

Trends in premature mortality in the Islamic Republic of Iran: probability of dying between ages 30 and 70 years

Elaheh Kazemi,¹ Ardeshir Khosravi,¹ Saeide Aghamohamadi,¹ Mohammad Shariati² and Hossein Kazemeini¹

¹Center for Health Network, Ministry of Health and Medical Education, Tehran, Islamic Republic of Iran. ²Department of Social Medicine, School of Medicine, Tehran University of Medical Sciences, Tehran, Islamic Republic of Iran. (Correspondence to: Ardeshir Khosravi: ardeshir1344@yahoo.com).

Abstract

Introduction: The burden of noncommunicable diseases (NCDs) is a major challenge facing the whole world. Around 15 million premature deaths due to NCDs occur in people aged 30–70 years annually.

Aims: Mortality data based on death registration systems and population data were used to estimate proposed mortality statistics in the Islamic Republic of Iran.

Methods: Various criteria and methods were used to assess the quality of mortality data. The probability of dying among those aged 30–70 years for all causes and for NCDs was calculated using the life table method.

Results: The mortality rate in the population aged 30–69 years was 343.12 (per 100 000 persons) in 2006 and decreased to 240.62 in 2016 in both sexes. The probability of dying due to NCDs was 21.36% in 2006 and declined to 14.95% in 2016 for both sexes.

Conclusions: The number of premature deaths due to NCDs have decreased over the last decade. We predict that this reduction will continue and the country will meet the targets of the WHO NCD action plan by 2025 and also the targets of the Sustainable Development Goals for reducing premature deaths by 2030. However, the morbidity and burden of NCDs are still public health concerns in the country. Due to advancements in health care technologies and also the aging population, these concerns will impose greater costs on the health system. Hence, prevention programmes for NCDs should be an urgent priority for Iranian health policy.

Keywords: probability of dying, mortality rate, vital statistics, noncommunicable diseases, Iran

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Introduction

The burden of noncommunicable diseases (NCDs), including cardiovascular diseases (CVDs), cancers, diabetes and chronic respiratory diseases, is among the major challenges worldwide in the current century: NCDs accounted for 72.3% of deaths in 2016 (1). Around 15 million premature deaths due to NCDs in people aged 30–69 years occur every year worldwide (2). Remarkably, low-income and lower-middle-income countries with half of the premature NCDs deaths have more problems than developed countries. Additionally, within countries, poor people suffer more from NCDs.

This multidimensional health problem is determined by various factors such as low socioeconomic situation, international marketing, trade in health-harming products, urbanization, demographic transition, and changes in lifestyle (3).

The Islamic Republic of Iran, a middle-income country, has faced considerable social, economic and demographical transitions over the past 4 decades. Although, general health outcomes have improved considerably, there was a significant and uniform shift from communicable, maternal, neonatal, and nutritional (CMMN) conditions to NCDs from 1990 to 2010 (4,5).

It seems that the country will face a 35% increase in burden of disease and injury over the next 2 decades, mainly due to aging or demographic and epidemiological changes. In this regard, communicable diseases (except HIV/AIDS) will have less contribution and on the other hand NCDs will play a significant role (6,7).

Shahraz et al. estimated the population health and burden of disease profile for the Islamic Republic of Iran among 20 countries in the region, from Afghanistan to Lebanon and Qatar, between 1990 and 2010 (4). They used classic global burden of disease metrics, and indicated the ranking of the countries. Overall health outcomes, life expectancy at birth and age-standardized death rate improved considerably in the Islamic Republic of Iran from 1990 to 2010. Additionally, the results showed that the burden of communicable, maternal, neonatal, and nutritional conditions sharply declined compared with that of NCDs. The Islamic Republic of Iran ranked 13th in health-adjusted life expectancy and 12th in age-standardized death rate.

In 2011, international agencies such as the UN and WHO targeted reducing premature deaths due to NCDs, and announced the list of all countries which were planning to control NCDs. According to this agenda, the target indicator is to decrease by 25% the probability of dying due to 4 NCDs (CVD, diabetes, cancer, and chronic respiratory disease) in individuals aged 30–70 years

by 2025 (8,9). In addition, in 2015 the UN General Assembly formally released the 2030 programme for the Sustainable Development Goals (SDGs), which incorporated an arrangement of 17 strong new global goals and 169 particular targets. The plan additionally incorporates reducing by 33% premature mortality due to NCDs from the current level (10).

The aim of this paper was to estimate the probability of dying between ages 30 and 69 years for all-cause mortality and for 4 NCDs from 2006 to 2016 in the Islamic Republic of Iran.

Methodology

Data source

We used mortality data based on death registration systems and population data in order to estimate proposed mortality statistics. The cause of death data were gathered from the Ministry of Health and Medical Education. We also used all-cause mortality data from the National Organization for Civil Registration for 2006–2016. As the data quality (considering cause of death from the National Organization for Civil Registration) was not acceptable, these data were only used to estimate total mortality statistics and also the completeness of the death registration system (11).

We obtained population data according to sex and 5-year age groups via the Statistical Center of Iran. These data (for 2006, 2011 and 2016) were based on census data; estimated data were used for intercensal years (2007–2010 and 2012–2015). The method for population projection was the cohort component method based on information on the structure of the population (12). The *People* software package was used; this required data and information on population structure, fertility, mortality, sex ratio and migration. These were obtained using various data sources and reports such as birth and death registries from the National Organization for Civil Registration, the Ministry of Health and Medical Education and the Statistical Center of Iran (12,13).

Statistical methods

Various criteria and methods were used to assess the quality of mortality data. We reviewed the missing data for age and sex information. Unknown sex- and age-related deaths were redistributed among cause–sex–age groups. We reviewed the quality of information on cause of death. One of the key criteria for checking the data quality of cause of death is the proportion assigned to “ill-defined or non-specific codes”, known as “misclassification” of cause of death (14,15). We redistributed deaths in the category symptoms, signs and ill-defined conditions proportionally to all well-defined causes except injury (16).

In this study we defined cause of death codes based on the International Classification of Diseases (ICD) system as: CVDs (ICD-10 codes I00–I99), cancers (ICD-10 codes C00–C97), diabetes (ICD-10 codes E10–E14), and chronic respiratory disease (ICD-10 codes J30–J98) (17–20).

In order to estimate the unconditional probability of dying due to all causes and to NCDs between ages 30 and 69 years, the life table method was used. In the first step, we calculated age-specific death rates in 5-year age groups (e.g. 30–34, 65–69) (18,21).

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

In the second step, we calculated probability of dying in each 5-year age range between 30 and 70 years.

$${}_5q_x = \frac{5 \cdot {}_5M_x}{1 + (2.5 \cdot {}_5M_x)} \quad [2]$$

The above formula is derived from the assumption that deaths are linearly distributed throughout the year (18).

In the next step, we calculated probability of survival in each 5-year age group between 30 and 69 years.

$${}_5p_x = 1 - {}_5q_x \quad [3]$$

And in the final step, we calculated the unconditional probability of dying from age 30 to 69 years.

$${}_{40}Q_{30} = 1 - \prod_{30}^{65} {}_5p_x \quad [4]$$

Correction for underreporting of deaths

Generally, data from death registration systems have the drawback of underreporting. To correct for this limitation, various statistical and demographical methods have been developed. We used the new method presented by Adair and Lopez, which is based on the mixed effects model for predicting completeness of data from death registration system (22). The model for predicting completeness is based on the relationship between registered crude death rate (Reg CDR), the true level of child mortality rate ($5q^0$), registered child mortality rate (Reg5q0), and population age structure (percentage of population 65 years old and above (%Pop 65i). Data on the registered crude death rate were obtained from the National Organization for Civil Registration. We also used child mortality data estimated from the UN Inter-agency Group as the true level of child mortality (22,23). The models are:

$$\text{logit}(C_i^{All}) = \beta_0 + \text{RegCDR}_i^2 * \beta_1 + \text{RegCDR}_i * \beta_2 + \%Pop65_i * \beta_3 + \ln(5q0)_i * \beta_4 + C_i^{5q0} * \beta_5 + \text{Year} * \beta_6 + e_i + \gamma \quad [5]$$

$$C_i^{All} = \frac{\text{RegCDR}}{\text{CDR}} \quad \text{Completeness of Registration of All ages}$$

$$C_i^{5q0} = \frac{Reg5q0}{5q0}$$

Completeness of Registration of ${}^5q^0$

In the above model e , is an error term, i is calendar year, and γ is a random effect and β_0 to β_6 are the coefficient. In the study by Adair and Lopez, all random effects of countries were presented in the appendices (22). We also had personal communication with them and they sent us an *Excel* template which contained all model coefficients (Adair T, personal communication, 15 August 2018).

Average annual rate of decline

As probability of dying from age 30 to age 70 years (${}_{40}q_{30}$) was estimated for each year during 2006 to 2016, we next estimated the average annual rate of decline applying regressing log probability of death for each year:

$$\ln({}_{40}q_{30}) = \alpha + \beta \times year \quad [6]$$

This generated a coefficient (β) separately for males, females and both sexes, from which we calculated the relative decline as follows:

$$\text{Annual average change in } {}_{40}q_{30} = 1 - e^\beta \quad [7]$$

We can use this annual average change in ${}_{40}q_{30}$ to compare the mortality risk of 4 NCDs between men and women on the same basis (18). We also predicted the trends for probability of dying for each year over the period 2017–2025. To do this, using the parameters obtained from Model [6], the trend for probability of dying was predicted.

Results

In 2006, about 129 668 (46.5%) deaths occurred in people aged 30–69 years in the Islamic Republic of Iran. This increased to 137 267 deaths in 2016.

Table 1 shows the proportion of adult deaths (30–69 years) due to NCDs for each sex during 2006–2016. In general, the proportion of NCD deaths was greater in females than in males: in 2006, these proportions were 75.92% and 60.88% respectively, and 74.73% and 65.69% respectively in 2016.

The trend in the mortality rate for people aged 30–70 years during 2006–2016 is shown in Table 2. Overall, the rates for males are nearly double the rates for females over this period. The all-cause mortality rates per100 000 for males and females were 673.47 and 371.47 in 2006; these decreased to 450.69 and 263.56 in 2016. All-cause mortality rates per100 000 population were 518.39 in 2006 and 348.82 in 2016 for both sexes. It can be seen that mortality rates due to NCDs

were higher in males than in females and also that they decreased considerably over the study period. The NCD mortality rates per 100 000 population were 410.01 for males and 282.01 for females in 2006, decreasing to 296.04 and 196.97 respectively in 2016. These rates were 343.12 in 2006 and 240.62 in 2016 for both sexes.

Table 3 shows the 2 most important mortality statistics: the probability of dying due to all causes and the probability of dying due to NCDs in individuals aged 30–69 years. Both indicators were higher in males than females; all indicators decreased over the study period. The probability of all-causes death was 33.28% and 22.75% for males and females respectively in 2006, declining to 24.38% and 15.63% respectively in 2016. The probability of dying was 27.75% in 2006 and decreased to 19.61% in 2016 for both sexes. The probability of dying due to NCDs was 24.63% and 18.35% in 2006 and fell to 18.24% and 12.39% in 2016 for males and females respectively. This index was 21.36% in 2006 and fell to 14.95% in 2016 for both sexes.

Next, we calculated the average annual rate of decline of ${}^{40}q_{30}$ over the period 2006–2016 using a re-creation model of $\ln({}^{40}q_{30})$. Regression analysis showed that the annual average rate of decline of ${}^{40}q_{30}$ for males in this period was 2.8% for all causes (Table 4). The annual average rate of decline of ${}^{40}q_{30}$ for females in this period was 3.4% based on Ministry of Health and Medical Education data for all causes. The annual average rate of decline of ${}^{40}q_{30}$ for both sexes in this period was 3.3% based on Ministry of Health and Medical Education data for all causes. The annual average rate of decline of ${}^{40}q_{30}$ for males over this period was 2.3% considering the 4 main NCDs as cause of death (using Ministry of Health and Medical Education data). This value was 3.7% for females considering the 4 main NCDs as cause of death (using Ministry of Health and Medical Education data). The annual average rate of decline of ${}^{40}q_{30}$ for both sexes over this period was 3.2% considering the 4 main NCDs as cause of death (using Ministry of Health and Medical Education data). Table 4 shows the predictor variables of the regression model for predication annual average reduction such as regression coefficient, *F*-ratio, *P*-value, and *R*². All predictor variables were statistically significant (*P* < 0.05).

Figure 1 shows the trends for the probability of dying due to NCDs in the population aged 30–69 years for both sexes using observed data (2006–2016) and predicated data (2006–2025). From the observed data, which were corrected for underreporting and misclassification, the probability of dying from NCDs for both sexes declined from 21.36% in 2006 to 14.95% in 2016. From the predicted model, this indicator was 21.23% in 2006 and is estimated to fall to 11.4% in 2025.

Discussion

Our results showed that mortality due to the 4 leading NCDs was a public health concern in the Islamic Republic of Iran over the last decade. Total deaths due to NCDs increased in the Iranian population aged 30–69 years from 69 072 in 2006 to 90 281 in 2016. Although the total number of deaths increased, the unconditional probability of dying due to NCDs in this age group decreased from 21.3% in 2006 to 14.95% in 2016; we predicted that it would fall to 11.40% in 2025.

This paper is the first comprehensive attempt to estimate different statistics for premature deaths based on various data available in the country. Usually, data from death registration systems have 2 limitations: underreporting and misclassification. There are various indirect demographic methods, such as the death distribution method, which can be used to correct mortality data for underreporting (22). Using these methods requires 2 assumptions: a stable population and closed to migration. In light of the demographic changes in the Islamic Republic of Iran over the last 4 decades, we therefore used new methods in order to correct underreporting of deaths. Misclassification is another challenge considering data on cause of death based on registration. We used the distribution method to correct ill-defined or non-specific codes for cause of death.

We found that the probability of dying due to 4 main groups of NCDs in the Iranian population aged 30–69 years decreased during 2006–2016. From WHO estimates, the probability of dying from NCDs was 17.3% in 2012, decreasing to 14.8% in 2015; this result is similar to our findings (24,25).

Our findings also showed that, excepting the premature death rate from diabetes, which increased (11.0 per 100 000 in 2006 and 16.7 in 2016), death rates from the other 3 NCDs (cancer, CVD and chronic respiratory disease) decreased between 2006 and 2016. These patterns of reduction for 3 groups of diseases but increasing for diabetes were noted in the WHO report and also the Global Burden of Disease study (26,27). In addition, incidences of these 4 diseases were 171.7 for cancer, 877.0 for CVDs, 450 for diabetes and 486 for chronic respiratory disease per 100 000 in 2006 and 210.6 for cancer, 879.3 for CVDs, 594.7 for diabetes and 505.3 for chronic respiratory disease per 100 000 in 2016. Hence, the incidence of CVDs did not increase considerably over the study period. However, morbidity and mortality increased for diabetes. This could be the result of socioeconomic and lifestyle changes in the Islamic Republic of Iran over the past 2 decades.

Among the 4 groups of diseases, CVD had the highest mortality rate, and as a result, this showed the greatest decrease during the study period. Therefore, CVD might have been responsible for the greatest contribution to reducing the probability of death (mortality) from NCDs. Considering

the significant improvements in access and continuous improvements in diagnosis and treatment of CVDs, the case-fatality for CVDs has decreased significantly (28).

According to a WHO report, at least 80% of premature heart disease, stroke and type 2 diabetes, and 40% of cancers can be prevented through interventions aimed at several risk factors, such as healthy diet, regular physical activity and avoidance of tobacco products (29).

In the context of international attempts, including the improvement of health service delivery based on universal health coverage, a memorandum of understanding was signed in 2015 between the Ministry of Health and Medical Education and other relevant ministries (aimed at the prevention and control of NCDs) (7,30). This document was planned to implement various programmes to prevent NCDs and related risk factors by 2025. Additionally, to provide universal health coverage, the Ministry of Health and Medical Education launched a transformation plan in 2014. Service packages delivered in the primary health care units were revised based on the WHO Package of Essential Noncommunicable Disease Interventions (known as IrPEN); these packages are currently available at primary health care units (31,32).

The information system for mortality and cause of death is a key component in monitoring and assessment of health interventions to prevent and reduce the NCDs and related risk factors. During the last decade, the cause of death registration system was improved in the Islamic Republic of Iran (24). Using multiple data sources for capturing cause of death information increased the completeness of the data. Using the detailed ICD-10 coding system has also improved the quality of cause of death data, particularly for females. An urgent priority for public health policy is focusing on better diagnosis of cause of death through the issuing of death certificates by physicians of adult mortality.

Although we attempted a comprehensive assessment of trends and levels of premature death due to NCDs, this research had several limitations. First, mortality data for 2 provinces (Tehran until 2014 and Isfahan 2007–2010) were not available in Ministry of Health and Medical Education data; thus, we assumed that their patterns for cause of death were the average of all other provinces. Second, the Statistical Center of Iran estimated population data for age and sex were used for the intercensal years. Third, in this study we corrected the cause of death data for garbage and ill-defined codes using a simple proportional distribution method.

In conclusion, premature deaths due to NCDs have decreased over the last decade in the Islamic Republic of Iran. We predicted that this reduction would continue and that the country will meet the targets of the WHO NCD action plan for 2025 and also the SDGs targets to reduce premature deaths by 2030. The improvements in curative services along with the aging population will impose more costs on the health system. Hence, a prevention programme for NCDs should be an urgent priority in Iranian health policy (29,33).

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Table 1. Proportion of deaths from noncommunicable diseases in the Iranian population aged 30–69 years, 2006–2016

Year	Sex		
	Male (%)	Female (%)	Both (%)
2006	60.88	75.92	66.17
2007	63.12	77.32	68.29
2008	62.07	76.78	67.48
2009	62.57	75.44	67.22
2010	61.81	76.67	67.15
2011	63.94	76.76	68.69
2012	65.13	76.39	69.25
2013	65.49	75.40	69.13
2014	69.60	76.66	72.19
2015	67.12	76.57	70.55
2016	65.69	74.73	68.98

Table 2. All-cause mortality and noncommunicable diseases (NCDs) mortality in the Iranian population aged 30–69 years, 2006–2016

Year	All causes of mortality (no. per 100 000)			NCD mortality (No. per 100 000)		
	Male	Female	Total	Male	Female	Total
2006	673.47	371.47	518.39	410.01	282.01	343.12
2007	590.09	342.82	464.99	372.48	265.07	317.56
2008	592.33	339.54	459.89	367.63	260.70	310.32
2009	581.80	332.00	453.45	364.05	250.47	304.82
2010	563.74	313.69	435.69	348.46	240.52	292.58
2011	524.16	311.50	418.49	335.13	239.11	287.46
2012	501.58	296.25	395.80	326.66	226.31	274.10
2013	482.53	283.13	377.59	315.99	213.48	261.04
2014	481.45	284.07	370.45	335.08	217.78	267.42
2015	463.23	268.24	355.96	310.92	205.39	251.12
2016	450.69	263.56	348.82	296.04	196.97	240.62

Table 3. Probability of dying due to all-causes and noncommunicable diseases (NCDs) in the Iranian males and females aged 30–69 years, Iran, 2006–2016

Year	All causes of death			4 main NCDs as cause of death		
	Male (%)	Female (%)	Total (%)	Male (%)	Female (%)	Total (%)
2006	33.28	22.27	27.75	24.63	18.35	21.36
2007	30.31	20.84	25.60	22.91	17.37	20.07
2008	30.65	20.71	25.49	22.98	17.18	19.86
2009	30.49	20.05	25.19	22.78	16.38	19.43
2010	29.67	19.09	24.31	22.14	15.75	18.81
2011	27.91	18.62	23.31	21.16	15.34	18.22
2012	27.08	17.67	22.22	20.65	14.44	17.35
2013	26.44	17.03	21.46	20.09	13.76	16.65
2014	26.20	16.97	20.96	20.56	13.80	16.61
2015	25.22	15.85	20.05	19.22	12.87	15.60
2016	24.38	15.63	19.61	18.24	12.39	14.95

Table 4. Regression analysis showing average annual rate of decline for cause of death, [all causes and 4 main noncommunicable diseases (NCDs)]

Cause of death	Alpha	Beta	1-exp (Beta)	F	P-value	R ²
<i>All causes</i>						
Male	42.979	−0.029	0.028	217.445	< 0.05	0.96
Female	51.795	−0.035	0.034	742.592	< 0.05	0.988
Total	50.031	−0.034	0.033	525.541	< 0.05	0.983
<i>4 main NCDs</i>						
Male	36.786	−0.024	0.023	123.325	< 0.05	0.939
Female	55.922	−0.038	0.037	617.047	< 0.05	0.987
Total	48.42	−0.033	0.032	452.049	< 0.05	0.983

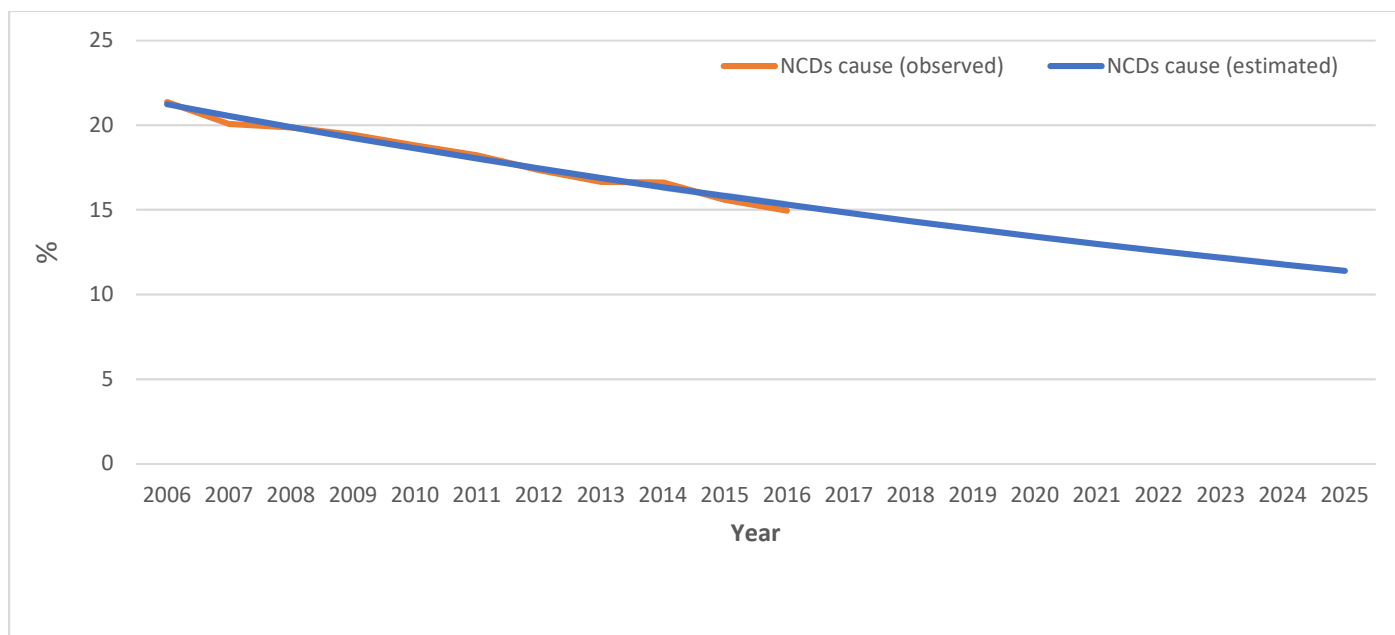


Figure 1. Trends in probability of dying (%) due to noncommunicable diseases in the population aged 30–69 years based on observed and predicated data, Islamic Republic of Iran, 2006–2025