2013b): infectious and parasitic diseases, maternal conditions, neonatal conditions, nutritional deficiencies and respiratory tract infectious diseases.

Figure 7 shows the change of probabilities in logarithmic scale. According to the findings, this rise is due to the increase in respiratory tract infectious diseases, as well as infectious and parasitic diseases. Respiratory tract infectious diseases constitute the highest share of CDs' death probabilities, and they show an increase over the years. Infectious and parasitic diseases are also increasing over the years. Probability of nutritional deficiencies is almost at the same level from 2013 to 2019 and that probability increases with age. Dying from maternal conditions decreases after women exit their 20s and there is declining trend between 2013 and 2019.

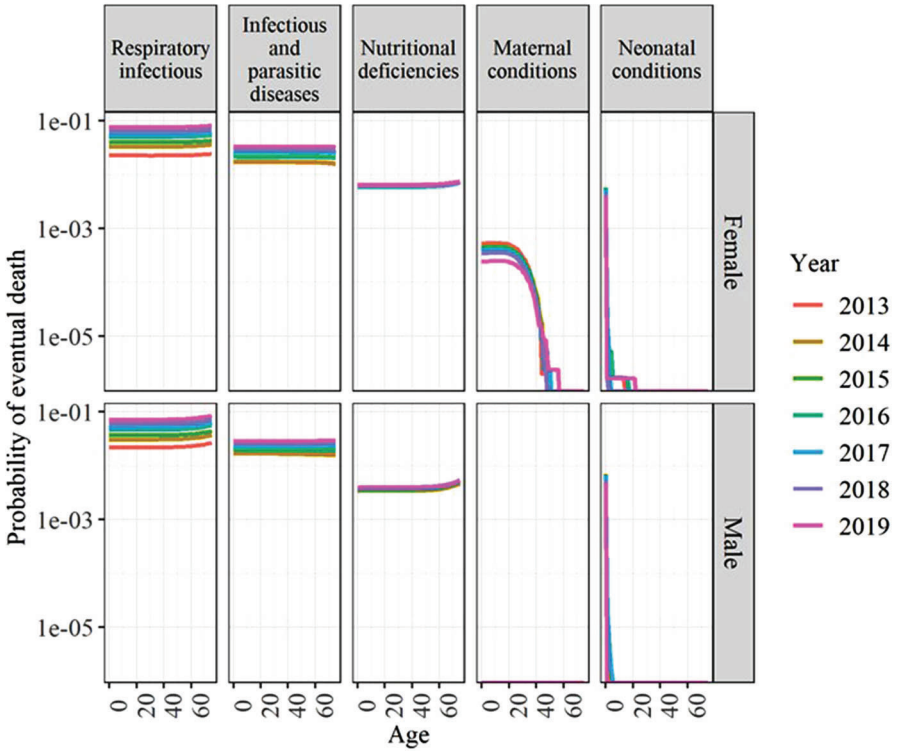

Figure 7: Probability of dying from communicable, maternal, perinatal and nutritional conditions by age and sex.

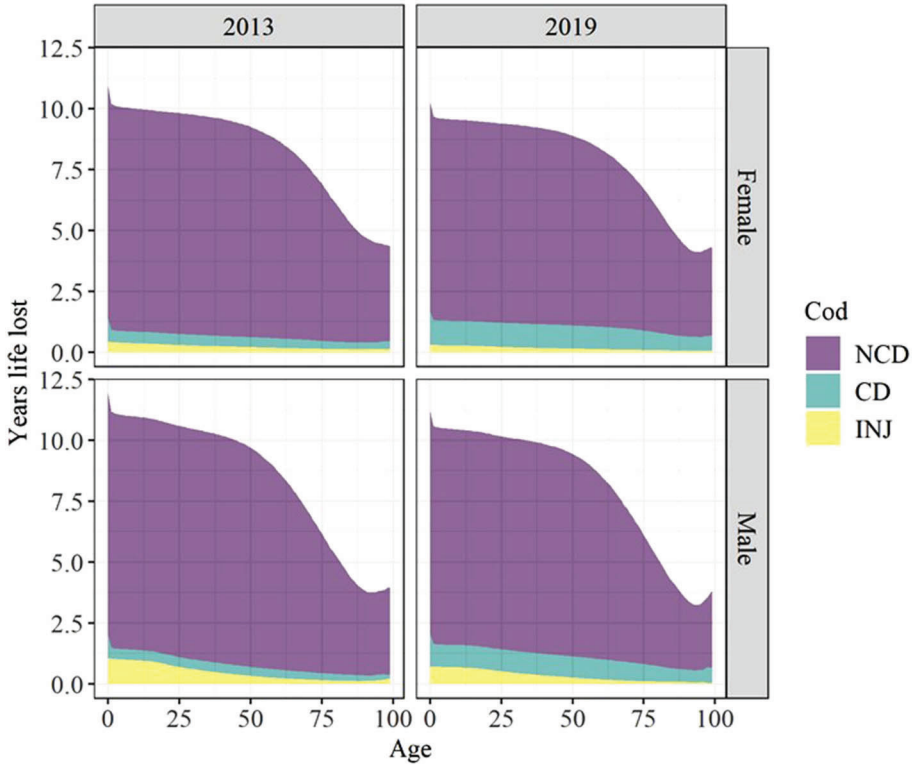

Figure 8: Distribution of years of life lost (YLL) by 3 main cause of death groups (NCD, CD, INJ).

Figure 8 presents the years of life lost (YLL) by 3 main causes of death. Between 2013 and 2019, total YLL at birth decreased from 10.9 to 10.2 years and from 11.9 to 11.2 among females and males, respectively. On the other hand, YLL at birth from CDs went up from 0.95 to 1.37 and 0.96 to 1.34 among females and males, respectively. Age specific YLLs due to CDs increased more than doubled at all ages between 2013 and 2019, peaking in age seventies.

Discussion

Since the establishment of the Turkish Republic has made progress in its healthcare system. Life expectancy at birth has increased and infant and child mortality rates have decreased significantly (33). This study examines the age and cause patterns of mortality by sexes in Turkey for 2013-2019 period. We revealed these patterns using death registration data. There have been improvements in the death notification system over the years, especially for coverage of causes of death. However, reporting of causes needs further improvement particularly for ill-defined causes. In the data preparation stage of this study, we assessed the initial data from the registration system and applied necessary modifications by redistributing garbage codes.

During the study period, life expectancy at birth increased nearly 1 year among females and 1.5 years among males. Moreover, as a novel finding of our study, modal age at death increased 0.4 years among females and 5.3 years among males in six years. This finding indicates that, distribution of the bulk of the bell-shaped deaths around the modal age shifted toward older ages for males and stayed almost stable for females. This finding also indicates that modal age at death converged in males and females. Different gains in life expectancy and modal age death between sexes is due to the fact that males just experienced the improvement females had previously experienced in adult mortality (34). In many developed countries gains in life expectancy among males were later than among females. For example, in accordance with our findings, Mesle and Vallin (35) revealed that Sweden, England, Denmark and Japan were also experienced the sex difference in gains in life expectancy between 1980-2000 period (35).

According to our results, NCDs have decreased from 87% to 84% among males and from 90% to 86% among females between 2013 and 2019, yet NCDs were still the leading causes of death. This finding shows that NCDs maintained the first rank among the causes of death, as was the case before 2013 (36), but their share decreased. Similar to this finding, some studies have shown a reduction in cardiovascular diseases over a period before 2013, thanks to medical and surgical advances (37, 38). We also found that both ASDRs, death probabilities and YLL due to NCDs decreased slightly over the years. Considering the importance of relation between chronical diseases and aging and according to elderly focused results, NCDs death rates are higher in elderly population for both sexes.

Death probability of INJs decreased over the years, but while deaths from INJs show a declining trend, they are still high for the male population. Probabilities here are also higher at younger ages and among males, therefore there is need for detailed analysis to enhance subsequent studies.

Undoubtedly, the most important result of this study is the increasing share of communicable diseases. CDs reached 11% among males and 12% among females in 2019. We found that CDs death rates were higher but declined over the years among children under five. Notably, CDs death rates increased at older ages and were higher for the male population in the 2013-2019 period.

Death probabilities of CDs also increased almost 2.5 times from 2013 to 2019 for both sexes. The main reason for this increasing trend stemmed from the rising probability of respiratory infectious and infectious and parasitic diseases. In accordance with our results, GBD study also show that lower respiratory infectious increased 73% from 2009 to 2019 and become among the top 10 causes of death in Turkey (39). Furthermore, YLL due to CDs doubled at all ages between the analysis period and reached its maximum level in the age 70s.

Overall, our findings suggested three important results. Firstly, age distribution of deaths shifted to older ages significantly among males as a result of compression of the mortality to older ages. Secondly, both ASDRs and death probabilities of CDs increased between 2013 and 2019 for both sexes; however, these indicators were higher among elderly male population. Finally, YLL due to CDs increased at all ages for both sexes.

Proportion of elderly population (65 and older) in total population in Turkey increased from 7.7 to 9.7 percent between 2013 and 2021, respectively (40). Increasing elderly population also effected the patterns of causes of death. According to our results, the shift in deaths, especially in males, to older ages and the addition of CDs burden to the existing NCDs in the elderly indicate the necessity of taking health measures for the elderly population. A similar result was obtained by a study (41) arguing that aging is a risk factor for infectious diseases and treatment is very difficult at advanced ages. Furthermore, Choe and colleagues (2018) found that infectious diseases have become an issue for age 65+ in South Korea (42). Trends and patterns of communicable diseases also differ among developed and developing countries. In a study it was revealed that contrary to the low-middle income countries such as Vietnam, Mongolia and Indonesia, deaths due to lower respiratory tract infectious diseases (LRTI) were increased in upper-middle income and high-income countries (such as Japan, Singapore and Taiwan) between 2000 and 2017 (43). Divergent trends in LRTI have been attributed to the different risk factors for developed and developing countries. The main risk factors of LRTI are aging population in high income countries, while in developing countries malnutrition, smoke pollution and lack of effective preventive measures (43). McDonald and colleagues (44) estimated the mortality burden of influenza between 2000 and 2013 among 60 years and older people in Netherlands. According to the findings, burden of influenza was highest among age group 80-84 years (44). Similar to these studies, in a study performed for Hong Kong, it was found that CDs showed the greatest increases between 2001 and 2010 for both sexes and mostly effected the elderly population (45).

As in the rest of the world, the fight against COVID-19 pandemic has been on Turkey's agenda for the last few years. COVID-19 left an extra burden on the health system especially concerning elderly population. To avoid post-pandemic health crisis, existing health problems should be handled urgently (46). Therefore, new strategies in health services to improve prevention, diagnosis and treatment are essential. Increasing vaccine coverage, improvement in early diagnosis and antibiotic treatment among elderly population may be an efficient preventive measures (43, 47).

One of the strengths of this study is that it presents not only the recent age specific death rates but also longevity statistics, probability distribution of causes of death and YLL by cause, age and sex. Another strength of this study is that due to the improvement in death registration system as of 2013, results were obtained from more reliable cause of death data.

Conclusions

When the findings of our study and international studies are evaluated together, the need for detailed studies on CDs among the elderly male population, where the burden of NCDs was already high, is clearly seen. Moreover, further analysis is needed on the contribution of causes of death to life expectancy or modal age at death to understand which diseases are improving or worsening.

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Appendices

Appendix 1: Total number of deaths and mid-year population.

Year	Total number of deaths (Causes of death dataset)	Mid-year population (Population dataset)
2013	361,673	75,166,434
2014	383,676	76,054,464
2015	397,037	76,997,548
2016	420,189	77,917,435
2017	416,881	78,827,508
2018	417,041	79,739,250
2019	410,400	80,637,010

Source: Turkish Statistical Institute.

Appendix 2: Cause of death groups and corresponding ICD-10 codes.

Communicable, maternal, perinatal and nutritional conditions	ICD-10 codes	Noncommunicable diseases	ICD-10 codes	Injuries	ICD-10 codes
Infectious and parasitic diseases	A00-B99, G00-G04, G14, N70-N73, P37.3, P37.4	Malignant neoplasms	C00-C97	Unintentional injuries	V01-X40, X43, X46-59, Y40-Y86, Y88, Y89
Respiratory infectious	H65-H66, J00-J22, P23, U04	Other neoplasms	D00-D48	Intentional injuries	X60-Y09, Y35-Y36, Y870, Y871
Maternal conditions	O00-O99	Diabetes mellitus	E10-E14 (minus E10.2-E10.29, E11.2-E11.29, E12.2, E13.2-E13.29, E14.2)		
Nutritional deficiencies	D50-D53, D64.9, E00-E02, E40-E46, E50-E64	Endocrine/blood/ immune disorders	D55-D64 (minus D64.9), D65-D89, E03-E07, E15-E34, E65-E88		
Neonatal conditions	P00-P96 (minus P23, P37.3, P37.4)	Mental and substance use disorders	F04-F99, G72.1, Q86.0, X41-X42, X44, X45		
		Neurological conditions	F01-F03, G06-G98 (minus G14, G72.1)		
		Sense organ diseases	H00-H61, H68-H93		
		Cardiovascular diseases	I00-I99		
		Respiratory diseases	J30-J98		
		Digestive diseases	K20-K92		
		Genitourinary diseases	E10.2-E10.29,E11.2-E11.29,E12.2,E13.2-E13.29,E14.2, N00-N64, N75-N76, N80-N98		
		Skin diseases	L00-L98		
		Musculoskeletal diseases	M00-M99		
		Congenital anomalies	Q00-Q99 (minus Q86.0)		
		Oral conditions	K00-K14		
		Sudden infant death syndrome.	R95		

Appendix 3: Age distribution of life expectancy and variance in 2013 and 2019, female.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
LE-2013	81.08	80.88	79.95	79.00	78.03	77.05	76.07	75.09	74.10	73.12	72.13	71.14	70.15	69.16	68.18
LE-2019	82.10	81.70	80.75	79.78	78.80	77.81	76.83	75.84	74.85	73.86	72.86	71.87	70.88	69.89	68.90
Var-2013	223.76	161.39	155.48	151.93	149.85	147.98	146.59	145.43	144.25	143.25	142.40	141.62	140.86	140.10	139.25
Var-2019	192.56	144.90	140.58	138.36	136.92	135.86	134.84	133.92	133.33	132.65	132.00	131.32	130.67	130.02	129.46
	15	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**
LE-2013	67.19	66.21	65.22	64.24	63.25	62.27	61.28	60.29	59.31	58.32	57.34	56.35	55.36	54.38	53.39
LE-2019	67.91	66.92	65.94	64.95	63.96	62.98	61.99	61.01	60.02	59.03	58.04	57.06	56.07	55.08	54.09
Var-2013	138.33	137.39	136.27	135.35	134.49	133.65	132.85	131.98	131.09	130.26	129.69	128.93	128.18	127.42	126.57
Var-2019	128.80	128.06	127.22	126.43	125.50	124.55	123.79	123.04	122.35	121.55	120.87	120.16	119.59	119.03	118.37
	30	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**
LE-2013	52.41	51.43	50.45	49.46	48.48	47.50	46.52	45.55	44.57	43.59	42.62	41.65	40.69	39.72	38.76
LE-2019	53.10	52.11	51.13	50.14	49.16	48.18	47.20	46.22	45.24	44.26	43.29	42.31	41.34	40.37	39.40
Var-2013	125.69	124.85	124.08	123.17	122.35	121.48	120.55	119.53	118.44	117.55	116.44	115.22	114.01	112.65	111.32
Var-2019	117.76	117.14	116.45	115.68	114.84	113.98	113.11	112.20	111.34	110.39	109.47	108.48	107.48	106.27	105.16
	45	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**
LE-2013	37.80	36.84	35.88	34.93	33.98	33.04	32.11	31.18	30.25	29.33	28.41	27.50	26.57	25.66	24.77
LE-2019	38.43	37.47	36.51	35.56	34.61	33.66	32.72	31.78	30.83	29.89	28.97	28.05	27.13	26.23	25.31
Var-2013	109.84	108.47	107.09	105.65	104.07	102.20	100.33	98.29	96.53	94.39	92.43	90.29	88.68	86.58	84.27
Var-2019	104.08	102.64	101.29	99.71	98.17	96.53	94.91	93.22	91.69	90.05	88.06	85.98	84.01	81.78	79.94
	60	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**
LE-2013	23.88	23.00	22.15	21.26	20.42	19.57	18.75	17.93	17.12	16.34	15.58	14.81	14.10	13.36	12.68
LE-2019	24.42	23.54	22.67	21.77	20.90	20.06	19.22	18.39	17.57	16.73	15.94	15.16	14.40	13.65	12.89
Var-2013	81.90	79.58	76.84	74.86	72.29	69.86	67.19	64.61	62.11	59.39	56.61	54.02	51.08	48.64	45.84
Var-2019	77.60	75.24	72.76	70.90	68.67	66.02	63.46	60.97	58.36	56.33	53.71	51.21	48.61	46.09	43.83
	75	**76**	**77**	**78**	**79**	**80**	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**
LE-2013	12.00	11.37	10.74	10.16	9.53	8.89	8.37	7.90	7.37	6.96	6.53	6.17	5.78	5.58	5.25
LE-2019	12.19	11.51	10.83	10.23	9.58	9.02	8.45	7.96	7.47	7.04	6.54	6.06	5.71	5.43	5.07
Var-2013	43.27	40.52	37.96	35.37	33.27	31.44	29.36	27.28	25.66	23.94	22.51	21.18	20.15	19.04	18.31
Var-2019	41.33	38.81	36.53	33.89	31.83	29.50	27.43	25.27	23.30	21.36	19.86	18.58	17.24	15.98	15.04
	90	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99+**					
LE-2013	5.17	4.94	4.86	4.74	4.59	4.57	4.60	4.50	4.57	4.36					
LE-2019	4.84	4.56	4.37	4.13	4.12	3.92	4.09	4.07	4.27	4.29					
Var-2013	17.52	16.95	16.43	16.00	15.74	15.56	15.31	15.09	14.81	14.64					
Var-2019	14.16	13.54	13.09	12.90	12.91	13.09	13.53	13.83	14.11	14.12					

Note: LE: mean life expectancy, Var: Variance

Appendix 4: Age distribution of life expectancy and variance in 2013 and 2019, male.

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
LE-2013	75.61	75.46	74.54	73.59	72.62	71.64	70.66	69.68	68.70	67.71	66.73	65.75	64.76	63.78	62.80
LE-2019	77.12	76.78	75.84	74.87	73.89	72.91	71.92	70.94	69.95	68.96	67.97	66.98	65.99	65.00	64.01
Var-2013	256.55	195.18	189.31	186.11	183.76	182.13	180.74	179.55	178.46	177.45	176.41	175.37	174.43	173.37	172.03
Var-2019	220.72	171.64	167.59	165.24	163.64	162.48	161.57	160.62	159.88	159.17	158.50	157.78	157.13	156.37	155.59
	15	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**
LE-2013	61.82	60.85	59.88	58.92	57.96	57.00	56.04	55.07	54.11	53.14	52.18	51.21	50.24	49.28	48.31
LE-2019	63.03	62.05	61.07	60.10	59.12	58.15	57.17	56.20	55.23	54.26	53.29	52.31	51.34	50.36	49.39
Var-2013	170.72	169.19	167.39	165.33	163.06	160.90	158.96	157.09	155.27	153.52	151.83	149.99	148.56	146.95	145.51
Var-2019	154.67	153.28	152.09	150.74	149.23	147.61	146.43	144.90	143.46	141.87	140.63	139.36	138.11	136.90	135.76
	30	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**
LE-2013	47.34	46.37	45.40	44.43	43.47	42.50	41.53	40.57	39.61	38.64	37.69	36.74	35.79	34.84	33.90
LE-2019	48.41	47.44	46.46	45.48	44.51	43.53	42.56	41.59	40.62	39.65	38.69	37.73	36.77	35.81	34.85
Var-2013	144.17	142.79	141.62	140.36	138.95	137.74	136.35	135.01	133.69	132.42	130.84	129.29	127.64	125.92	124.10
Var-2019	134.62	133.59	132.53	131.49	130.39	129.42	128.33	127.33	126.25	124.97	123.67	122.37	121.04	119.64	118.38
	45	**46**	**47**	**48**	**49**	**50**	**51**	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**
LE-2013	32.97	32.04	31.11	30.18	29.28	28.39	27.49	26.62	25.73	24.89	24.05	23.22	22.37	21.55	20.76
LE-2019	33.90	32.96	32.02	31.09	30.16	29.24	28.34	27.44	26.54	25.64	24.77	23.92	23.07	22.25	21.40
Var-2013	122.19	120.09	118.19	116.30	113.87	111.21	108.75	105.87	103.45	100.30	97.14	93.85	91.09	88.00	84.50
Var-2019	116.82	115.12	113.43	111.52	109.56	107.45	105.12	102.72	100.56	98.22	95.51	92.64	89.76	86.54	83.92
	60	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**
LE-2013	19.98	19.21	18.46	17.67	16.96	16.25	15.55	14.86	14.15	13.51	12.88	12.22	11.65	11.03	10.47
LE-2019	20.61	19.82	19.04	18.23	17.48	16.77	16.05	15.36	14.68	13.93	13.30	12.65	12.01	11.40	10.76
Var-2013	81.12	77.69	74.09	71.26	67.66	64.15	60.76	57.40	54.46	51.16	47.88	45.06	41.77	39.12	36.19
Var-2019	80.50	77.17	73.85	71.15	67.80	64.19	60.79	57.35	53.88	51.35	47.94	44.89	41.91	38.96	36.44
	75	**76**	**77**	**78**	**79**	**80**	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**
LE-2013	9.89	9.36	8.85	8.39	7.77	7.21	6.83	6.47	6.05	5.69	5.35	4.99	4.71	4.48	4.23
LE-2019	10.19	9.64	9.07	8.59	8.04	7.57	7.08	6.63	6.23	5.88	5.33	4.87	4.62	4.41	4.10
Var-2013	33.63	31.05	28.50	25.93	24.30	22.72	20.77	18.91	17.39	15.95	14.66	13.62	12.70	11.89	11.28
Var-2019	33.66	30.96	28.61	25.98	23.90	21.68	19.78	17.89	16.06	14.23	13.14	12.15	11.05	9.98	9.17
	90	**91**	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99+**					
LE-2013	4.07	3.89	3.78	3.67	3.68	3.78	3.74	3.70	3.86	3.98					
LE-2019	3.88	3.66	3.43	3.25	3.16	3.10	3.14	3.22	3.39	3.83					
Var-2013	10.80	10.50	10.37	10.42	10.64	10.86	11.02	11.33	11.72	11.86					
Var-2019	8.45	7.89	7.52	7.40	7.51	7.86	8.49	9.29	10.22	10.86					

Note: LE: mean life expectancy, Var: Variance