Trends and Forecasts on Prediabetes and Diabetes in Adult and Elderly Population in Turkey

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ABSTRACT

Aims

Diabetes is a chronic disease that limits the quality and duration of life. We aimed to estimate the trends in prediabetes and diabetes between 2010-2020, and the projections to 2023 and 2045 in Turkey.

Materials and methods

Prediabetes and diabetes estimates were calculated by direct standardization using age/sex-specific data from the previous TURDEP-II survey as reference. The 2010-2020 population demographics were obtained from TurkStat. Comparative age-adjusted diabetes rates were estimated using standard population models of world and Europe.

Results

Estimates depicted that the population (20-84 years) of any degree of glucose intolerance in Turkey increased by approximately 5.3 million (diabetes: 2.2 million and prediabetes: 3.1 million) from 2010 to 2020. While the increase in prediabetes and diabetes rates was 22% and 31.6% in overall population, corresponding increase were 45.2% and 45.6% in the elderly. Notably, diabetes awareness was comparable (54% and 58%). Age-specific prediabetes and diabetes rates were significantly higher in women than in men (diabetes: 14.1% versus 17%; prediabetes: 38.6% versus 30.2%). The comparative age-adjusted prevalence of diabetes to the standard European but not the world population model, showed a higher rate of 19.4%. According to the projections the prevalence of diabetes will reach 15.9% in 2023 and 19.1% in 2045.

Conclusion

Diabetes has reached epidemic proportions in Turkey and will continue to grow in the coming decades. The fact suggests that there is an urgent need to developing and implementing the country-specific prevention program to halt this increase. Otherwise, the burden of diabetes on social, economic and health services will continue to increase.

Keywords: Epidemiology, Population-based field survey, Age-standardized prevalence, Age-adjusted prevalence, Prediabetes, Diabetes

INTRODUCTION

Diabetes mellitus, particularly type 2, is recognized as a serious public health problem with a significant impact on human life and health expenditures. With the increase in obesity and the adoption of a sedentary lifestyle in recent decades, the incidence and prevalence of diabetes have increased rapidly all over the world in both developed and developing countries. According to recent estimates by the International Diabetes Federation (IDF), global diabetes prevalence in 2021 is 10.5% (over half a billion people with diabetes); the rate raised by 16% since the previous estimates in 2019 [1, 2]. Diabetes is expected to increase to 11.3% by 2030 and 12.2% by 2045.

Diabetes is a costly disease due to high complications, treatment, and monitoring expenses; It is also noteworthy that diabetes reduces the quality of life and life expectancy as it responsible for an estimated USD 966 billion in global health expenditure in 2021 [1]. Although much progress has been achieved in promoting population health and extending life, diabetes remained the second biggest cause of reduced global health-adjusted life expectancy worldwide [3]. Approximately 6.7 million adults are estimated to have died due to diabetes or its complications in 2021. This accounts for 12.2% of global deaths from all causes [1].

Although many epidemiologic studies have been conducted at different time points and regions in Turkey, the number of reproducible studies reflecting the general population is limited. In this respect, population-based TURDEP surveys provided important knowledge in terms of the frequency of prediabetes and diabetes, risk factors, and comorbidities such as obesity and hypertension. In TURDEP-I survey conducted in the adult (20+ years, n=24,788) population of Turkey in 1998, the age- and sex-specific diabetes prevalence was reported 7.2% (F: 8% and M: 6.2%) [4]. Twelve years after, in the TURDEP-II survey (n=26,499), performed at the same 540 centers and using the same methodology, the age- and sex-specific crude prevalence of diabetes increased to 16.5% (F: 17.2% and 16% for men). The latter investigated glycemic control rates as well. When TURDEP-II results were standardized to the latest official census data, the estimated diabetes prevalence was 13.7% [5] It is noteworthy that prevalent diabetes increased by 90% over 12 years. Other relatively smaller studies conducted in the period close to this study such as CREDIT [6], TEKHARF [7], and MetSend [8] also confirmed this increase. Considering the rising prevalence in the population, diabetes remains one of the most important non-communicable diseases and one of the major public health problems [9].

Unfortunately, no field study conducted to observe diabetes epidemiology across the country since 2010. In fact, carrying out such an extensive study may not be feasible due to the ongoing pandemic. Although global, regional, and country-based diabetes estimates are periodically published by large research groups [10-14], studies that reference the country's own population-based studies and use real demographic dynamics may provide more valuable information on diabetes trends.

The lack of high-quality data in recent years has been an obstacle to reassessing the course of diabetes epidemic in Turkey. In fact, a new study was planned to use the same methodology as previous population-based surveys to understand the changes from 2010 to 2020, nevertheless, it could not be performed due to pandemic conditions. Therefore, this study is planned to predict the epidemiological trends of the country in terms of prediabetes and diabetes and to provide information about the future prospects of diabetes considering the population dynamics.

MATERIAL AND METHODS

Population and demographic data

Demographic data of the population in Turkey at the provincial and regional levels between 2010 and 2020 are obtained from the official portal of National Institute of Statistics (TurkStat data portal) which is publicly available [15]. WHO [16] and Europe [17] standard population models are used to calculate the comparative age-adjusted prevalence of prediabetes and diabetes.

Age groups and age-specific rates

In consistent with previous population-based field surveys, adults between 20 to 84 years included in the study, and gender differences also examined. The estimations for years before 2010 were based on the age-specific rates from TURDEP-I survey [4]. The estimations of the age-standardized prediabetes and diabetes rates between 2010 and 2020 and future projections to 2023 and 2045 were calculated based on the age- and sex-specific rates of TURDEP-II survey [5].

Calculation of the age-standardized rates

All age-standardized prediabetes and diabetes rates estimated for gender-specific general as well as the elderly populations. The calculations were carried out considering the age-specific rates by 5-year intervals as determined in TURDEP surveys. The age-standardized prediabetes and diabetes rates were estimated at the provincial level first, and then the regional and national averages were calculated via weighted averages considering the population of the provinces. The age-standardized rate in year j (r_j) estimated using the direct standardization method, whereby the observed age-specific rates are applied directly to the population:

$$r_j = \frac{\sum_i w_i d_i}{\sum_i d_i}$$

Where age groups are indexed by the subscript i , d_i is the number of subjects in age group i , and w_i is the age-specific rate in age group i . The 95% CI for the age-standardized rate was determined by:

$$r_j \pm 1.96 \sqrt{\frac{r_j \times (1 - r_j)}{y_j}}$$

Where years are indexed by the subscript j , r_j is the age-standardized diabetes rate in the year j , y_j is the population size in year j .

The estimates of age-standardized diabetes prevalence were calculated using 2000 and 2007 national census data in reference to TURDEP-I survey, and the annual data of the TurkStat Address-Based Population Registry System between 2010 and 2020 referring to TURDEP-II survey.

Future projections

Because of the linear increasing trends in the age-standardized rates of diabetes between 2010 to 2020, a linear regression model was used to estimate diabetes projections for the years 2023 and 2045. The year 2023 was chosen because it is the 100th anniversary of the Republic of Turkey.

Ethical approval

Ethics Committee approval was obtained from Istanbul Faculty of Medicine for the TURDEP-II study [5] which forms the basis of the current paper (16.4.2008/699). Although ethics committee approval is not required for the

present study, the subject was discussed at the Turkish Institute of Public Health and Chronic Diseases Board and it was found appropriate to conduct the study (November 9th, 2020, Decision no. 9).

Statistical analysis

The results were shown as frequencies (percentages) for categorical variables, and mean values and 95% CIs for continuous variables. Pairwise comparisons analysed with Student's t-test or Pearson chi-squared test, as appropriate. A p value <0.05 was used as the level of statistical significance.

A linear regression model was used to estimate diabetes projections to 2023 and 2045. The accuracy of the model was assessed through the explained variance of the model ($R^2 > 0.99$ and $p < 0.05$).

RESULTS

Trends in age-standardized prediabetes rates

While the age-standardized estimated total prediabetes rate was 29.6% (F: 32.3%, M: 24.4%) in 2010, it was calculated as 30.2% (F: 32.9% and M: 25.5%) for 2020. The estimated 10-year population growth with prediabetes was 22% (2010: 14,278,728 million vs. 2020: 17,413,358 million). For the year 2020, 14.2% of the estimated entire prediabetes population was in the 65-84 age group. In contrast, the estimated prevalence of elderly prediabetes was 34% (F: 34.9%, M: 32.6%) and the 10-year population increase was calculated as 45.2% (Table 1).

For the diagnosis of impaired fasting glucose-IFG category, we used American Diabetes Association-ADA cut-points (fasting plasma glucose-FPG 5.6-6.9 mmol/L). The prevalence of isolated IFG (i-IFG) in the general population in 2010 was 14.6% (F: 14.5%, M: 14.6%), isolated impaired glucose tolerance (i-IGT) 7.7% (F: 9% and M: 5.2%), and combined glucose intolerance (IFG+IGT) 7.3% (F: 8.9%, M: 4.6%). The estimated increase in people with i-IFG, i-IGT, and IFG+IGT between 2010 and 2020 was 19.7%, 22%, and 26.5%, respectively.

In the elderly group in 2010, the prevalence of i-IFG was 10.9% (F: 9.8%, M: 12.3%), i-IGT 10.9% (F: 11.2% and M: 10.5%), and IFG+IGT 12.2% (F: 14%, M: 10%). The estimated increase in people with i-IFG, i-IGT, and IFG+IGT between 2010 and 2020 was 46.3%, 45.8%, and 43.7%, respectively (Table 1).

Similarly, in 2010, the age-standardized prevalence for the high risk group (HRG, which is defined if HbA1c was higher than 39 mmol/mol but lower than 48 mmol/mol) [18]. The frequency of HRG in the general population was 21% (F: 23%, M: 17.3%), while in the elderly it was 35.9% (F: 36%, M: 35.7%). In the 10-year period from 2010 to 2020, the estimated increase in people at HRG category was 26.7% for the general population and 44.7% for the elderly group (Table 1).

Trends in age-standardized diabetes rates

The estimated age-standardized total diabetes rate in the general population in 2000 was 6.6% (F: 7.6%, M: 5.6%), and the 2009 estimate was 7.2% (F: 8.2%, M: 6.1%). Annual estimates for age-standardized diabetes prevalence between 2010-2020 showed a linear trend, increased from 14.1% (F: 15.5%, M: 12.7%) in 2010 to 15.5% (F: 17.0%, M: 14.1%) in 2020 (Table 2, and Fig. 1A).

Approximately, 28% of people with diabetes was in the elderly age. Estimated age-adjusted diabetes rate was 35% (F: 38.7%, M: 30.1%) in this group. The estimated diabetes increase over the 10-year period was 31.6% in the general population and 45.7% in the elderly group. In other words, the number of adults (20-84 years old) with diabetes increased by approximately 2.2 million between 2010 and 2020, exceeding 9 million in total (2.5 million of whom in the elderly ages).

Between 2010 and 2020, the age-standardized estimated rate of known diabetes in the general population increased from 7.6% to 8.5%. Undiagnosed diabetes also increased, from 6.7% to 7.2%. Both known and recent diabetes were higher in women than men. In the elderly group, known diabetes was 20% and new diabetes was 14.9%. Similar to the general population, both were more common in women than men. Diabetes awareness in this period was 54% in the general population and 58% in the elderly population, with comparable rates among women and men (Table 1).

Future projections

Based on the linear increasing trend between 2010 and 2020, the age-standardized diabetes prevalence is predicted to reach 15.9% in 2023 and 19.1% in 2045. The corresponding projected rates will be 17.4% and 14.5% in 2023, and 20.7% and 17.5% in 2045 for women and men, respectively (Table 2 and Fig. 1B).

Regional status

Geographically, the diabetes trends were increasing in all regions of the country with the highest estimated rate in Western Anatolia (from 15.6% in 2010 to 17.2% in 2020), and the lowest rate in Northern Anatolia (from 11.7% in 2010 to 12.9% in 2020). Whereas diabetes trends in Central, Southern, and Eastern Anatolian regions were similar, and close to each other (Fig. 1C).

Comparative age-adjusted prevalence rates

Based on the TURDEP-II crude age-specific prevalence of prediabetes (based on FPG and/or OGTT) 31%, HRG 23.5%, and that of diabetes was 16.8%, (Supplementary Table 1). Estimated age-adjusted comparative rates of prediabetes at any degree were 29.8% and 31.3% based on standard world and European population models, respectively. Whereas, the comparative age-adjusted rates for the HRG category were calculated 18.2% and 22.1%, in the same order. On the other hand, the comparative age-adjusted diabetes rates using the standard world and European population models were estimated 15.0% and 19.4%, respectively (Fig. 1D, Supplementary Table 1).

DISCUSSION

Considering only the population dynamics between 2010 and 2020, this study estimates that the 10-year growth in the country's population with any degree of glucose intolerance is over 5.3 million (approximately 2.2 million with diabetes and 3.1 million with prediabetes). Diabetes prevalence is projected to increase to 15.9% in 2023 and 19.1% in 2045. In the general population (20-84 years), the estimated increase in the prediabetes population between 2010 and 2020 is 22% and diabetes 31.6%. However, the rate of increase in the elderly group (65-84 year) is much higher (both at about 45%).

Our study is referenced on two nationwide population-based field surveys [4, 5]. These studies have provided important information about changes in the prevalence and risk factors of diabetes, hypertension and obesity in

the country over a twelve-year period. A meta-analysis of studies with a low risk of bias between 2003 and 2011 in Turkey suggested that the increase in diabetes prevalence reached a stable level [20]. However, the results of the current study did not confirm this; On the contrary, it has been revealed that the diabetes epidemic continues and the increase will go on in the coming decades. Undoubtedly, one of the most important reasons for this increase is the sociocultural and economic transition of the society experienced in the last quarter-century. The effect of this transition on public health was inevitable with changing lifestyle, i.e. consuming high-calorie foods, and reduced physical activity. Genetic and epigenetic factors and the longer life expectancy are other accountable factors for the increase in the prevalence of diabetes.

Aging of the population

Increasing life expectancy due to decreasing birth and mortality rates has led to the aging of the society. Median age, which is one of the best indicators in this regard, increased from 24.8 years to 32.7 years in Turkey between 2000 and 2020, corresponding to an increased average life expectancy (from birth) from 67 to 75.9 years in men and from 73 to 81.3 years in women [15]. While the population aged 65 years and above was 8.2% of the total population in 2015, it has increased by 22.5% within the last five years and reached 9.5% (over 8.2 million people) in 2020 (55.8% women). The proportion of the elderly population will continue to increase; It is expected to be 10.2% by 2023 and 16.3% by 2040 [20].

Diabetes mellitus is a common chronic disease in the elderly, being either a known disease with a long history (often type 2 diabetes) or may have been ignored for a rather long time. Age and weight are main risk factors for the development of diabetes. Notable in normal aging there is a 0.1 mmol per liter per decade rise in FPG, placing older people at increased risk for the development of diabetes. Weight gain and decreased muscle mass are often seen with increasing age, resulting in worsened insulin resistance and impaired beta-cell function. In addition, concomitant diseases, decreased activity, and medications can worsen insulin resistance. According to the 2020 estimates of the current study, the prevalence of age-standardized diabetes in the general population is 15.7%, while it is 2.2 times higher (35.1%) in the 65 years and older group. Furthermore, the 10-year diabetes increase in the elderly group is 1.4 times higher than in the general population (45.7% vs. 31.6%) with a slightly higher awareness rate (58% vs. 54%, respectively). The situation is even worse in developed countries. One-third of the U.S. population over 65 years old has diabetes, and one half of those has prediabetes [21].

Previous nationwide studies on diabetes and prediabetes

Although a limited number of population-based studies have been conducted in the country since the beginning of the 2000s, there was no consistency between the studies, especially in terms of the age of the participants and the method of diagnosis of diabetes. Except for the TURDEP surveys, OGTT was not used as a diagnostic method in any of these population-based studies. Diagnosis of diabetes in most studies based on either FPG and/or HbA1c, or self-reported diabetes on antidiabetic therapy.

In the 2002-2006 cohort (n=2825) of the 'TEKHARF study', diabetes prevalence in participants aged 35-74 years was 11.8%, while in the 2007-2012 cohort (n=2359) the prevalence raised to 18.4% [7]. In the 'Chronic Renal Disease In Turkey' study (n=10.748), the frequency of diabetes was reported to be 12.7% in participants aged 18 years and over [6]. Likewise, in the Turkish arm of the PURE study' (n=4056), diabetes in the 35-70 age group increased from 13.7% in 2008 to 21% in 2015 [22]. On the other hand, the Ministry of Health also periodically

screens for chronic diseases in the population aged 15+ years. Accordingly, in 'Turkey Frequency of Chronic Diseases and Risk Factors Survey, 2011' (n=14,992) the prevalence of diabetes was 11.1% [23], and in the 'STEPS-Turkey, 2017' (n=3257) was 17.3% [24]. In 'Turkey Nutrition and Health Survey, 2017' (n=9290) diabetes in the population 20+ years was 13.5% [25]. In almost all of these studies, revealed that the prevalence of diabetes in the population increased over time and it was always more prevalent among women than men.

In contrast, prediabetes was investigated only in the studies by the Ministry of Health. However, since OGTT was not performed in these studies, we do not have information about IGT. Besides, there is an uncertainty for IFG as some studies used ADA (FPG 5.6-6.9 mmol/L) [26] and others WHO (FPG 6.1-6.9 mmol/L) criteria [27]. The prevalence of IFG (based on ADA criterion) in the population aged 15+ years in the 'Turkey Frequency of Chronic Diseases and Risk Factors Survey, 2011' was 15.8% [23]. The 'STEPS -Turkey, 2017' in population 15 years and above reported a 7.9% IFG [24] and the 'Turkey Nutrition and Health Survey, 2017', in population aged 20+ years resulted in a 17.3% IFG prevalence. Both studies used WHO criterion to define IFG. In the latter, 24.3% of the study participants was found in the HRG category [25]. Based on our estimation study, when isolated and combined IFG and IGT cases are taken together, approximately 30% of the population may have prediabetes of any degree, and 21% is in the HRG category. In the population aged 65 and over, considering the both categories one-in-three elderly people may have any degree of prediabetes. In general, IFG is more common than IGT in the population; however, IGT is more prevalent among women and older people. In addition, 10-year increase in rates of prediabetes and HRG are close to each other; estimates for the general population were 22% and 26.7%; while both were much higher in the elderly, resulted in 45.2% and 44.7% in the same order (Table 1).

Geographic distribution

In 'Turkey Frequency of Chronic Diseases and Risk Factors Survey, 2011', known diabetes was highest in West Marmara (10.2%) and lowest in Northeast Anatolia (5.9%) [23]. Similarly, in the 'Turkey Nutrition and Health Survey, 2017', the highest prevalent diabetes was in Western Black Sea Region (14.4%) [25]. The results of the current study are consistent with the above-mentioned studies; accordingly, it is estimated that total diabetes is seen lowest in North Anatolia (11.7%) and highest in West Anatolia (15.6%).

Diabetes in the Middle East and Balkan countries

According to the diabetes trends between the years 1980-2014 reported by WHO, the Eastern Mediterranean Region has experienced the greatest rise in diabetes prevalence [11]. Likewise, IDF's Middle East and North Africa regions had the highest prevalence above seven regions [2]. For instance, diabetes affects over 25% of the adults in Saudi Arabia [28], while in Qatar, even in 2012 the prevalence was 16.7% in adults [29]. Rapid transformation of lifestyle from rural to urban, socioeconomic development, decreased physical activity, and high consumption of fat and sugary foods caused rising rates of obesity and diabetes can be count as reasons for the epidemic of diabetes in these countries [30]. Whereas, based on IDF estimations in 2019 Lebanon (11.2%) and Libya (10.2%) had the closest prevalence with Turkey (11.1 %) [2].

The lifestyle in Balkans shows much similarities with the Turkish population. In Greece, according to the national EMENO survey (2013–2016), 11.6% of the adult population reported to have diabetes [31]. In the Republic of Macedonia, diabetes prevalence of diagnosed cases in population 20–79 years was 5.0%, higher in females than in males and in rural than in urban; it was highest in the age group 60–79 years (14.6%) [32]. A nationwide study

in Bulgaria reported a 7.9% diabetes prevalence in 2006 and 9.6% in 2012, both were in more prevalent among men [33].

The overall prevalence of diabetes was 13.3% in the 2016 WHO-STEPwise surveys [34]. According to the STEPS studies repeated at regular intervals in the region, the prevalence of diabetes in Iran in 2005 was 7.7%, higher among females than males; however, in 2016 rose to 10.9% [35]. In Jordan, diagnosed adults aged 18+ years increased from 6.4% in 2002 to 7.5% in 2004, 9.4% in 2007, and 23.7% in 2017 [36].

Global situation of diabetes and prediabetes

NCD Risk Factor Collaboration found that age-standardized diabetes prevalence in adults increased or at least unchanged all over the world since 1980. However, mainly due to population growth and aging the number of adults with diabetes nearly four times increased over three decades [12]. Age-standardised adult diabetes prevalence in 2014 was lowest in north-western Europe and highest in Polynesia and Micronesia, at nearly 25%, followed by Melanesia and the Middle East and North Africa [12].

Global Burden of Disease collaborators emphasized that the prevalence of type 2 diabetes in 2017 was 13.2%, higher among males than females, and the regions where male prevalence rates exceeded those of females by the largest margins were high-income countries. Generally, the burden of diabetes had increased significantly since 1990. In 2017, the global incidence, prevalence, death, and disability-adjusted life-years related with diabetes were 22.9 million, 476 million, 1.4 million, and 67.9 million, with a projection to 26.6 million, 571 million, 1.6 million, and 79.3 million in 2025, respectively [37]. Accordingly, in Turkey, 257,336 incidents of type 2 diabetes were reported in 2017, representing 35.6% increase in incident cases since 2007. The age-standardized incidence rate was 290 per 100 000 populations in 2017, representing a 7.6% increase throughout the study period [38].

WHO estimated the incidence of age-standardized comparative diabetes to be 12.2% in Turkey in 2014 [11]. On the other hand, in the country profile of 2016, the prevalence was reported 13.2% [39]. Notably, these estimations could be useful in policy-making, priority setting, and resource allocation in diabetes prevention and treatment.

Our estimations from 2000 to 2020 shows an increasing temporal trend of diabetes cases. This is consistent with the existing studies in the regions and it seems to continue over the couple of decades.

According to recent estimates by the IDF, Turkey ranks the top first country in Europe in terms of both diabetes prevalence and population with diabetes from now [1]. In this study, the age-adjusted comparative diabetes prevalence was calculated as 19.4% according to the European population model. Given the fact that our society is aging like European populations, this shows the burden of diabetes will increase in the near future.

Finally, the projected diabetes prevalence is forecast to increase among the elderly appreciably in Turkey. IDF estimates imply that Turkey will rank the top ninth country with nearly 5 million people with diabetes aged 65+ years by 2045 [40]. It is clear that the public health impact and challenge of increasing numbers of older people with diabetes will likely be substantial. Diabetes continues to stretch the financial budget for public health and social care services due to more years lived unhealthy, frailty, and disability in our aging society.

The strengths and limitations

This study is the first comprehensive analysis to estimate age-standardized diabetes prevalence rates and forecast the future expectations in Turkey using reference data from previous field surveys and annual demographic

dynamics of the population in Turkey. The fact that these analyses were based on studies conducted in the same centers with country representation, made it easier to make future projections. In addition, the use of both FPG, OGTT, and HbA1c in these studies made it possible to make predictions for various degrees of prediabetes categories.

Nevertheless, we were not able to model different risk factors such as nutritional and exercise habits, BMI, hypertension, smoking, alcohol consumption, birth weight, socioeconomic status, or public health and medical interventions. Considering that the restrictions imposed by the COVID-19 pandemic, which has affected the whole world since the beginning of 2020, have increased inactivity and changed people's eating behaviours; facing a globally more intensified diabetes pandemic at least over the next decade may be inevitable. In this scenario, our modelling is likely to have underestimated future diabetes trends.

CONCLUSION

Forecasts based on population dynamics that provide projections for the country's medium-term future will be critical information for health policy makers. Periodic prevalence estimates and projections for diabetes today can offer a rational guidance to facilitate the promotion of prevention programs, particularly for type 2 diabetes, and improve care for all people with diabetes. According to our estimates, more than 9 million people (including 2.5 million elderly) are currently suffering from diabetes in Turkey, and another 17.4 million with any degree of prediabetes (including 2.4 million elderly). It is projected that the prevalence of diabetes will increase to 15.9% in 2023 and 19.1% by 2045 reflecting a steady increase in diabetes in all regions of the country in both men and women over the next decades.

This scenario poses major social and economic burdens for the society that could hinder the development. Further action is needed to understand the drivers of this problem and to develop rational prevention strategies to address the growing global public health challenge. Unless fundamental steps are taken through a national prevention program to halt the escalating trends in Turkey, the burdens of diabetes on social, economic, and health services will become even more overwhelming.

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Author Contributions

IS designed the study and gathered the data. HI and KYA created the database. SB and FO analysed data with input from SC, NE and MY. SB, YDM, MY and SC searched the literature and assisted in the interpretation of the results. GG drew the figures. IS and SB drafted the manuscript. KYA and HI critically revised it for important intellectual content. All authors have read and approved the final version of the paper.

Table Captions

Table 1 Estimated age-standardized prediabetes and diabetes rates between 2010 and 2020 in Turkey (20-84 years and 65-84 years)

Table 2 The distribution according to years and genders of the age-standardized diabetes rates in Turkey

Figure Captions

Fig. 1A Change of standardized diabetes rates between the years 2010 and 2020 in Turkey.

Fig. 1B Comparison of estimated rates for 2023 and 2045 with those of 2000, 2010, and 2020. Statistical comparisons made on the general population. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Fig. 1C Age-standardized diabetes rates of the five geographical regions of Turkey between 2010 and 2020.

Fig. 1D Comparative age-adjusted prediabetes and diabetes prevalence according to the world¹⁶ and European¹⁷ standard populations. *Prediabetes rates based on fasting plasma glucose and/or oral glucose tolerance test. (Ref. no. 16. Ahmad, et al. 2001; Ref. No. 17. Eurostat, 2013).

Electronic Supplementary Material

Supplementary Table 1 Comparative age-adjusted prediabetes and diabetes prevalence according to the world and European standard populations. *Prediabetes rates based on fasting plasma glucose and/or oral glucose tolerance test. (Ref. no. 5. Satman et al, 201; Ref. no. 16. Ahmad et al, 2001; Ref. no. 17. Eurostat, 2013).

Figures

Figure 1

- A Change of standardized diabetes rates between the years 2010 and 2020 in Turkey.
- B Comparison of estimated rates for 2023 and 2045 with those of 2000, 2010, and 2020. Statistical comparisons made on the general population. *p < 0.05, **p < 0.01, ***p < 0.001.
- C Age-standardized diabetes rates of the five geographical regions of Turkey between 2010 and 2020.
- D Comparative age-adjusted prediabetes and diabetes prevalence according to the world16 and European17 standard populations. *Prediabetes rates based on fasting plasma glucose and/or oral glucose tolerance test. (Ref. no. 16. Ahmad, et al. 2001; Ref. No. 17. Eurostat, 2013).

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- [ESMSuppl.Table1.pdf](#)