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Original Article

The Burden of Type 2 Diabetes Mellitus and Attributable Risk Factors in Iran, 1990–2019: Results from the Global Burden of Disease Study 2019

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Abstract

Background: This study presents estimates for type 2 diabetes mellitus (T2DM) burden and attributable risk factors in Iran from 1990–2019, using data from the 2019 Global Burden of Disease study.

Methods: This study reports prevalence, incidence, death, disability-adjusted life years (DALYs), years of life lost (YLLs), and years lived with disability (YLDs) of T2DM in Iran, by sex, age, and province, from 1990 to 2019. We also present the T2DM burden attributable to risk factors. Results are reported in absolute number and age-standardized rates.

Results: Overall, the burden of T2DM had increased greatly since 1990. In 2019, the T2DM incidence and prevalence cases were 291,482 (a 374% increase) and 5,035,012 (a 417% increase) respectively. Moreover, the number of death and DALYs were 14,191 (a 488% increase) and 716,457 (a 417% increase) respectively. DALYs and YLDs in women were consistently higher than men were, whereas women experienced slower increases in YLLs from 1990 to 2019. The **a**ge-standardized DALYs rate increased for all Iranian provinces during study period. High body-mass index, ambient particulate matter pollution, and low physical activity remained the three major attributable risk factors in all provinces in 2019.

Conclusion: T2DM constitutes a major health burden in Iran. The remarkable upsurge in the T2DM burden represents an ongoing challenge, given the rapidly aging population in Iran. Thus, integrated and multi-sectoral actions that decrease exposure to risk factors and improve the prevention and early diagnosis are needed.

Keywords: Global burden of disease, Type 2 diabetes mellitus, Disability-adjusted life years, Risk factors

Introduction

Estimates from the latest global data show that people in low-middle, middle, and high-middle income countries are more prone to type 2 diabetes mellitus (T2DM) compared to high-income countries due to different reasons, such as social and economic transformation (1). People with T2DM have a 2-3 times risk of any cause of death (2). Moreover, the disparity in the diabetes death rate is very large, as, for example, evidenced by the 24-fold difference between the highest (Oceania regions) and lowest (high-income Asia Pacific) age-standardized death rates in 2017 (1). Diabetes is the second greatest negative total effect on reducing global health-adjusted life expectancy worldwide (2). The 2019 International Diabetes Federation (IDF) Diabetes Atlas 9th edition has reported that the Middle East and North Africa (MENA) region has the highest age-adjusted prevalence of diabetes in adults in 2019, 2030, and 2045 (12.2%, 13.3%, and 13.9%, respectively) (3). Therefore, the rising burden in Iran, which has the third-largest number of adults with diabetes aged 20–79 years in the MENA (3), is no wonder. The geographical distribution of T2DM is markedly by regional heterogeneities in Iran, with diabetes prevalence rates ranging from 9.9% in the southern regions to 14.1% in the central regions in 2019 (4). This increasing prevalence could be explained by a complex array of contributing factors such as population aging, urbanization, changes in nutrition, and sedentary lifestyles, along with limited access to health services and diabetes care (5). A systematic review conducted across all countries in the MENA suggests that obesity, physical inactivity, urbanization, and poor nutritional habits have contributed to the high prevalence of diabetes in this region (6).

Moreover, trends demonstrate a considerable rise in mortality due to diabetes over the past three decades in Iran. Given the trends of diabetes prevalence and mortality in Iran, it is necessary to investigate the burden to inform the current public health policies and provide a guide for disease prevention and health promotion strategies in the future. Disability-adjusted life years (DALYs) measure the total burden of disease—both from years of life lost (YLLs) due to premature death and years lived with disability (YLDs) due to prevalent cases of the disease in a population.

We aimed to determine the incidence, prevalence, death, DALYs, YLLs, and YLDs due to T2DM in Iran by sex, age, and Iranian provinces from 1990 to 2019. We aimed to verify the T2DM burden attributed to behavioral, environmental/occupational, and metabolic risk factors at national and subnational levels in Iran as well.

Methods

Data sources

The GBD 2019 study is incorporated risk factors and injuries in 204 countries and territories between 1990 and 2019. Overall, 369 disease and injury causes, 286 death causes, and 87 risk factors were analyzed. A detailed description of the methodology used in GBD studies, and the main changes incorporated into the GBD 2019 methods, have been described elsewhere (7). We extracted estimates from the GBD 2019 study through GBD results tool, which is publicly available to explore the T2DM burden in Iran (8). Prevalence, incidence, death, DALYs, YLLs, and YLDs were utilized to measure the burden of T2DM. DALYs capture loss of health owing to both fatal and non-fatal disease burden estimated by the summation of YLLs owing to premature mortality and YLDs. In short, YLLs were based on remaining life expectancy compared to a reference standard life table at death age. The YLDs were estimated by multiplication of prevalence of disease and a disability weight. Disability weighting was obtained from population-based surveys (9), and the GBD reference population was used to calculate age-standardized values.

Results are reported by sex, age group, year, and burden measures with their respective 95% uncertainty intervals (UIs) according to the 2.5th

and 97.5th values of the ordered 1000 draws of the uncertainty distribution in terms of absolute numbers and age-standardized rates (per 100,000 population) at national and provincial levels of Iran (7, 9). The age groups were classified by 5-year groups as follows: 15-19, 20-24, 25-29, etc. Percentage changes were reported to demonstrate increasing and decreasing differences between 1990 and 2019, respectively.

Geographical location and time period

Iran is divided administratively into 31 provinces. We present results for T2DM burden at the national level and all 31 provinces. GBD 2019 calculated the cause-specific burden for the years 1990–2019 (7). This study focuses on burden estimates for 2019, with reference to changes from 1990.

Socio-demographic index (SDI)

The SDI, an indicator of a location's socio-demographic development, is based on average income per person, average years of education among persons older than 15, and total fertility rate (1). The SDI ranges from 0 to 1, with a higher value showing a higher level of socioeconomic development. This index was used to categorize the country into five SDI quintiles.

Decomposition analysis

To investigate three components of population aging, age structure change (population growth), and changes in the age-specific incidence rates on the 30-year overall change of T2DM new cases, two hypothetical scenarios were developed. For the first cases, the age and sex structures, and the age-specific rates from the first year were applied to the last year's total population and the difference between the total number of cases in the first year and the first hypothetical scenario was assigned to population growth. Differences between the second hypothetical scenario (the age-specific rates from the first year were applied to the age and sex structures and population size of the last year) and the first hypothetical scenario were assigned to population aging. The proportion of age-specific rates was assumed as the differences between the total number of cases in the last years and the second hypothetical scenario (10).

Risk factor estimation

The estimations for the attributable burden of a particular **risk** factor–diabetes **outcome pair** were explained in GBD 2019. Based on the general framework established for comparative risk assessment (CRA), the attributable death, DALYs, YLLs, or YLDs were calculated as a total burden for the diabetes outcome multiplied by the population attributable fraction (PAF) for each risk factors. It indicates the proportional decrease in the average risk of disease over a given time that would be attained by removing the exposure of interest while leaving the distribution of other risk factors in the population unchanged (7).

Sixteen risk factors were obtained: metabolic, environmental–occupational, and behavioral. The metabolic risk factor was the high Body-Mass Index (BMI). The environmental–occupational risk factors were included ambient particulate matter (PM) pollution, household air pollution from solid fuels, high and low temperature. The behavioral risk factors themselves were placed into four categories: tobacco use (smoking and secondhand smoke), dietary (a diet low in whole grains, in fiber, in nuts and seeds, in fruits, and a diet high in sugar-sweetened beverages, in processed meat, in red meat), alcohol use, and low physical activity. Not all risk factors related to each burden measure may be equal to the sum of each one due to the interaction between risk factors.

Ethics approval

Ethical approval was not applicable, because this study was based on data that are publicly available and without nominal identification of individual data [https://vizhub.healthdata.org/gbd-compare/].

Results

The trend of T2DM burden from 1990 to 2019 in Iran

The disease burden of T2DM increased from 1990 to 2019 (Fig. 1). The overall new cases rose by 374.3% during the last 30 years, which this overall change can be separated, to population growth (44.0%), age structure change (103.4%), and incidence rate change (226.9%) (Table S1). The T2DM new cases rose from 61449 (95% UI 55484–68016)/100,000 in 1990 to 291482 (265077–320393)/100,000 in 2019, whereas the age-standardized incidence rate (ASIR) increased by 90% during the same period, from 170.5 (154.9–188.4)/100,000 in 1990 to 323.3 (295.7–354.4)/100,000 in 2019 (Table S2).

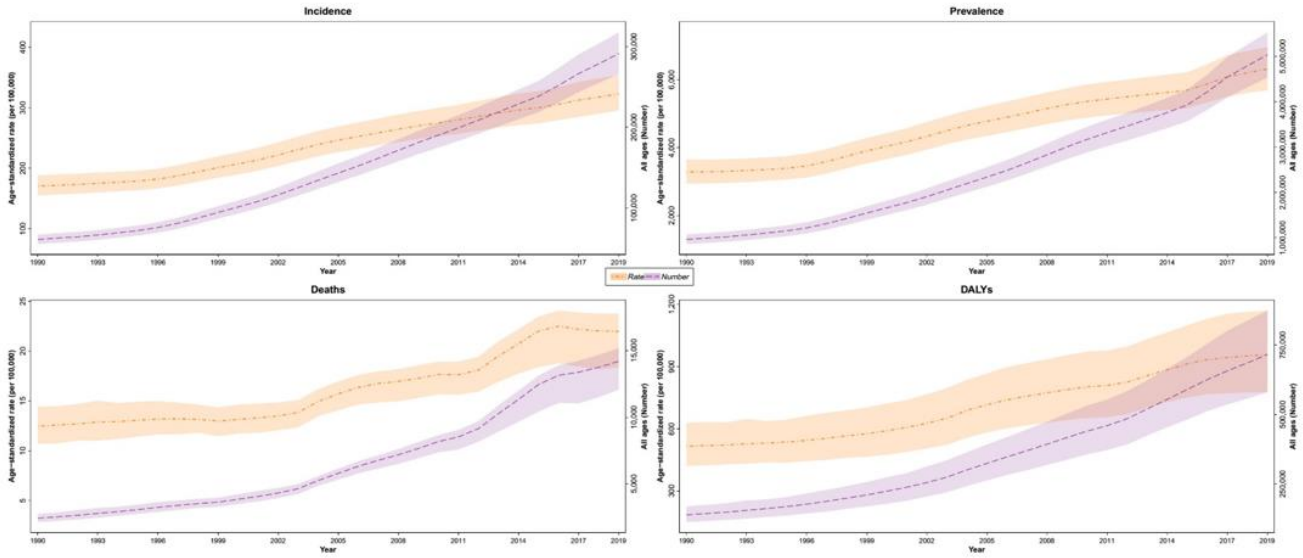

Fig. 1: Burden of type 2 diabetes from 1990 to 2019

The prevalence increased from 974556 (867290–1092764) in 1990 to 5035012 (4514277–5574025) in 2019, with a 417% increase. The age-standardized prevalence rate (ASPR) increased from 3285.6 (2940.8–3652.4)/100,000 in 1990 to 6312.9 (5690.2–6959.5)/100,000 in 2019, a 92% increase (Table S2). In 1990, men had higher ASIR and ASPR, while women had higher ones than men in 2019 (Table S2). There appears to be a major shift in the sex distribution from 1990 to 2019. Besides, the incidence and prevalence rates for both sexes were the highest in 45–49, 50-54, 55–59, and 60–64 yr old people, in 2019 (with a peak in 55–59-year-old people) (Fig. 2, A-B).

Deaths due to T2DM increased from 2414 (2110–2761) in 1990 to 14191 (12014–15320) in 2019, with a 488% increase. The age-standardized death rate (ASDR) increased from 12.5 (10.7–14.4)/ 100,000 in 1990 to 22.0 (18.4–23.8)/100,000 in 2019, a 76% increase (Table S2). DALYs increased from 138646 (111692–170125) in 1990 to 716457 (578136–882592) in 2019, with a 417% increase. The age-standardized DALYs rate increased from 516.5 (420.7–628.2)/100,000 in 1990 to 958.1 (776.6–1170.2)/100,000 in 2019, an 86% increase (Table S2). In 2019, the DALYs rate for both sexes were the highest in 65–69, 70–74, 75–79, and ≥80 yr old people (with a peak in the 75–79 yr aged) (Fig. 2, C). DALYs and YLDs rates in women were consistently higher than men, whereas women experienced slower increases in YLLs from 1990 to 2019.

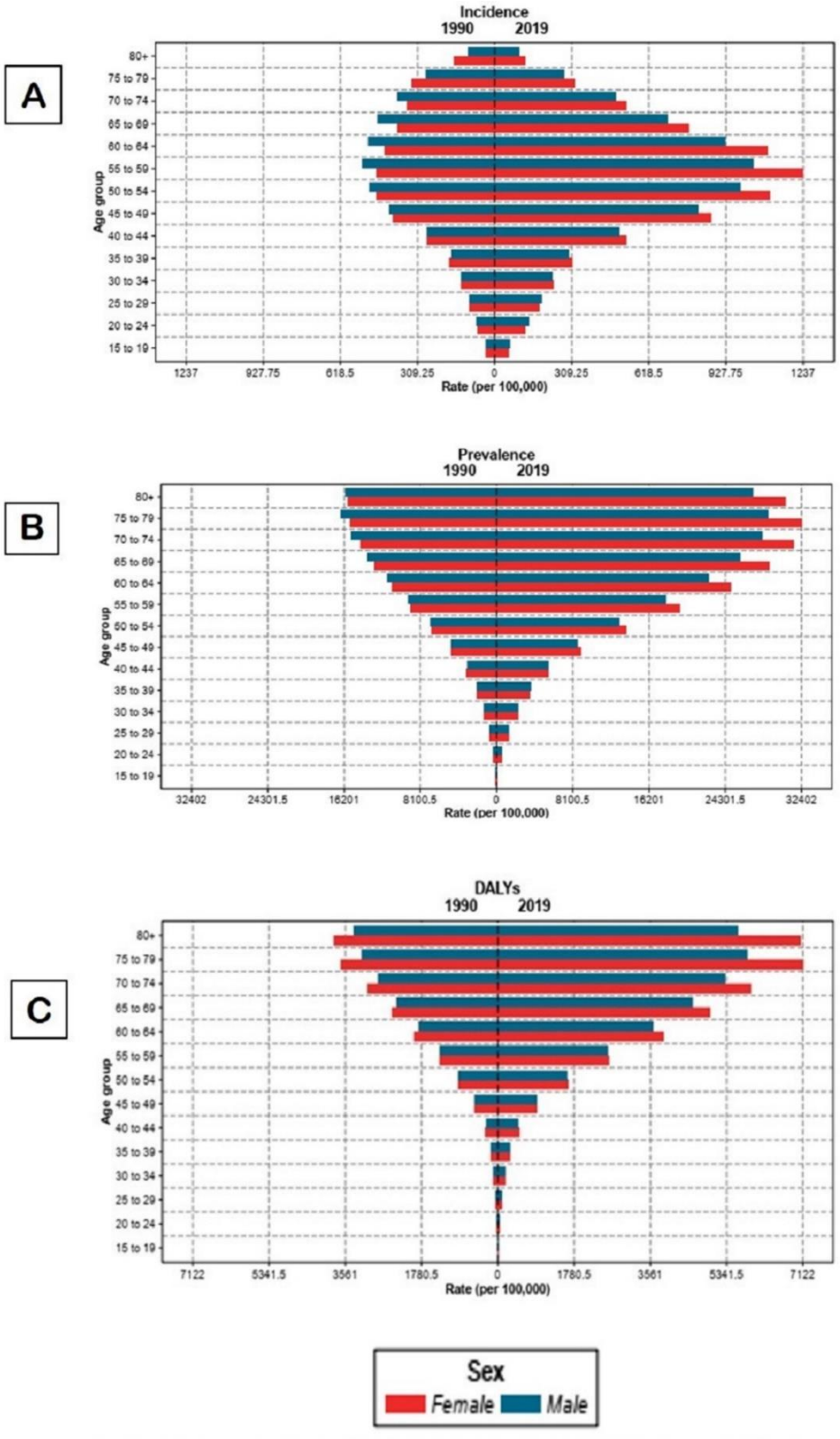

Fig. 2: Estimated age-specific incidence, prevalence and DALYs rates of T2DM by sex, between 1990 and 2019

T2DM burden trends at the provincial level

ASIR, ASPR, ASDR, age-standardized DALYs rate due to T2DM experienced an increasing trend in most Iranian provinces (Fig. 3, Table S3). In 2019, the ASIR ranged from 225.4 (204.1–249.1)/100,000 for Zanjan to 424.5 (386.8–467.9)/100,000 for South Khorasan. Provincial decomposition analysis revealed that the highest proportion in new cases change cause during 30 years in population growth (105.0%), age structure change (180.2%), and incidence rate change (396.8%) were belonged to Hormozgan, Alborz and Alborz, respectively (Table S1).

The ASPR also varied considerably by province, ranging from 4471.1 (3977.7–5003.1)/100,000 for Zanjan to 9288.3 (8378.6–10359.8)/100,000 for South Khorasan in 2019.

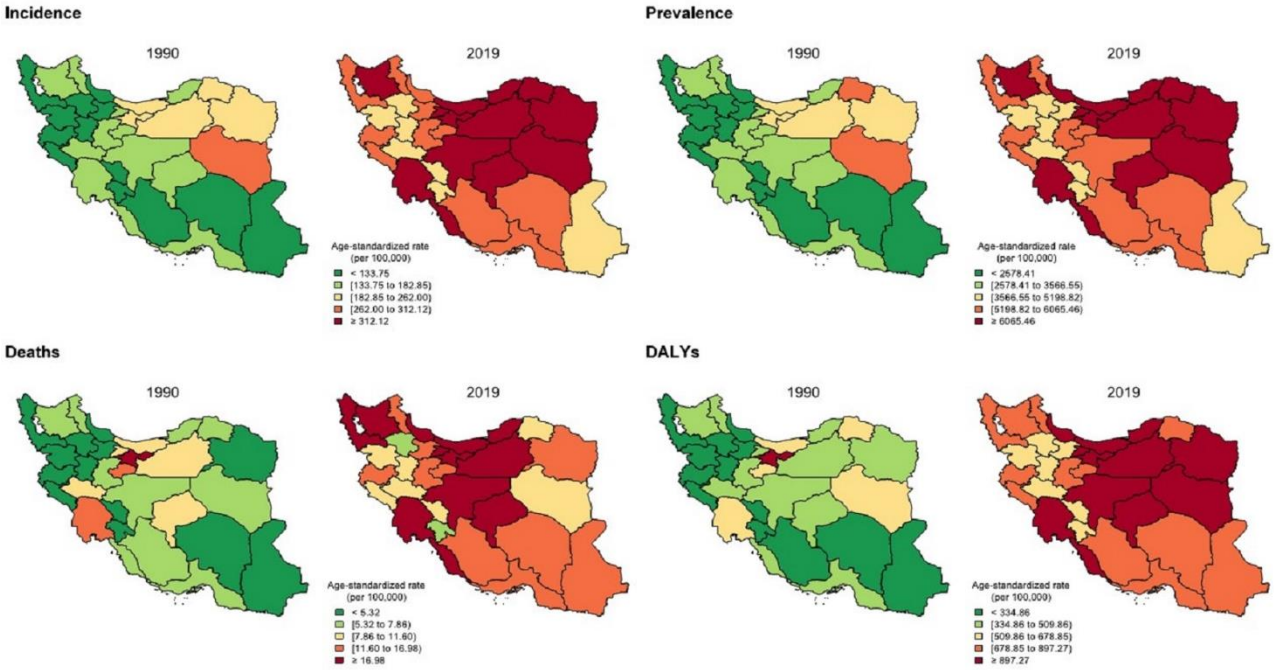

Fig. 3: Age-standardized incidence, prevalence, death and DALYs rates for T2DM in Iranian provinces between 1990 and 2019

In 2019, the ASDR (per 100,000 population) were highest in Khuzestan [38.0 (28.5–44.1)], and lowest in Zanjan [7.3 (6.3–9.2)]. All provinces experienced an increase in ASDR between 1990 and 2019 except for Tehran, the capital of Iran (-9%), which showed a non-significant decrease. The highest increases were observed in Bushehr (303%), Gilan (297%), and Golestan (289%) and Ilam (232%) (Table S3).

The age-standardized DALYs rates (per 100,000) were highest in Khuzestan [1462.8 (1193.4–1756.4)], Yazd [1240.1 (1006.2–1515.5)] and Tehran [1194.3 (946.2–1437.5)]. In contrast, Zanjan [532.2 (405.0–680.7)], Kohgiluyeh and Boyer-Ahmad [539.7 (409.6–690.8)] and Chaharmahal and Bakhtiari [550.4 (421.1–703.1)] had the lowest age-standardized DALYs rates in 2019. The age-standardized DALYs rates increased in all 31 provinces between 1990 and 2019, with the highest growth observed in Gilan, Golestan, Bushehr, Ilam, and West Azerbaijan (a relative increase of 150% or more), while the smallest increases were observed in Tehran, North and South Khorasan, Lorestan and Qom. The rise that was observed in Tehran was non-significant (Fig. 3, Table S3).

The age-standardized YLDs rates (per 100,000) showed an increasing trend in all provinces during 1990-2019, with the highest increases observed in Gilan (149%), Fars (136%), Yazd, (133%) and Khuzestan (130%). Moreover, the age-standardized YLLs increased in almost all provinces between 1990 and 2019, with faster slope in age-standardized rates when compared to YLDs. The greatest rises in the age-standardized YLLs rates were observed in Golestan (298%), Bushehr (291%), Gilan (290%), and Ilam (228%) (Table S3).

The burden of T2DM by socio-demographic status

At the provincial level, the ASIR, ASPR, ASDR, and age-standardized DALYs rates (per 100,000) increased across the five SDI regions from 1990–2019 (Fig. 4). The increase in ASIR and ASPR was largest in economically less developed provinces, including Gilan, Fars, Yazd, Ilam, and Khuzestan. Except for Tehran, the remaining provinces had an increment in the ASDR and age-standardized DALYs rate even in high and high-middle SDI provinces.

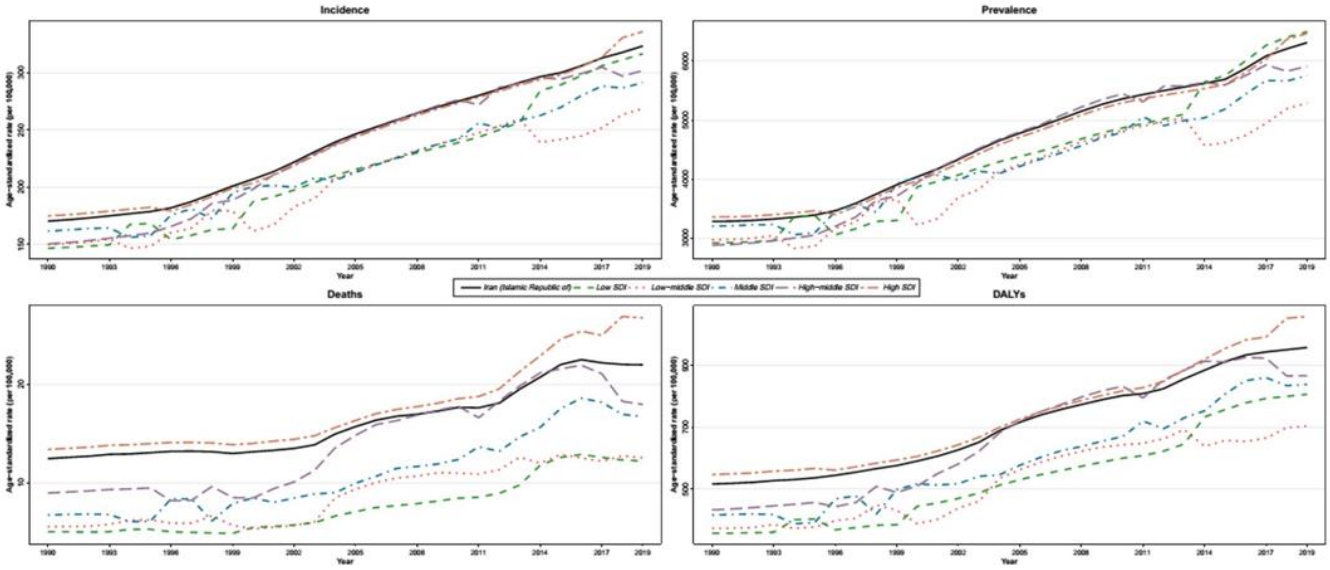

Fig. 4: Burden of type 2 diabetes in different SDI regions in Iran from 1990 to 2019

Modifiable risk factors

High BMI (63.0%), ambient PM pollution (22.2%), and low physical activity (12.9%) remained the three major risk factors based on the percent of attributed age-standardized DALYs rate in Iran (Table S4). The top three major risk factors at the provincial level in 2019 showed homogeneity. Among dietary risk factors, the diet low in whole grains had the highest contribution of diabetes DALYs compared to other dietary patterns in all provinces (Fig. 5).

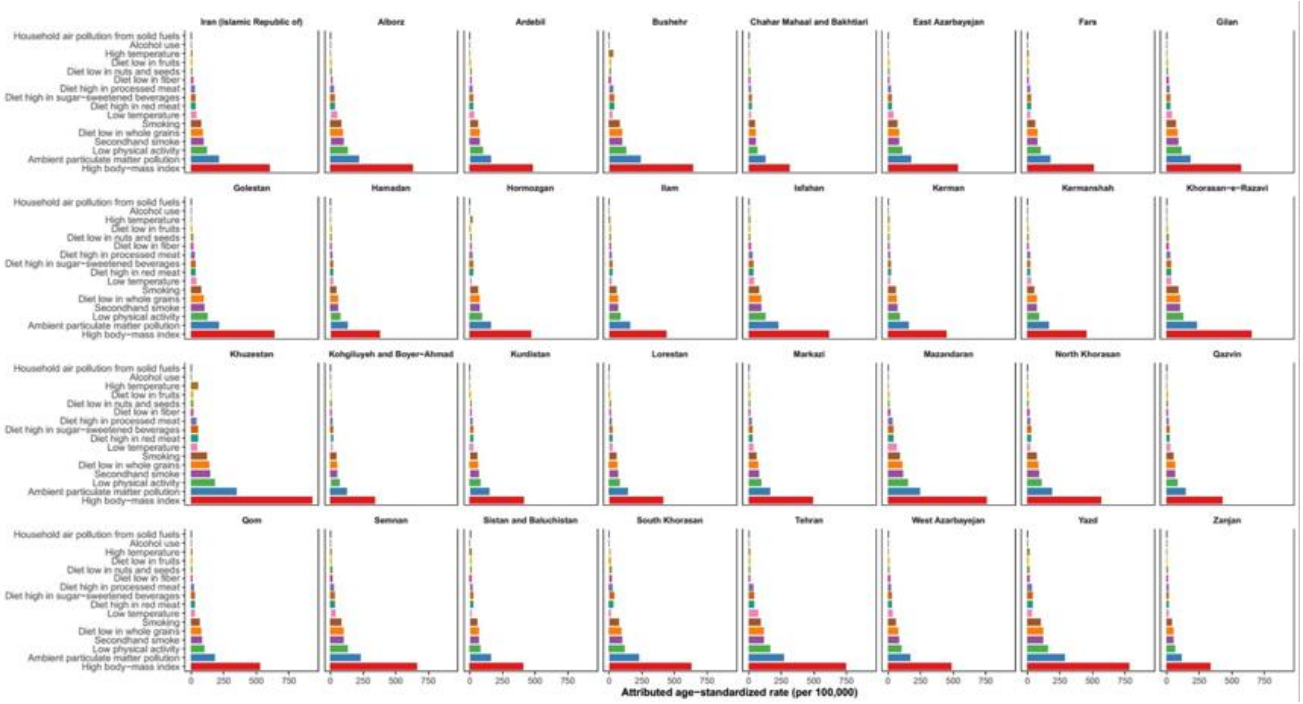

Fig. 5: T2DM age-standardized DALYs rate attributable to different risk factors in Iran, year 2019

Discussion

GBD 2019 findings showed that the ASIR, ASPR, ASDR, and age-standardized DALYs rate have nearly doubled during the period 1990–2019 in Iran. In 2019 compared to 1990, the prevalence rate in people aged 25-54 yr had considerably increased, which indicates the overall diabetes population has become younger. A relatively high prevalence of overweight/obesity among children in Iran has been shown in studies. Obesity in childhood and adolescence can be a trigger for starting insulin resistance, which may lead to an increase in the risk of T2DM among younger segments of the population (11). However, compared with developed countries, diabetes in Iran has been lately characterized by significant growth, mostly related to early disease onset, which remains much room for improvements in diabetes care quality and education (12). Therefore, diabetes-related health education is needed be done among Iran's working and middle-aged individuals.

Relatively noticeable discrepancies were found between sexes in the T2DM burden. Besides the overall increase of diabetes at the national level, the highest annual percentage changes in incidence and prevalence rates were observed in women than men between 1990 and 2019. The reason for this upward trend among women, except for a higher rate of diagnosis awareness in women (13), could be explained by the higher prevalence of overweight and obesity in this gender. Results from population-based studies in Iran showed that over the last decades, women have become more obese, with twice the prevalence among men (14).

Our study showed that the mortality rate increased in both sexes during the 1990–2019; however, the total number of deaths was higher in women. In a study conducted in Iran to investigate the trend and projection of mortality rate due to NCDs, a constant upward trend was observed for diabetes in both sexes from 2001 to 2015. The diabetes mortality rate will be higher in females, continuing to 2030 (15). This difference between men and women could be the result of

experiencing various risk factors, including high BMI (14), sedentary lifestyles, or air pollution exposure (16).

Provinces have witnessed an increase in the T2DM burden since 1990, especially after 2010. Furthermore, the increase in YLLs exceeded the rise in YLDs in most provinces by far. According to the recent estimates, diabetes was the ninth leading cause of age-standardized YLLs for both sexes in Iran. Despite the improvements in the quality of diabetes care and access to treatment (12), diabetes survival is relatively low in Iran, demonstrating the weak and challenged diabetes response in our country.

All the health metrics of the T2DM burden increased in each province between 1990 and 2019, regardless of its SDI category. However, the highest rates in 2019 were observed in provinces in the middle and high-middle SDI quintiles, and the remaining showed a lower increase. These results showed the higher diagnosis rates, up-to-date healthcare infrastructure, and primary care in these quintiles (17). Over the 30-year period, significant increases were also observed in incidence and prevalence rates in the low SDI quintile probably due to improvements in access to diagnostic facilities.

This remarkable upsurge in the T2DM burden could be partly explained by a homogeneous pattern in risk factor exposures across provinces. In fact, high BMI, ambient PM pollution, and low physical activity were the top three major risk factors in all provinces. Diabetes is multifactorial, and modifiable risk factors play a key role in DALYs and deaths due to T2DM. For example, in Qatar and Bahrain, a high prevalence of obesity has been reported, which may be a strong reason for the high death and DALY rates of T2DM in these countries (18).

Over the study period, Iranian society has experienced demographic shifts, changes in lifestyle, economic and social structures, and environmental factors that have had a considerable impact on potential T2DM risk factors (19). Metabolic risk factors such as high BMI, which is a significant risk factor for T2DM has become a major public health problem in Iran. The prevalence of obesity among adults in Iran has doubled during 1990–2019 (14). Obesity has turned into the number-one factor for diabetes in Iran. Although grains are a staple food among the Iranians, most of the dietary carbohydrate intake is from refined grains such as rice and white flour, which usually have higher amounts of glycemic index. There has been a consistent association between high intakes of refined grains and the risk of obesity and diabetes (20), so higher intakes of whole grains need to be encouraged. Other eating behaviors are also concerning, since consumption levels of healthy dietary factors such as fruits and vegetables remain stably low (21). In this regard, emerging hypermarkets are also blamed for the decline in consumption of whole grains, fruits, and vegetables since they make processed, high-fat, energy-dense, sugar- and salt-laden meals more readily available at comparatively low prices. Therefore, policies restricting the availability of unhealthy foods should be considered. Moreover, physical inactivity and smoking are also leading contributors to the diabetes burden in our country. Population-based lifestyle interventions could be an effective way to reduce the incidence of diabetes. For example, weight loss using intensive lifestyle interventions during a 10-year follow-up in Qatar and Bahrain showed the potential to reverse T2DM (22).

The 2015 Iranian project to tackle the NCDs (23), consistent with the WHO Action Plan (24), emphasized on the control of diabetes and its risk factors but has yet to generate favorable trends in diabetes burden. On the positive side, the National Plan for Prevention and Control of Diabetes has proven to be successful in identifying individuals at risk; however, the rising current of diabetes is leaving behind these efforts. WHO targets (24) are consistent with the focus of that plan including controlling risk factors, such as poor nutritional habits and sedentary lifestyles. However, what appears to be lacking is more effective implementation and close multi-sectoral collaboration and coordination among various stakeholders from inside and outside of the health sector in the policy formulation and practice (25). The prevention and control of diabetes

have the potential not only to enhance the general population's health, but also to support the sustainable development of economy and society in the country.

Our research has some strengths and limitations. First, it presents the most advanced and accurate information on the burden of T2DM in Iran and provides a point of reference for healthcare policymakers. Second, the GBD 2019 study has a standardized methodology for estimating the diabetes metrics, allowing comparisons on a global scale and at provincial levels in each country studied. However, there may be some defects and biases in the data availability and processing based on methodology.

Conclusion

The T2DM burden has increased rapidly in Iran between 1990 and 2019. Our study provides necessary baseline information about the T2DM burden in Iran, expected to allow a better plan to meet our burden and manage our limited resources more productively. What we reported for Iran, however, in one degree or another, can be found in most developing countries around the world.

Our results highlight the importance of reinforcing control and surveillance plans and policies in Iran through integrated and multi-sectoral actions that decrease exposure to risk factors and improve the prevention and early diagnosis of this disease. Local healthcare authorities can use these data to map appropriate and timely population-level initiatives and interventions in areas where the ability to respond to diabetes has been compromised.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of interest

The authors declare that there is no conflict of interests.

Data accessibility

The supplementary tables and dataset used in this study are available in the GBD compare tool (https://vizhub.healthdata.org/gbd-compare).

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