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ORIGINAL ARTICLE

Diabetes in southern Iran: a 16-year follow-up of mortality and years of life lost

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Abstract

Background Diabetes mellitus (DM) had one of the highest global disease burdens and is associated with premature morbidity, mortality, and reduced life expectancy. There has been little study regarding mortality and years of life lost attributable to DM in low-and-middle income countries.

Methods In this cross-sectional study, mortality rate and years of life lost (YLL) due to diabetes and its complications were examined during the years 2004–2019. Death statistics were collected through electronic registration of death of ministry of health and medical education for Fars province. Age standardized mortality rate (ASR) and joinpoint regression analysis carried out.

Results A total of 6,403 deaths due to diabetes and its complications were recorded. Of these, 53.11% (3,401 cases) were women. The total YLL during the same period was 35,664 (1.13 per 1000 people) in men, and 42,459 (1.37 per 1000 people) in women. Diabetes resulted in a total of 78,123 YLL with an average 12 years of life lost per person with diabetes. According to the joinpoint regression, the 16-year trend in the YLL due to diabetes and its complications was increasing. The APC (annual percent change) was 4.7% (95% CI 1.9–7.5, p=0.002) for men, and 4.5% (95% CI 2.9–6.1, p<0.001) for women.

Conclusions In this study, we found that from 2004 to 2019, the crude mortality rate, age standardized rate, and years of life lost due to diabetes were on the rise. We found obvious sex differences in diabetes-related deaths. The highest YLLs were in the age range 50–64. An accurate estimation of diabetes mortality could provide empirical support for future diabetes prevention and control strategies, determine priorities in health protection, and provide a basis for accurate prevention and control of diabetes in different regions and groups.

Keywords Diabetes · YLL · Trend · Joinpoint regression · Iran

Introduction

Diabetes mellitus (DM), a non-communicable disease, had one of the highest global disease burdens according to study of the global burden of 369 diseases in 204 nations [1–3]. DM is also associated with premature morbidity, mortality, and reduced life expectancy [4, 5]. Life expectancy is an outcome measure for health improvement activities and a key index for comparing healthcare systems between countries [6]. DM has been shown to reduce life expectancy by 3.3 years to 18.7 years [7, 8]. Persian men and women diagnosed with diabetes between 1992 and 2010 have been shown to have a years of life lost (YLL) measure of 13.2 and 13.9 years, respectively [4]. One of the most important aspects of healthcare planning is determining the disease mortality rate. Clearly determining the contribution of each disease to the reduction in life

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expectancy informs healthcare policymakers in the process of managing healthcare expenditure and public health priorities [8]. There has been little study regarding mortality and years of life lost attributable to DM in low-and-middle income countries [9–11]. This study used a joinpoint regression model to determine the trend in mortality and YLL attributed to DM.

People with DM have a higher mortality rate and a lower life expectancy in comparison to the overall Persian population [4]. Patients with DM living in the Persian community are reported to spend a vast amount of money on healthcare, with an average paraclinic cost per patient of 393.6 USD and inpatient cost per patient of 1520.7 USD [12]. In addition, the prevalence of DM has been shown to be increasing in both developing and developed countries over the past three decades. The quality of diabetes care has also gradually improved over this period. This growing prevalence of DM and increasing cost of health care motivate long-term study to monitor the mortality and YLL attributable to DM each decade in order to establish a strategic diabetes planning program and prioritize intervention [10]. Such study is essential in monitoring healthcare programs, allocating resources, prioritizing intervention programs, setting epidemiological research priorities, establishing health policies, and conducting medical research [10]. The YLL is an essential criterion for ranking society's health status and evaluating its challenges. Based on WHO report, the value of 1 year of life is three times more than the gross domestic product of each country [13]. Because there has been no study to measure YLL due to diabetes in southern Iran, this study is designed to compensate for this lack of information.

Methods

Study design and data sources

In this cross-sectional study, the mortality rate and years of life lost (YLL) due to diabetes and its complications were examined during the years 2004–2019. The analysis was undertaken by trained physicians in Iran. First, death statistics were collected through electronic registration of death of ministry of health and medical education. Deaths were then codified for cause of death according to the national protocol and the international classification of diseases (ICD) code [14, 15].

All deaths of people with diabetes and its complications were associated with the person's age, sex, and year of death based on ICD-10 (Code E10-E14) to identify the leading cause of death [16]. Duplicate records were excluded based on similarities in the father's name, time of death, and national number.

The total estimated population of Fars province was estimated using basic data from the population census from 1996 to 2016, and from health centers, taking into account the annual population growth. For standardization, the 2013 standard population for low-and-middle-income countries was used [17].

Statistics

Qualitative data were reported using frequency and percentage. Crude mortality and age standardized rate (ASR) of mortality due to diabetes and its complications were calculated by sex and year of death during the study years. The chi-square test was used to calculate the mortality trend over the study period. p-values <0.05 were considered statistically significant.

Data were analyzed using SPSS version 22 and Microsoft Excel 2016.

The YLL was calculated using the World Health Organization standard life table to determine life expectancy at birth by age and sex, as well as the number of deaths due to diabetes and its complications, also by age and sex, and based on the following relation [18]:

$$\boldsymbol{TLL} = NCe^{ra}/(\beta+r)^2\left[e^{-(\beta+r)(L+a)}[-(\beta+r)(L+a)-1]-e^{-(\beta+r)a}[-(\beta+r)a-1]\right]$$

where N = the number of deaths given a certain age and sex, L = the standard life expectancy of the deceased of a given age and sex, r = the discount rate (which was set to the default value of 0.03), β = the age-weighting constant (which was set to the default value of 0.04), C = a modified adjustment constant for age-weights (which was set to the default value of 0.1658), a = the age at which death occurred, and e is the mathematical constant (taken to be 2.71).

The analysis of the YLL due to premature death, due to diabetes and its complications was performed using the YLL template of 2015 from the World Health Organization in Microsoft Excel 2016.

To examine the trend of YLL across several years, joinpoint regression was used, based on the log-linear model. Joinpoint regression analysis is used to describe changing trends over successive periods of time and to quantify the increase or decrease within each period. The resulting line segment between joinpoints is described by the annual percent change (APC), based on the slope of the line segment and the average annual percent change (AAPC). One popular method of trend analysis is to estimate the conventional annual percent change (APC). The APC is estimated by fitting a simple linear model to calculate and interpret for long-term trend analysis. When the trend is not constant over the entire time period of interest, the nonlinearity of the trend may be characterized using the annual percent change from segmented analysis [19]. This joinpoint analysis of the trend was carried out by Joinpoint Regression Program version 4.9.0.0.

Results

During the 16-year study period from 2004 to 2019, 6,403 deaths due to diabetes and its complications were recorded in the geographical region covered by Shiraz University of Medical Sciences. Of these, 53.11% (3,401 cases) were women and the largest number (15.28%) were over 85 years old.

As can be seen in Table 1, the estimated diabetes-attributable crude mortality rate in men increased from 5.4 per 100,000 population in 2004 to 11.5 per 100,000 population in 2019 (a significant trend, $p<0.001$). The estimated diabetes-attributable crude mortality rate in women increased from 7.5 per 100,000 in 2004 to 16.1 per 100,000 in 2019 (a significant trend, $p<0.001$). Analysis showed that the ASR of mortality increased from 7.5 per 100,000 in 2004 to 11.9 per 100,000 in 2019 in men (a significant trend, $p<0.001$), and increased from 11.3 per 100,000 in 2004 to 15.2 per 100,000 in 2019 in women (a significant trend, $p<0.001$).

The total YLL during the same period was 35,664 (1.13 per 1000 people) in men with diabetes, and 42,459 (1.37 per 1000 people) in women with diabetes. Diabetes resulted in a total of 78,123 YLL with an average 12 years of life lost per person with diabetes.

The highest number of YLLs in men was in the age range 50–64, while the lowest was in the under 20s. The highest number of YLLs in women was in the age range 65–79, while the lowest was also in the under 20s. Across all deaths, the highest YLLs were in the age range 50–64, while the lowest was in the under 20s (Fig. 1).

Joinpoint regression showed that the 16-year trend in the YLL due to diabetes and its complications was increasing. The APC was 4.7% (95% CI 1.9–7.5, $p=0.002$) for men, 4.5% (95% CI 2.9–6.1, $p<0.001$) for women, and 4.6% (95% CI 2.7–6.6, $p<0.001$) for both sexes. The model did not show any joinpoint, and hence, the AAPC is the same as the APC (Figs. 2, 3, and 4). The joinpoint regression was also fit across the age ranges of 15–34 (young), 35–64 (adults), and ≥ 65 years (elderly). The APC was 1% (95% CI–5.3 to 7.6; $p=0.752$) in the young, 1.4% (95% CI–0.2 to 3.2; $p=0.086$) in adults, 4.1% (95% CI 2.5–5.7, $p<0.001$) in the elderly.

Discussion

There has been little study reporting the mortality and YLL attributable to diabetes and its complications in the Persian population in the last decade. This study has shown that the ASR per 100,000 population increased from 7.5 in 2004 to 11.9 in 2019 in men and from 11.3 per 100,000 in 2004 to 15.2 in 2019 in women. In addition, during the 16-year study period (2004–2019), there were 6,403 deaths due to diabetes and its complications and a total YLL of 78,123 with an

Table 1 Crude and age-standardized mortality rate (per 100,000 population) and years of life lost due to diabetes and its complications, by sex and year in the geographical region covered by Shiraz University of Medical Sciences between 2004 and 2019

Year	No. of deaths		Crude mortality rate (per 100,000)		ASR* (95%CI) (per 100,000)		YLL			
							Number		Per 1000	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
2004	101	134	**5.4**	**7.5**	7.5 (6.5-8.6)	11.3 (10.0-12.6)	1,383	1,953	0.74	1.09
2005	94	109	5.1	6.1	6.8 (5.8-7.8)	9.0 (7.8-10.2)	1,124	1,482	0.60	0.83
2006	117	111	6.3	6.2	8.5 (7.4-9.6)	8.7 (7.5-9.9)	1,580	1,544	0.85	0.85
2007	133	144	7.1	7.9	8.8 (7.6-10.0)	10.6 (9.3-11.9)	1,656	1,987	0.88	1.08
2008	135	169	7.2	9.1	9.0 (7.8-10.2)	12.0 (10.6-12.4)	1,688	2,404	0.89	1.29
2009	124	148	6.5	7.9	8.0 (7.9-9.1)	9.4 (8.1-10.7)	1,445	1,997	0.75	1.06
2010	168	200	8.7	10.5	10.5 (9.2-11.8)	12.2 (10.8-13.6)	2,106	2,649	1.09	1.39
2011	238	263	12.3	13.7	13.7 (12.1-15.3)	15.8 (14.1-17.5)	2,798	3,233	1.44	1.68
2012	297	212	15.1	10.9	15.0 (13.3-16.7)	11.2 (9.7-12.7)	3,847	2,644	1.95	1.35
2013	232	250	11.6	12.7	12.5 (11.0-14.0)	13.6 (12.0-15.2)	2,700	3,126	1.35	1.59
2014	163	216	8.1	10.9	8.5 (7.3-9.7)	11.5 (10.0-13.0)	1,833	2,635	0.90	1.32
2015	201	245	9.8	12.2	9.9 (8.6-11.2)	12.5 (11.0-14.0)	2,306	2,870	1.12	1.42
2016	261	287	12.6	14.1	12.8 (11.3-14.3)	14.2 (12.6-15.8)	2,852	3,470	137	1.71
2017	247	287	11.9	14.2	12.0 (10.5-13.5)	13.9 (12.3-15.5)	2,891	3,334	1.38	1.64
2018	249	297	11.9	14.6	12.3 (10.8-13.8)	14.4 (12.7-16.1)	2,715	3,505	1.29	1.72
2019	242	329	**11.5**	**16.1**	11.9 (10.4-13.4)	15.2 (13.5-16.9)	2,740	3,626	1.30	1.77
Total	3002	3401	9.5	11.1	10.8 (10.4-11.2)	12.5 (12.1-12.9)	35,664	42,459	**1.13**	**1.37**

*: Age standardized mortality rates

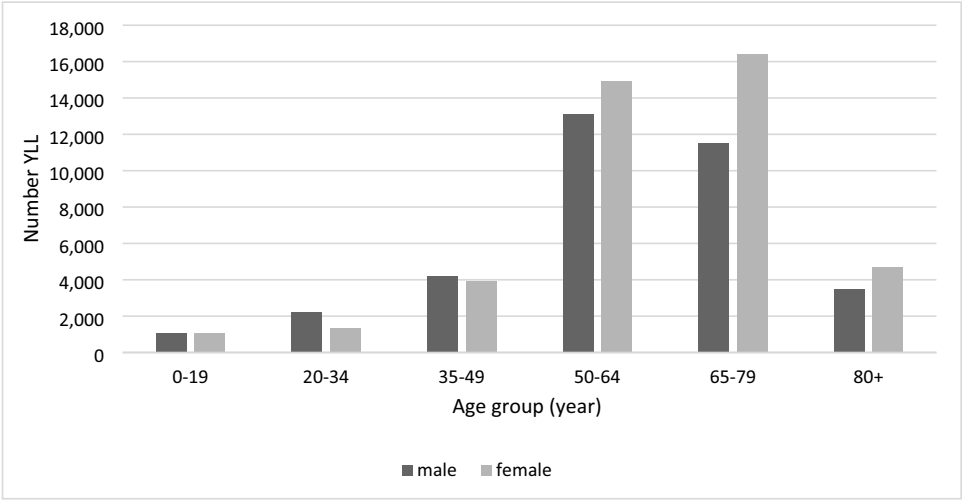

Fig. 1 Years of life lost by sex and age group

average 12.5 YLL per person with diabetes. The highest and lowest YLLs were in the age groups of 50–64, and less than 20 years, respectively. Joinpoint regression showed that the 16-year trend in YLL attributable to premature mortality increased without a significance change point in all age groups except for the elderly 4.1% (95% CI 2.5–5.7, $p<0.001$).

Diabetes-attributable mortality is one of the primary indices used by healthcare policymakers to allocate national resources and assign priorities in health interventions [20]. Estimating diabetes-related mortality has been of great concern due to the lack of reliable mortality data in some countries [20]. Some countries have implemented electronic death registration in order to improve the reliability of mortality data. In the last two decades, Iran's Ministry of Health and Medical Education has also implemented electronic death registration. This study found that the ASR of mortality in men increased from 7.5 per 100,000 in 2004 to 11.9 per 100,000 in 2019, while in women it increased from 11.3 per 100,000 in 2004 to 15.2 per 100,000 in 2019. A comparison of these findings with those of previous studies revealed that in developing countries, ASR of mortality has increased over the last decade. In Central Asia, ASR mortality increased from 18.2 per 100,000 in 2007 to 19.4 per 100,000 in 2017, whereas in South Asia it increased from 27.2 per 100,000 in 2007 to 29.7 per 100,000 in 2017. Conversely, there is a trend of decreasing ASR mortality in high-income countries such as the high-income countries of the Asia Pacific region, Western Europe, Australia, and high-income regions of North America from 2004 to 2017. In 2013, World Health Organization member countries declared targets demonstrating their commitment to lowering mortality from major no communicable diseases by 25% by 2025. They proposed to do this by

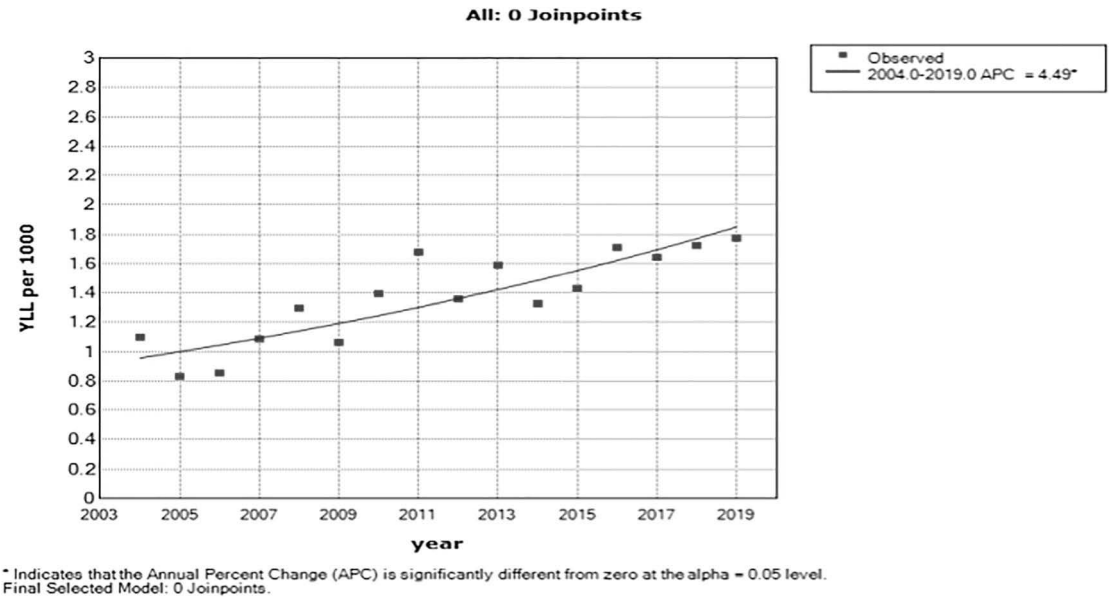

Fig. 2 16-year trend of years of life lost (YLL) due to diabetes and its complications in females, Iran, 2004–2019

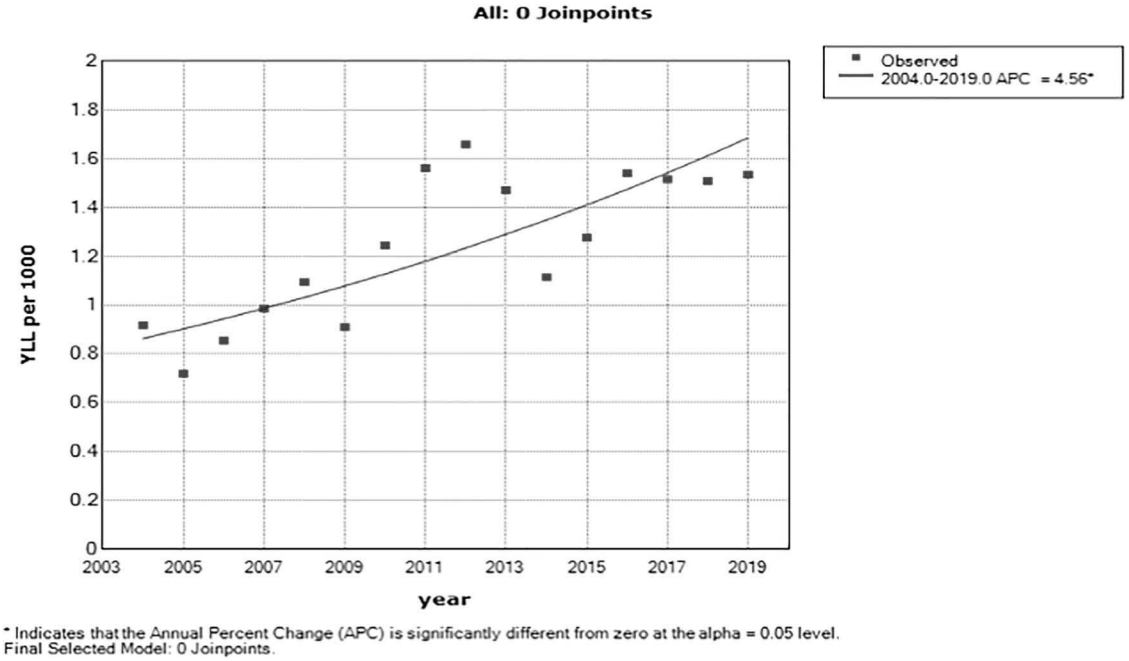

Fig. 3 16-year trend of years of life lost (YLL) due to diabetes and its complications in males, Iran, 2004–2019

reducing risk factors and improving access to the necessary treatments and technology [21]. This indicates that developing countries, including Iran, require comprehensive and strategic planning to effectively manage the trend mortality attributable to diabetes in the coming decade.

Diabetes has had a measurable impact on productivity loss due to different factors such as decreased productivity in people of working-age and loss of life due to diabetes [22]. The current study indicated that the total YLL during the 16-year study period were 1.13 per 1000 people in men with diabetes, and 1.37 per 1000 people in women with diabetes, resulting in a total of 78,123 YLL. This corresponds to an average of 12 YLL per person with diabetes; 12.5 years per person for women and 11.8 years per person for men. A comparable study conducted in Central Europe reported a YLL of 86 in 2015, which is lower than the current study's findings [23]. Increasing YLL is a future concern in both developing and developed countries, and YLL is anticipated to increase by

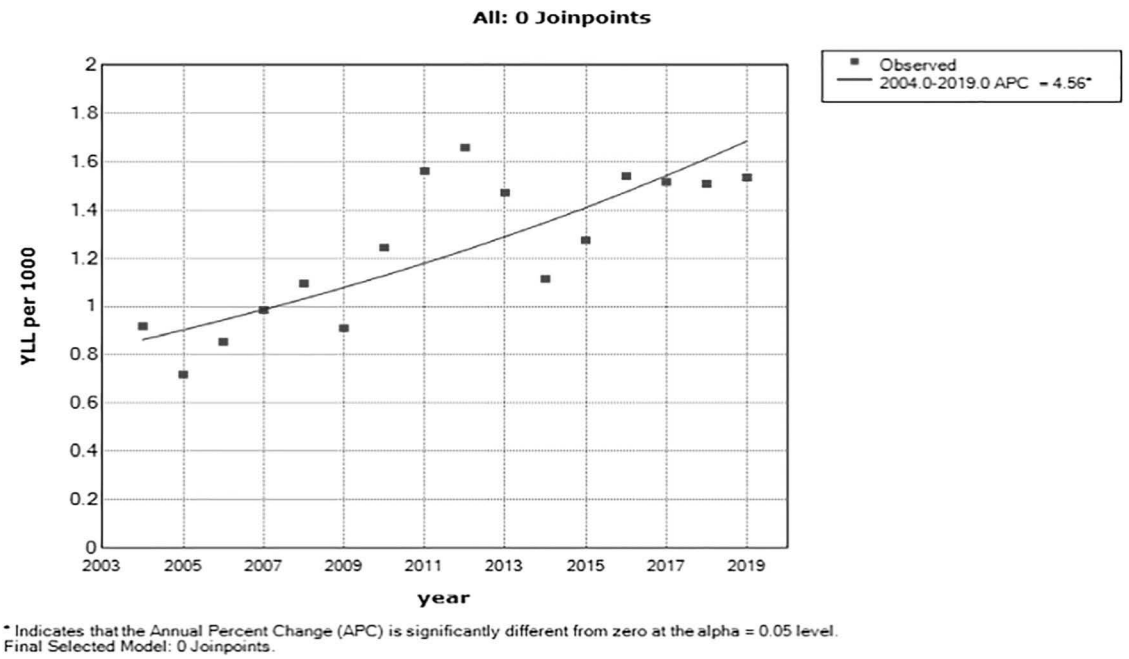

Fig. 4 16-year trend of years of life lost (YLL) due to diabetes and its complications in both sexes, Iran, 2004–2019

between 1.0 and 1.3 years up to the year 2040 [24]. This issue could serve as a warning to healthcare policymakers, emphasizing the importance of prevention strategies. Future studies are therefore recommended to expand the understanding of factors that contribute to increased mortality and YLL associated with diabetes.

The highest YLLs across both women and men were found to be in the age group of 50–64. This provides evidence in agreement with our earlier observations, showing that the age group of 50–64 represents individuals advancing in age who tend to have more chronic health conditions and are at an increased risk of disability [25]. A possible explanation for this group exhibiting the highest YLLs is the increased prevalence of microvascular and macrovascular diseases in this group [26]. In addition, the 16-year trend of YLL and its complications in both men and women was that of increasing without any change point, with the APC in YLL being 4.6% across all deaths due to diabetes. These results reflect those of Askarishahi et al. (2015) who reported an APC in YLL of 6.6% during the period 2003–2007 [27]. In a study (2011 and 2016) conducted in Yazd province, YLL (per 1000) due to cancers, respiratory disease, and traffic accidents had a rising trend and had a decreasing trend in cardiovascular diseases [28].

In another study (2006 and 2010) conducted in Hamadan Province, age-specific mortality rates in both genders for all age groups were higher in 2010 than in 2006. The percentages of YLL from ischemic heart diseases, cerebrovascular diseases, transport accidents, and intentional self-harm were among the greatest sources of premature death [29].

These results therefore need to be interpreted with caution. Further studies, which take these variables into account, will need to be undertaken. To reduce the prevalence of diabetes risk factors in the population, it is necessary to improve public awareness about the trend of increasing diabetes incidence. This will require strategic planning to modify behaviors and implement suitable and effective community-wide provision to reduce these risk factors.

Study strengths and limitations

A limitation of the present study was that YLL was not evaluated throughout the whole of Iran due to an unavailability of the necessary data. We first did the analysis by type of diabetes, but we noticed that some coding were not done correctly in the first years, and due to the irrational changes in the number of deaths, the crude mortality rate, the standardized mortality rate, and the years of life lost, we had to do the analysis in general. However, in all other aspects, this study was of high quality and with a strong study design, large sample size, and extensive time-period of data analyzed. This represents the first such study to have been conducted on mortality and YLL attributable to diabetes in the Persian population.

Health policy makers need to have a holistic approach in order to decrease the burden of diabetes within the next years, and this issue needs a strong health organizational and social commitment.

Because this study is a population-based study conducted over a long period of time in one of the most populous provinces of Iran, its results can help health policy makers and planners in Iran to reduce the burden of diabetes.

Conclusion

In this study, we found that from 2004 to 2019, the crude mortality rate, age standardized rate, and years of life lost due to diabetes were on the rise. We found obvious sex differences in diabetes-related deaths. The highest YLLs were in the age range 50–64. An accurate estimation of diabetes mortality could provide empirical support for future diabetes prevention and control strategies, determine priorities in health protection, and provide a basis for accurate prevention and control of diabetes in different regions and groups.

Author Contribution AH was responsible for the field working including data collection and management and wrote the discussion. JM collected data and wrote the manuscript. HJ wrote the manuscript. MA collected data and edited the final version of the manuscript. SMH has done the analysis of data and DRS wrote the manuscript and edited English language. All authors approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

Data availability The data for the current study will not be shared publicly.

Declarations

Ethics approval The protocol describing this study was reviewed and approved by the ethics committee of Shiraz University of Medical Sciences (reference: IR.SUMS.REC.1399.772). All aspects of the study were conducted according to the University Code of Ethics.

Consent for publication Not applicable.

Conflict of interest The authors declare no competing interests.

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