JBE Journal of Biostatistics and Epidemiology
J Biostat Epidemiol. 2025;11(1): 50-62

ORIGINAL ARTICLE
DOI: *https://doi.org/10.18502/jbe.v11i1.19317*
*Received **November** 03, 2024; Accepted **December** 26, 2024;*
*Published online **March** 15, 2025.*

Understanding Premature Mortality Patterns from Non–Communicable Diseases in Iran (2012-2020)

Batoul **Rabbani**[1], Kazemi **Elaheh**[1], Amin **Ataey**[1], Elham **Rashidian**[1], Ardeshir **Khosravi**[2*]

[1]Deputy for Health, Ministry of Health and Medical Education, Tehran, Iran.
[2]Health Equity Research Center, Tehran University of Medical Sciences, Tehran, Iran.

ABSTRACT

Introduction: More than 85% of premature deaths from major non-communicable diseases (NCDs) occur in low- and middle-income countries. This study aimed to investigate trends of premature deaths (30-70 years) due to the non-communicable diseases in Iran, from 2012 to 2020.

Methods: The present study is a descriptive study. Data on the causes of death from 2012 to 2020 were extracted from the death registration system of the Ministry of Health and Medical Education, and the data is not based on sampling. After calculating the completeness of the death registration system using the method proposed by Lopez and Adair, the probability of premature deaths due to noncommunicable diseases was determined.

Results: From 2012 to 2020, non-communicable diseases accounted for a significant percentage of all deaths, ranging from approximately 54% to 72%. Premature deaths due to these diseases varied between 50% and 71% during the study period. The probability of premature deaths due to these diseases fluctuated between 14.95% and 17.35%.

Conclusion: With the knowledge that the most common cause of premature death in women is non-communicable disease and the most common cause in the general population is cardiovascular disease, evidence-based planning and policy-making should be done to achieve further reductions in premature mortality, with an approach to be adopted in a unified way by focusing on modifiable risk factors in different sectors and disciplines in Iran.

Key words: Mortality; Non-communicable diseases; Premature death; Mixed effect model; Iran

*Corresponding Author:
ardeshir.khosravi@gmail.com

INTRODUCTION

Many deaths in developing countries like Iran occur at active ages, contributing significantly to premature mortality. Premature mortality imposes enormous financial restrictions on affected families and considerable economic burdens on society.[1]

The analysis of causes impacting on premature deaths is an essential function of public health surveillance. According to the increasing burden of non-communicable diseases (NCDs) and its impact on premature deaths, its relevance for public health surveillance has been emphasized.[2] Non-communicable diseases (NCDs) are becoming the leading cause of death worldwide and considered to be the major health challenges of the 21st century.[3] The increase in the burden of non-communicable diseases leads to a lack of health resources, an increase in treatment costs, and a delay in economic growth.[4] In 2018, the total economic burden of non-communicable diseases (NCDs) on the Iranian economy was IRR 838.49 trillion per year, equivalent to 5% of the country's annual Gross Domestic Product (GDP).[5] These diseases affect all socio-economic strata, especially vulnerable strata, such as groups with low education and income level, and cause further increase in poverty, disabilities, limitations and decrease in productive force.[6] Cardiovascular diseases (CVD) are the most significant non-communicable diseases, accounting for about 50% of all deaths due to non-communicable diseases worldwide, and they present a significant barrier to sustainable human development. To a large extent, CVD is preventable and is closely linked to a wide range of risky, yet modifiable, behaviors such as unhealthy dietary patterns, tobacco use, physical inactivity, social stressors, and harmful alcohol consumption. In Iran, many of the main risk factors leading to mortality and disabilities, or behavioral risk factors for non-communicable diseases, include tobacco use and dietary risks or moderate risk factors such as high blood pressure, high body mass index, high fasting glucose, and abnormal lipid profiles.[7, 5] World Health Organization recognizes the probability of premature death from non-communicable diseases as an important indicator in assessing the level of prevention and control of these diseases that is not affected by age composition.[4] This organization has defined the probability of premature death (30-70 years) due to non-communicable diseases as the unconditional probability of dying between the ages of 30 and 70 due to cardiovascular diseases, cancer, diabetes or chronic respiratory diseases.[8] In other words, this index expresses the probability that a 30-year-old person will die due to a non-communicable disease and not reach the age of 70.[9] According to international planning, NCD management interventions are necessary to achieve the global goal of reducing the relative risk of premature death from NCDs by 25% by 2025 and the SDGs target of reducing premature deaths from NCDs by one third by 2030.[10] One of WHO's global priorities is to move towards universal health coverage, promoting health and well-being, and protecting against health emergencies. The importance of these strategic priorities has been emphasized during the COVID-19 pandemic. Prevention and control of non-communicable diseases are important during this pandemic, as non-communicable diseases are the main risk factors for patients with covid-19 disease.[11]

During the COVID-19 pandemic, the crisis phase saw the suspension of most screening, risk assessment, and diagnostic services. Follow-ups and care for patients with NCDs were primarily

conducted through telephone consultations rather than in person. In the reopening phase, general strategies were adopted to increase capacity and compensate for delayed care. A plan for major NCD services at the primary healthcare (PHC) system was developed across three peaks of pandemic settings. Finally, key strategies were proposed with an integrated approach, focusing on essential services, considering vulnerable groups, and utilizing e-health technologies.[12]

Since the possibility of early death (30 to 70 years old) from non-communicable diseases is one of the important indicators at the international and national level, and in order to plan and develop appropriate policies for implementing preventive strategies and achieving Sustainable Development Goals (SDGS), the present study aims to investigate the trend of premature deaths due to four main non-communicable diseases in the last decade, from 2012 to 2020.

MATERIALS & METHODS

Source of death data

Data on causes of deaths from 2012 to 2020 were extracted from the death registration system of the Ministry of Health and Medical Education. It should be noted that the classification of causes of death in this system is based on the classification system presented in the tenth edition of the International Statistical Classification of Diseases and Health Problems (ICD-10). To carry out this study, the information of people whose underlying cause of deaths are non-communicable diseases in four major groups, namely cardiovascular diseases (I00-I99), cancers (C00-C99), chronic respiratory diseases (J30-J98) and diabetes (E10-E14) were extracted based on gender and age groups.[13] The population data used in this study were the information obtained from the population and housing census (year 2016) and the population estimates for the years after the census by sex and 5-year age group, which were prepared and published by the Iranian Statistics Center.[14]

Analysis method

The present study is a descriptive study. Different methods were used to evaluate the quality of death data. First, the death data were redistributed according to the percentage of death in groups with specified sex and age. Then, one of the key criteria for checking the quality of the cause of death data is the proportion of deaths assigned to "uncertain or null codes" including the codes of the R00-R99 group in ICD-10, which is known as "error in the classification" of the cause of death. Based on the standard method that is used in many studies, these causes of death were redistributed proportionally according to age and gender in other registered causes of death except accidents.[15-19] To check the coverage or undercounting of the death registration system, the new method proposed by Adair and Lopez, was used to calculate the percentage of death under counting by sex. In the model proposed by Adair and Lopez, the calculation of the coverage of the death registration system is calculated based on the relationship between several variables, including the recorded raw death rate, the recorded child death rate, and the population structure (percentage of the population 65 years and older). Based on the above method, using the random effects model, the coverage of the

death registration system of 110 countries during the years 1970 to 2015 (2451 country-years) was calculated using the Global Burden of Diseases 2015 (GBD2015) database. The necessary variables for using this model include the crude death rate based on registered data (Reg CDR), the death rate of children under 5 years old (5q0) on a natural logarithm scale, the percentage of the population 65 and above (%Pop65i) and the completeness of the child death registration for children under 5 years old. Calculations have been done separately for men, women and both sexes. The formula for calculating the coverage of the registration system is based on the mentioned method as follows.[20]

$$CDR = \frac{Total\ deaths}{Population} * 1000 = \left(\frac{\sum_x m_x * P_x}{\sum_x P_x}\right) * 1000$$

1-1

$$RegCDR = \frac{Registered\ deaths}{Population} * 1000$$

1-2

$$Completeness = \frac{Registered\ deaths}{Total\ deaths} = \frac{RegCDR}{CDR} = \frac{RegCDR}{\left(\frac{\sum_x m_x * P_x}{\sum_x P_x}\right) * 1000}$$

1-3

$$logit\left(C_{jk}^{All}\right) = \beta_0 + RegCDR_{sq_{jk}} * \beta_1 + RegCDR_{jk} * \beta_2 + \%65_{jk} * \beta_3 + \ln(5q0)_{jk} * \beta_4 + C_{jk}^{5q0} * \beta_5 + k * \beta_6 + e_{jk} + \gamma_j$$

1-4

$$logit\left(C_{jk}^{All}\right) = \beta_0 + RegCDR_{sq_{jk}} * \beta_1 + RegCDR_{jk} * \beta_2 + \%65_{jk} * \beta_3 + \ln(5q0)_{jk} * \beta_4 + k * \beta_5 + e_{jk} + \gamma_j$$

1-5

$$C_{jk}^{5+} = \frac{RegDeaths_{jk}^{5+}}{\left(\frac{RegDeaths_{jk}^{All}}{C_{jk}^{All}}\right) - \left(\frac{RegDeaths_{jk}^{0-4}}{C_{jk}^{5q0}}\right)}$$

1-6

To calculate the probability of premature death due to non-communicable diseases in the age group of 30 to 70 years old by gender, the following formulas were used in order.

In the first step, the age-specific death rate is calculated using the following formula:

$$ {}_5M_x = \frac{\text{deaths among persons aged x to x+5 during a given year}}{\text{population aged x to x+5 at the mid-point of the same year}} \qquad 2\text{-}1 $$

Using this formula, the age-specific death rate is calculated for four groups of premature death caused by non-communicable diseases, which include cardiovascular diseases, cancers, chronic respiratory diseases and diabetes.

In the next step, the probability of death for the indicated age groups was calculated using the following formula:

$$ {}_5q_x = \frac{5 * {}_5M_x}{1+(5/2 * {}_5M_x)} \qquad 2\text{-}2 $$

At this stage, using the age-specific death rates of the four mentioned diseases and through the above formula, the death probability for age groups is calculated and extracted.

Then, in the next step, the following formula is used to calculate the probability of survival:

$$ {}_5p_x = 1 - {}_5q_x \qquad 2\text{-}3 $$

Finally, by subtracting the probability of death for age groups from the number one, the probability of survival is calculated. And the last step is to calculate the probability of death between the ages of 30 to 70 using the following formula.

$$ {}_{40}q_{30} = 1 - \prod_{30}^{65} {}_5p_x \qquad 2\text{-}4 $$

RESULTS

The total number of deaths registered in Iran from 2012 to 2020, according to the Ministry of Health and Medical Education, was 3,027,349, with 57% being men. During this period, the percentage of deaths due to non-communicable diseases (NCDs) ranged from 54% to 72%. Premature deaths (ages 30-70) accounted for 34-40% of total deaths, with 50-71% of these premature deaths (excluding 2020) caused by NCDs (Table 1).

Figure 1 shows that the premature death rates (ages 30-70) due to major NCDs from 2012 to 2020 varied, with the lowest rate for women being 229 per 100,000 in 2016 and the highest for men being 579 per 100,000 in 2020. Cardiovascular disease was the leading cause of premature deaths (except in 2020), accounting for 27-40%, followed by cancer (16-24%), diabetes (1.5-2%), and chronic respiratory diseases (3-4%) (Figure 2).

Table 1. Percent of deaths and premature deaths from four major NCDs* by sex, in Iran, 2012-2020**.

Year	Total deaths	NCD/Total death %	Premature deaths/Total death %			NCD premature deaths/premature deaths %		
			Male	Female	Total	Male	Female	Total
2012	256092	70.47	39.1	31.2	35.8	58.36	69.66	62.47
2013	265956	69.13	36.71	29.22	33.55	62.33	73.3	66.38
2014	272282	72.19	37.23	29.79	34.11	66.76	77.65	70.76
2015	327525	70.55	38.15	29.9	34.67	62.92	73.68	66.83
2016	339981	68.98	38.12	29.39	34.4	63.37	74.33	67.36
2017	349293	69.44	38.91	29.97	35.06	66.69	76.13	70.16
2018	353581	69.17	39.89	30.46	35.4	65.78	75.3	69.26
2019	378124	67.94	43.41	32.75	36.31	63.79	72.25	66.86
2020	484505	54.15	41.46	32.97	37.82	48.93	52.38	50.22

*Non–Communicable Diseases.
**The death data in 2012 is related to the whole country except Tehran province.

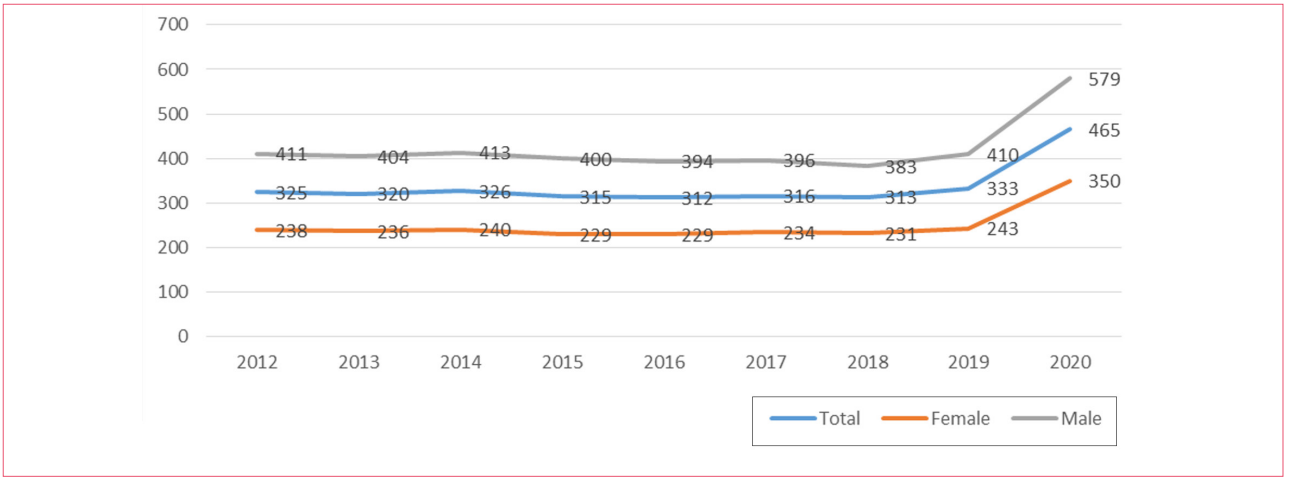

Figure 1. Premature death rate (per 100000 population) (30 to 70 years) by sex, in Iran, 2012 - 2020.

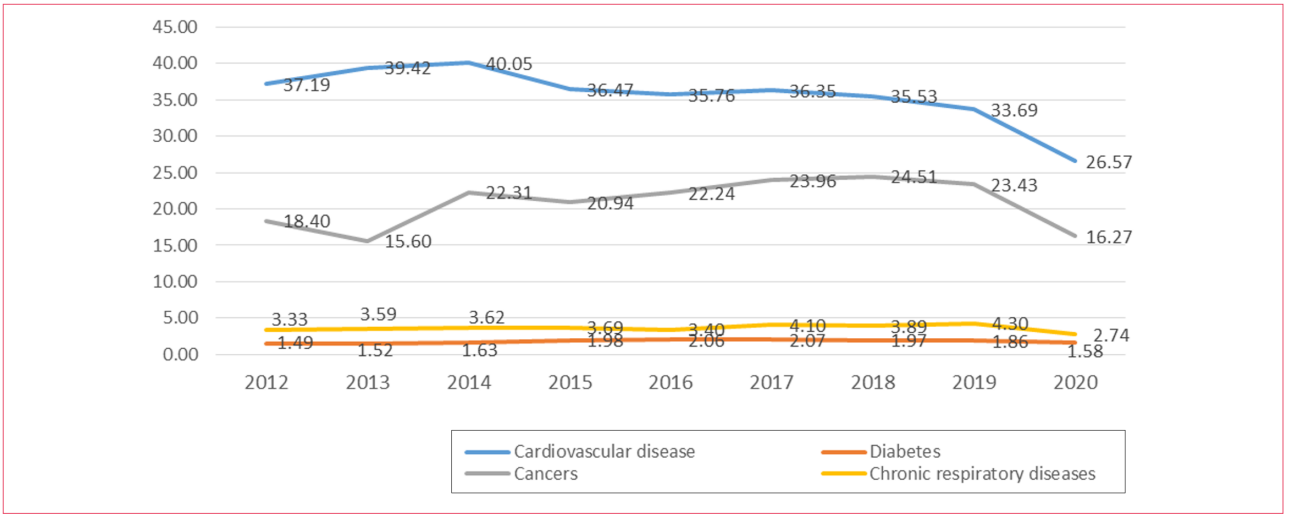

Figure 2. Percent of premature death (30 -70 years) from four major NCDs, in Iran, 2012- 2020*.
*Four major NCDs (CVD, cancers, chronic respiratory diseases and diabetes)

The probability of premature deaths (ages 30-70) due to major NCDs, after adjusting for undercounting, ranged from 14.95% to 17.35% between 2012 and 2020. By sex, the lowest probability was 12.15% for females in 2017, and the highest was 20.65% for males in 2012 (Table 2).

Table 2. Probability of premature death due to four major NCDs* by sex, in Iran, 2012 - 2020.

Year	Total (%)	Female (%)	Male (%)
2012	17.35	14.44	20.65
2013	16.65	13.76	20.09
2014	16.61	13.8	20.56
2015	15.6	12.87	19.22
2016	14.95	12.39	18.24
2017	15.15	12.15	18.27
2018	15.25	12.16	18.44
2019	16.63	13.09	20.19
2020	15.81	12.37	19.29

*Four major NCDs: CVD, Cancers, Chronic respiratory diseases and Diabetes.

DISCUSSION

Our course of this nine years, 1,072,503 premature deaths occurred in Iran. Similar to other studies, despite the significant improvement in the overall rate of premature deaths in Iran, the trend of premature deaths was increasing with the onset of the Covid-19 pandemic in late 2019. In our study, on average, 65% (693,323) of premature death were caused by non-communicable diseases with a male-to-female ratio of 1.6.[21-23]

Several hypotheses can explain the higher mortality risk of non-communicable diseases (NCDs) in men. Men are more likely to engage in riskier behaviors such as smoking, excessive alcohol consumption, and poor dietary habits, which are significant risk factors for NCDs. They often work in more hazardous environments, exposing them to physical and chemical risks. Additionally, men are generally less likely to seek medical help and undergo regular health check-ups, leading to later diagnoses and poorer management of NCDs. Biological differences may predispose men to higher rates of certain NCDs, such as cardiovascular diseases. Men also tend to experience higher levels of stress and are less likely to seek help for mental health issues, exacerbating conditions like hypertension and heart disease. Socioeconomic factors, such as unemployment or lower income, can further limit men's access to healthcare and healthy lifestyle choices.[24-26]

A rapid assessment done 2020 by WHO found that 75% of countries reported gaps in NCD services. Excessive mortality from the disruption caused by Covid-19 may make any gains against the virus a risky victory. Service disruptions have been particularly problematic for those living with non-communicable diseases who need regular or long-term care.

However, to establish more rollouts health systems during and offer a crisis, governments must

ensure that essential health services for people with NCDs are not disrupted. Countries must address the impact of non-communicable diseases in their response to Covid-19 and their development preparedness plans.[27]

Similarly in some studies, the most common cause of premature death in this study was cardiovascular diseases (27% to 40%). Their trend increased by 3% from 2012 to 2014 and decreased by 3% from 2014 to 2019.Starting in 2020, with the onset of the Covid-19 pandemic, the trend of cardiovascular diseases suddenly decreased by seven percent.[2, 6, 7, 21] This phenomenon can be justified by considering that individuals with cardiovascular disease have an increased risk of contracting and dying from Covid-19.28 Another contributing factor to the increase in CVD might be the lack of necessary care for individuals suffering from this type of disease during the Covid-19 pandemic. The trend of premature deaths due to diabetes, chronic respiratory diseases and cancer up to 2017 was upward, contrary to some studies.[6, 21]

Between 2012 and 2016, the probability of premature deaths due to four major non-communicable diseases, observed in GBD 2019 Iran and the Malta study, declined. However, from 2016 to 2019, it increased. In 2020, with the pandemic of the Covid-19 disease, this probability decreased, while in low-income countries and the average is estimated to be around 25%, which is more than our study.[6, 23, 29] Consistent with Yang's study and PAHO reporting, the probability of premature death was greater in men than in women in this research.[21, 30]

This indicator serves as an impact measure, and to mitigate its effects, several strategies must be employed at the national level, including the reduction of risk factors. Among the most significant risk factors associated with NCDs are blood pressure diseases, lack of physical activity, obesity, smoking, and alcohol consumption.

Additionally, socioeconomic changes such as economic growth, urbanization, education levels, income inequality, employment rates, healthcare infrastructure, and social policies significantly influence trends in premature mortality from non-communicable diseases (NCDs). Economic growth can enhance access to healthcare and improve living conditions, while urbanization may lead to lifestyle changes that impact health. Higher education levels are linked to better health outcomes, whereas income inequality can create disparities in healthcare access. Employment provides financial stability and health insurance, reducing stress and improving health outcomes. Investments in healthcare infrastructure facilitate early detection and treatment of NCDs, and social policies like anti-smoking laws and public health campaigns can positively affect NCD trends.[31-32]

Since 2012, the implementation of the Health Transformation Plan in Iran has integrated service packages aimed at reducing these risk factors within the country's service delivery system. To further combat this disease, targeted efforts should strengthen the Primary Healthcare (PHC) system.

The Health Transformation Plan (HTP) has significantly enhanced the Primary Healthcare (PHC) system, reducing non-communicable disease (NCD) risk factors. Key improvements include

developing health teams and family practice models, integrating new services like smoking cessation and NCDs prevention programs, and expanding PHC services to rural and suburban areas. Intersectoral collaboration has addressed social determinants of health, while improvements in the referral system and financial protection have ensured appropriate care at the primary level, reducing the burden on higher-level facilities and out-of-pocket expenses. These initiatives collectively emphasize health promotion and proactive disease prevention, contributing to the reduction of NCD incidence and impact.[33]

This study had several limitations. First, it relied on estimated population data for years after 2015, which may introduce some inaccuracies. Second, mortality data for Tehran Province, the capital city of Iran, were not available until 2014 in the Ministry of Health and Medical Education records, potentially affecting the completeness of the data. Third, the redistribution of data for unknown age and sex, as well as ill-defined causes of death, was performed using the weight distribution method, which may lead to potential misclassification within the death registration data. Additionally, assumptions made in mortality estimates could introduce biases.

These limitations could have several implications. The reliance on estimated population data and the absence of mortality data for Tehran Province until 2014 might affect the accuracy of trend analysis and regional comparisons. The potential misclassification and assumptions in mortality estimates could impact the reliability of the findings, particularly in identifying specific trends and patterns in mortality data. These factors should be considered when interpreting the results of this study.

CONCLUSION

During the years of our study, non-communicable diseases were the primary causes of premature deaths, particularly among men. Given the potential for the recurrence of communicable disease epidemics like COVID-19, it is crucial to develop appropriate policies and planning to address non-communicable diseases within the country's health and treatment network. Specific recommendations include improving accessibility to NCD services, establishing crisis-resilient healthcare systems, and prioritizing rural healthcare accessibility. Ensuring equitable access to care for all, especially vulnerable populations such as marginal areas of cites and lower-income groups, is essential. These measures will help mitigate the impact of NCDs and enhance the overall resilience of the healthcare system.

ACKNOWLEDGMENTS

The authors would like to express their gratitude to the deputy for public Health universities/faculties of medical sciences and the experts responsible for the program of registering and classifying the causes of deaths in the universities/faculties of medical sciences across the country who have cooperated in collecting, entering and correcting the death registration information.

Conflict of Interests

The authors state no conflict of interest in the present study.

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