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Original Article

Twenty-Six-Year Trend of Mortality Rate due to Ischemic Heart Diseases (IHDs) in Iran: 1990-2015

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Abstract

Background: Ischemic Heart Diseases (IHDs) are the main causes of deaths all over the world. Since there is no comprehensive study on IHDs mortality rate in Iran, the present study aimed to estimate age-standardized IHDs mortality rate by sex, age, geography, and time trends at both national and sub-national levels in Iran.

Methods: We used the Death Registration System (DRS) data from 1990 to 2015 collected by the Iranian Ministry of Health and Medical Education across the country, Tehran, and Isfahan main cemetery, not included in the DRS. Utilized death distribution methods to overcome the incompleteness of data. Statistical models including Spatio-temporal and Gaussian-Process Regression models were used to extrapolate all-cause and cause-specific mortality rates.

Results: Age-standardized IHDs mortality rate in Iran almost doubled from 1990 to 2015. Forty-nine deaths per 100.000 population in 1990, which increased to 91.6 deaths per 100.000 in 2015). Male to female age-standardized mortality rate increased from 1.07 to 1.32 during the studied period. Aging was associated with an increase in age-standardized IHDs mortality rate in both sexes, all provinces, and all of the years. The range of age-standardized IHDs mortality rate for both sexes was from 58 to 136.2 deaths per 100,000 across provinces in 2015.

Conclusion: Due to the increase in age-standardized IHDs mortality rate in Iran, it seems necessary to design and implement appropriate public health interventions by health authorities to prevent and control this group of diseases.

Keywords: Ischemic heart disease; Myocardial ischemia; Burden; Iran

Introduction

Reducing premature death due to non-communicable diseases (including CVDs) by one-third is one of the target 3.4 of the Sustainable Development Goals (SDGs) met by the member states by 2030 through taking preventive and treatment measures (1). Although cardiovascular diseases mortality rate has decreased in all high-income countries and some middle-income areas during the past decades (2), it is still the main cause of mortality in all countries (3) including Iran (4). Among all CVDs, (IHDs) are ranked as the leading cause of death throughout the world (4, 5) which caused 8.92 million deaths in 2015 (5).

There were an estimated 8.92 million deaths due to IHDs in 2015, making IHDs the leading cause of death in the world (6, 7). On the other hand, data used in almost all national studies suffer from misclassification and incompleteness, regardless of the level of study (8, 9). Therefore, given the important share of IHDs in total mortality rate in the country and for providing a baseline data in order to evaluate the extent to which Iran has achieved SDG's 3-4 target, we aimed to estimate the distribution of IHDs mortality rate by sex, age, geography, and time trends at both national and sub-national levels from 1990 to 2015.

This study was a sub-component of the "National and sub-national patterns of cause of death in Iran from 1990 to 2015" derived from "National and Subnational Burden of Disease" study (NASBOD) (10). To the best of our knowledge, it is the first study estimated the trend of IHDs mortality rate at both national and sub-national levels among Iranian people during a period of 26 years, using all available and valid data sources and advanced demographic and statistical methods to address the problems in the DRS.

Methods

We used the data obtained from the DRS and utilized demographical models including Summary Birth History (SBH) and Complete Birth History (CBH) to address the incompleteness of data on child mortality rate; it also used Death Distribution methods to overcome the incompleteness of data on adult mortality rates (11). In addition, statistical models including Spatio-temporal and Gaussian-Process Regression models were used to extrapolate all-cause mortality rates (12-14).

Afterward, we extracted cause-fractions from dataset and extrapolated them for all the eligible groups. Finally, by multiplying cause-fraction and all-cause mortality rates, cause specific mortality rates were obtained (15).

Definition

IHDs is consisted of a group of diseases that includes unstable angina, stable angina, myocardial infarction, and sudden cardiac death (16). Since the International Classification of Diseases 10 (ICD10) codes are used for registration of the causes of deaths in Iran, at first, all of the ICD10 codes were converted to 165 GBD codes in this study to become compatible with the DRS (15). ICD10 codes for IHDs are I20–I25, and its GBD code is B.2.2. More details on the structure of data are presented elsewhere (15).

Data sources

Deaths data

We used the DRS data from 1995 to 2010 collected by the Ministry of Health and Medical Education (MOHME) across the country. There were two exceptions for Tehran main cemetery (Behesht-e-Zahra) and Isfahan main cemetery (Bagh-e-Rezvan) not included in the DRS. We estimated the completeness of DRS, also we corrected the misclassification of DRS and certified cause of deaths by addressing garbage codes and ill-defined codes. The detailed are provided elsewhere (13).

The population and housing censuses

The data that obtained from the population and housing censuses 1996, 2006, and 2011 were used for estimating at risk population for all eligible age-sex groups. For other years, the populations for all

age-sex groups were estimated by the growth formula.

Covariates

This study also used some covariates from Household Income and Expenditure Surveys (HIES) including Years of Schooling (YOS), Wealth Index (WI), and urbanization rate in each province (15).

Statistical analysis

Due to several inconsistencies in final dataset, including the presence of duplicates, misalignments, misclassifications, missing values, and incompleteness, firstly, we imputed age and sex missing values using Multiple Imputation (MI) and Expectation-Maximization (EM) algorithm approach in Amelia package (17). Since the collected data (DRS, Behesht-e-Zahra, and Bagh-e-Rezvan) were suffering from a degree of incompleteness, demographic characteristics including CBH and SBH (11, 18) for children mortality estimation and death distribution methods for adults mortality estimation were used to address the incompleteness of the DRS. In addition, we applied statistical models including Spatio-temporal (13) and Gaussian Process Regression (GPR) (14) models to estimate and extrapolate all-cause mortality rates. In order to calculate mortality rate for each cause, all-cause mortality rates were divided into cause-specific rates using cause-fractions. These fractions for all age-sex groups were calculated in each province and year. For extrapolating cause-fractions, we used a two stages Spatio-temporal model which included a mixed effects regression model and a weighting system for the residuals of this model. Simulation approach was used to determine the uncertainty intervals for each estimation. This integrated approach is recommended by Foreman et al (19). Using this approach, we addressed the differences in mortality rate due to a specific cause between different ages and genders. In this study, the time trends of mortality rates are presented as point estimates with 95% Uncertainty Interval (UI). All prepared graphs and maps and statistical analyses were performed using R statistical software version 3.4.2 and STATA ver. 11. Furthermore, direct age-standardized approach was applied using "epitools" package in R statistical software (20).

DRS data at individual level were recruited and after resolving main problems such as duplicate, misalignment, and misclassification observations, and lost space-time data points, we collapsed them to be as aggregated data and by considering incompleteness of DRS, all imputation and meta-regression models were run at aggregate level data.

Results

At national level, IHDs caused 41885 (95% UI: 33776-52085) deaths in males and 31622 (95%UI: 24920-39127) deaths in females in Iran in 2015. Using statistical analysis including mixed effect model, Spatio-temporal and Gaussian Process Regression (GPR) models as well as summary birth history and death distribution methods indicated that the increasing trend of age-sex standardized IHDs mortality rate per 100,000 population continued by 2003 and then, there was a declining trend until 2015. Age standardized mortality rate was 49.0 (95%UI: 34.8-67.9) in 1990, 146.5 (95%UI: 112.0-187.4) in 2003 (it was the year with the highest IHDs mortality rate during the studied time period), and 91.6 per 100,000 (95%UI: 71.9-113.7) in 2015 (Appendix 1) (The appendices are available upon the request from the corresponding author). There was about 100% increase in this rate during the period of 26 years. Male to female age-standardized mortality rate changed from 1.07 in 1990 to 1.32 in 2015. Age-standardized IHDs mortality rate among females and males, respectively, were 47.0 (95%UI: 33.4-64.8) and 50.1 (95%UI: 35.5-69.7) in 1990 that increased to 79.1 (95%UI: 62.3-97.8) and 104.1 (95%UI: 81.5-129.4) in 2015 (Fig. 1).

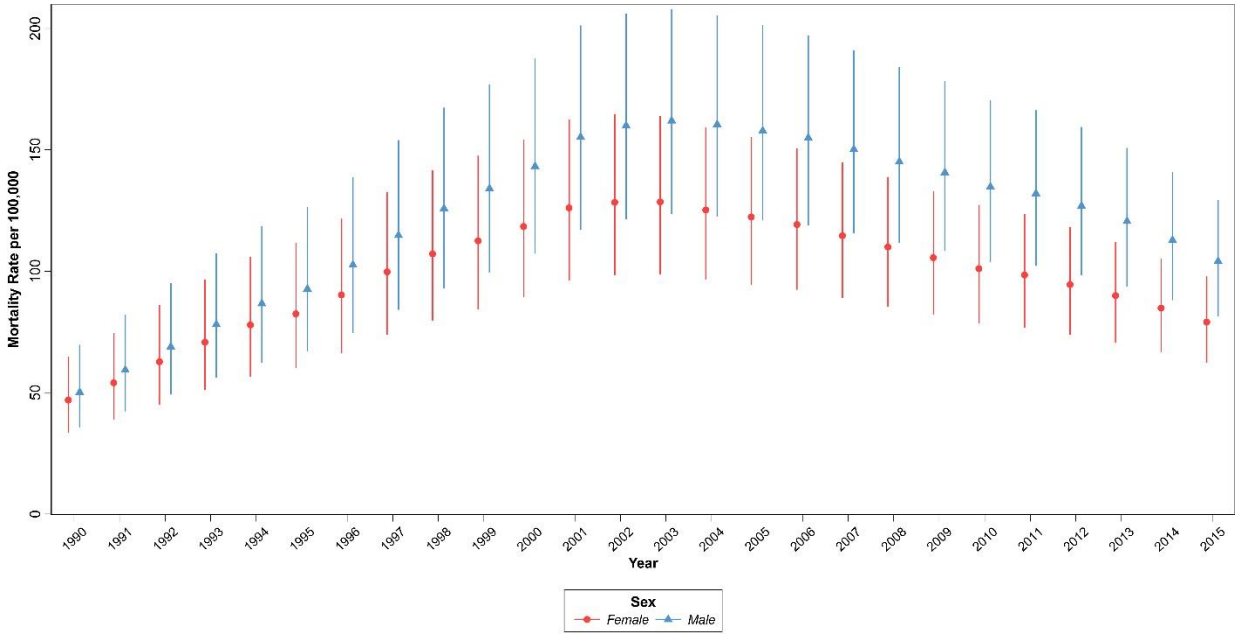

Fig. 1: Time trend of age-standardized IHDs mortality rate per 100,000 by sex from 1990 to 2015 at national level

However, the age-standardized mortality rate was almost always higher in males than in females at all provinces and in all of the years (Fig. 2). At sub-national level, the provinces with the highest and the lowest age-sex standardized IHDs mortality rate per 100,000 population were 136.2 (95%UI: 109.5-165.0) and 58.0 (95%UI: 44.9-73.4) in 2015, respectively (Appendix 2).

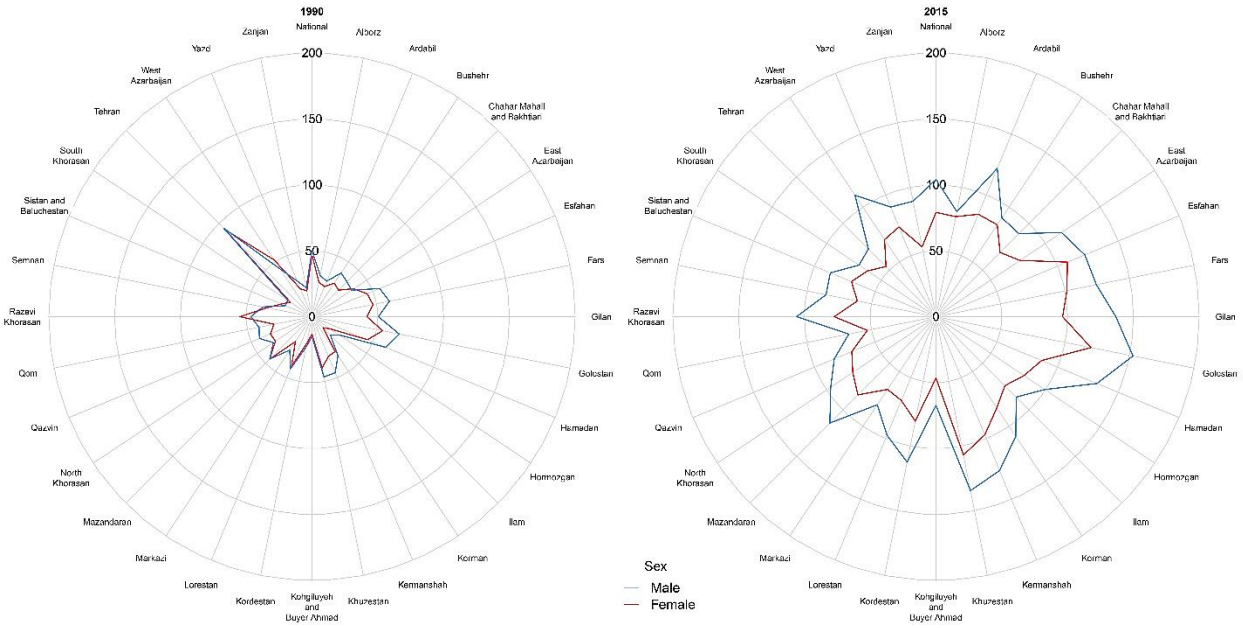

Fig. 2: National and sub-national age-standardized mortality rate due to IHDs per 100,000 by sex in 1990 and 2015

The results indicated 2.6 and 4.1 annually percent of change in age-standardized IHDs mortality rate among females and males, respectively, from 1990 to 2015 at national level (Appendix 3). It indicates a difference of more than two times between provinces with the lowest and the highest rates of age-standardized mortality. The changes in the trend of IHDs mortality rate at sub-national level was similar to the changes in its trend at national level except for four provinces (Fig. 3).

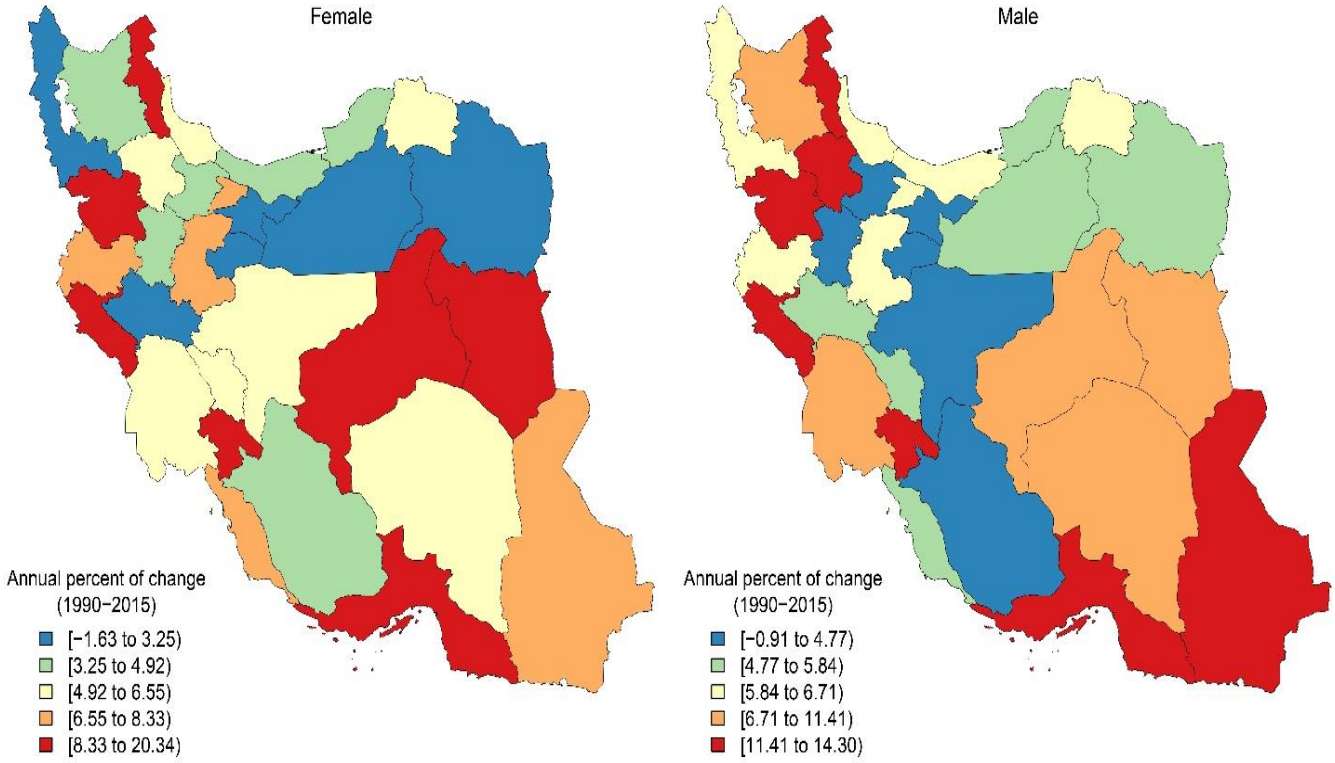

Fig. 3: Provincial distribution of annual percent of change (1990-2015) of mortality rate due to IHDs by sex

In two of them (i.e. Ilam and Hormozgan), the increasing trend of age-standardized mortality rate continued until 2010, and in two others (i.e. Tehran and West Azerbaijan), the increasing trend was stopped in 2000 (Appendix 4).

There was a remarkable increase in IHDs mortality rate in age group 80+ at national and sub-national levels. The second highest rate of increase was observed in people aged 70-79 years, as compared with the other age groups (Appendix 5A, Appendix 5B). The maximum mortality rate per 100,000 population among people aged 80 year and more was 2048.6 (95%UI: 1463.3-2811) in females and 1863.4 (95%UI: 1341.8-2552.3) in males in 1990 that increased to 4531.7 (95%UI: 3578.1-5586) in females and 4295.3 (95%UI: 3375.4-5305.1) in males in 2015 (Fig. 4).

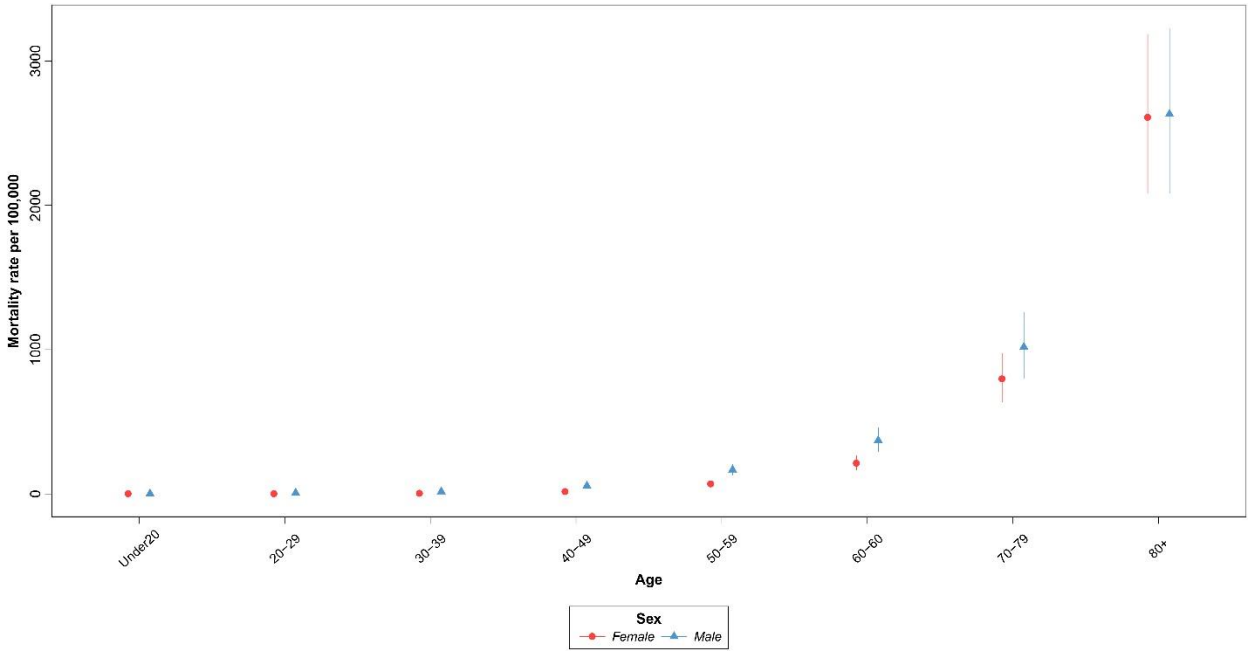

Fig. 4: Age-specific IHDs Mortality Rate per 100,000 by Sex in 2015 at national level

Discussion

Age-standardized IHDs mortality rate per 100.000 population almost doubled among Iranian population over a period of 26 years (from 1990 to 2015). The rate was higher among males of almost all ages, and it had an increasing trend from 1990 to 2003 (almost tripled); then, there was a decreasing trend until 2015. The highest age-standardized IHDs mortality rate per 100.000 population was observed in 80+ age group.

Incompleteness is an important component to assess the validity of any registration systems including DRS. In the NASBOD study, the data sets of Tehran and Isfahan cemeteries were added to DRS to achieve satisfactory and comprehensive information coverage. Furthermore, by addressing incompleteness of DRS, the result of this study can be generalized to the Iranian population (9, 11).

In general, the findings of this study were in line with the findings of most of the national and international studies and reports in this field. The declining trend in IHDs mortality rate in Iran is similar to that in high-income countries (7) and some other developing countries.

The GBD- which is one of the most valid studies estimated the burden of diseases throughout the world- showed that despite the decline in the trend of IHDs mortality rate per 100.000 population during recent years, it was yet the main leading cause of deaths in 2016 across the world (21). The results of the GBD-2016 study indicated that IHDs mortality rate per 100.000 population was 111.8 (95%UI: 95.4-130.0) in Iran, which had no significant difference with our estimation that was 91.6 (95%UI: 71.9-113.7).

The decrease in age-standardized IHDs mortality rate per 100.000 population which occurred from mid-2000 in Iran, was reported in a number of studies during that period of time and even earlier (22). The decrease in the trend of IHDs mortality rate have different reasons. It is associated with the income and development status of each country, and the lower socioeconomic status and even demographic characteristics are associated with higher IHDs mortality rate (23-27). Thus, it is not far from the mind that high-income countries experienced a decrease in age-standardized IHDs mortality rate per 100.000 population (28) earlier than the middle-income countries such as Iran and

Turkey, for instance, Turkey as a developing country has experienced a decreasing trend in IHDs mortality rate from 1995 (29).

Some studies have attributed an increase in the number of deaths from CVDs worldwide to the growth and aging of population (29), in spite of the decrease in age–standardized mortality rates in most of the countries (30). The effect of age on IHDs mortality rate is so strong that in developed countries with higher population of old people, the total mortality rate due to IHDs remains high (22). Among the studies at national level, in spite of the decrease in age-standardized IHDs mortality rate per 100.000 population from 1990 to 2015, the total burden of IHDs increased in Iran due to the growth of population and aging, and it was reduced by 21.7% in both sexes during these years, and this accelerating rate had a positive correlation with age (31).

Gender is another important variable that has a significant impact on IHDs mortality rate. We found that in all points of our estimations (1990, 1995, 2000, 2005, 2010, and 2015), the rate of age-standardized IHDs mortality rate per 100.000 population was higher in males. The results of other studies (22, 32-34) are in line with ours.

The other important item with notable effect on age-standardized IHDs mortality rate is geographic factors. The long distance between the place of the incidence of IHDs and the reference cardiology center is a determinant factor for death from this group of diseases (35, 36). Poor patients who live in places away from equipped urban centers will have some problems to access health care services that can lead to higher IHDs mortality rate (shown in our study too) (37).

Based on our findings at sub-national level, the level of age-standardized IHDs mortality rate per 100.000 population varied from one province to another significantly. For the highest compared to the lowest rates at sub-national level in 2015, the difference reached more than two times attributed to poorer or better access to health and treatment services as well as different socio-economic status. Living in a more developed regions with an appropriate lifestyle can decrease the incidence of IHDs (38), and reducing-morbidity and mortality due to NCDs (39, 40), for instance, by controlling blood pressure in Iran, a very large proportion of deaths due to CVDs can be avoided (41). The effect of culture and environment on the trend of IHDs in population can't be ignored. We suggest to include cultural and environmental exposure variables in causality methods to be able to quantify the contribution of these two factors on developing IHDs among population.

However, health system performance assessment is a critical and challenging issue that makes it necessary to have a comprehensive indicator for evaluating the effect of health system on population health (42). Iran performed poorly about IHDs, relative to the selected countries. Maybe it is the time for all countries to direct their priorities toward public health prevention, health promotion, and economic growth (43). It might be also useful to implement appropriate policies that target the changes in lifestyle including inappropriate diet, physical inactivity, smoking, and harmful use of alcohol (44). In addition, all countries should try to invest on CVDs surveillance and population-based registry (6).

Some strengths of this study can be summarized as below: it is the first study on mortality rate, the level and the trend of deaths due to IHDs at sub-national level in Iran. We used the most comprehensive dataset (including all five available datasets), and believe that we have not miss any registered death. In addition, we applied up-to-date and advanced statistical methods in this study to achieve the most accurate and valid estimations for all causes of death at different levels and trends; accordingly, we were able to address misclassification and incompleteness of data by using these statistical models, and calculated uncertainty intervals for all data (45).

Regarding the limitations of this study, by using multinomial models, we could consider all causes variation at the same time, but due to computational limitations, we modeled each cause proportion separately; therefore, we could address a part of between-causes correlation using cause-fraction approach. We suggest modeling the DRS data by multinomial models if there are no computational

limitations. On the other hand, although we assumed homogeneity of misclassification across all causes of death, but experiences show that IHDs is more likely to be misclassified comparing with other causes of death. Furthermore, as we discussed in the protocol papers of NASBOD study (10, 13, 15); data scarcity for mortality rates were dealt by models. In addition, administrative divisions of Iran had been changed during 26 years of this study; we reconstructed new provinces formed based on district information for the time when they did not exist. Moreover, death data before establishment of death registration system were not available estimated. Regarding garbage codes, the uniform distribution was hypothesized if the result violate this assumption and lead to homogen we consider different distributions for garbage codes that needs further studies to consider patterns or functions for non-homogen garbage codes.

Conclusion

The rate of IHDs has a decreasing trend in Iran, but evidence shows that it is a major health problem in this country yet, and leads to a high rate of mortality among population. Population-level intervention such as polypill, and Irapen and also deploying risk prediction should be performed and applied to change this high rate of IHDs in Iran.

Ethical 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 interest.

Note

The appendices are available upon the request from the corresponding author.

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