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Estimating the Life Expectancy at Birth for Iranian Provinces during 2011-16

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ABSTRACT

Background: Life expectancy at birth is a useful indicator of mortality across a population at a particular point in time. Due to the incomplete and different coverage of mortality data in the provinces of Iran, constructing a life table without data correction can have misleading results. In this study, after evaluating and correcting the mortality data, life expectancy at the national and provincial levels for the period 2011-16 has been estimated.

Methods: This was a cross-sectional study. Regarding the period 2011 to 2016, mortality data were obtained by age and sex (2051602 deaths) from the National Organization for Civil Registration, and the population data were obtained by age and sex from the Statistics Center of Iran. After evaluating and correcting the mortality data regarding children and adults, through the life table technique, life expectancy at birth for the provinces Iran was calculated by sex.

Results: The death registration regarding men and women, during 2011-2016, in the national level was 93% and 85% respectively. Moreover, the range of this coverage for the provinces has been between 70% and 98%. The life expectancy at birth for men was 73.1, and for women it was 76 years. Isfahan (77.9 for females and 74.8 for males) had the highest level of life expectancy at birth, and the lowest level was in Sistan and Baluchestan province (70.4 for females and 69.2 for males).

Conclusion: Considering that there are important differences between the life expectancy of men and women in the provinces of Iran, identifying the causes of provincial differences in regarding life expectancy in the provinces of Iran can ultimately lead to improved life expectancy at the national level.

Keywords: Mortality, Life Table, Life Expectancy, Iran.

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Introduction

Life expectancy at birth actually refers to the average number of years a newborn is expected to live, if mortality patterns at the time of its birth remain constant in the future (1). Life expectancy at birth is not only a summary of mortality, but also an accepted indicator for the development of a country (2, 3). Beyond being a key indicator of the health and well-being of a population, it is, in a sense, an indirect indicator of poverty, stress, and stability — and of a government's willingness or ability to safeguard the public health (4, 5). Life expectancy at birth is a very useful indicator of mortality conditions across a population at a particular point in time. It also provides an objective means of comparing trends in mortality over time, between parts of a country and with other countries. This is used to monitor and investigate health inequalities and to set public health targets.

The world has experienced significant increase in life expectancy at birth over the past seven decades. In 1950, the global life expectancy stood at 45.7 years. Life expectancy continued to increase, and reached 72.6 years in 2019. In 2019, life expectancy for women exceeded men by 4.8 yearsglobally (6). Although decrease in mortality rates has narrowed the global gap of life expectancy at birth, there are still many differences. Improvements in living conditions, nutrition and medicine are among the main reasons for this development (7, 8). These changes in economic, social and health conditions first triggered an important decline in infants, children, and early adults' mortality, which contributed to the reduction in lifespan disparities (6, 9).

The rise in life expectancy in Iran, like in many developing countries, began after World War II (10). In Iran, life expectancy at birth increased from 45 years in 1956 to over 70 years in 2011. The decrease in child mortality has been the main reason for the increase in life expectancy during the mortality transition process (11, 12). Research shows that there are significant differences in life expectancy at birth at the provincial level, and provinces are at different stages of demographic transition (13, 14). To plan for health and social services and pensions, especially the fair distribution of facilities, estimation of mortality and life expectancy in the provinces of Iran are needed. In this regard, the present study aimed to estimate the life expectancy at birth in Iran at the provincial level during 2011-2016, based on direct life table technique.

Methods

This was a cross sectional study which estimated life expectancy at birth at the national and provincial levels in Iran.

The required data

The data for the manuscript was extracted from a research project on "The role of age groups and causes of death in provincial differences of life expectancy at birth in Iran" with the research code No. 11.104276. It was conducted by the National Institute for Population Research (15). In this study, death information for Iranian provinces during 2011 to 2016 was obtained from the Iranian National Organization for Civil Registration system. In this method, the death is recorded at the time of occurrence, and is the most appropriate method which can generate mortality data. Current mortality data from the National Organization for Civil Registration were used according to gender and the ordinary age groups of five years. In addition, the population statistics for the provinces of Iran have been obtained from the Statistics Center of Iran.

Data Analysis

In developing countries such as Iran, mortality data mainly contain content errors such as deregistration (16). Therefore, conducting any study in this field requires evaluating these data and determining the degree of unregistered data and its correction. Techniques for evaluating and correcting death registration statistics are divided into two independent groups of adult (5 years and older) and children (under 5 years). Among the available methods for evaluating adults' mortality data, synthetic extinct generations (SEG) method was used (17). SEG method is one of the methods

regarding age distribution of mortality. In these methods, the completeness of the death record is assessed according to census and provides information for age-specific mortality rates (17). This method entails the following assumptions:

- The coverage of each census is the same for all ages.
- The completeness of death reports is the same for all ages above the minimum age (usually age 15).
- The population was closed. Although the method can be adapted to allow for migration, an accurate and enough estimate of the net number of migrants to do so seldom exist. Regarding national populations, net migration is often low enough to ignore, but for situations where migration is significant, one needs to take this into account when interpreting results and deciding on an estimate of completeness.

The method was applied in the following steps:

Step 1: Estimate the number of deaths reported in the period between the dates of the two estimates of the population: In this article, the total statistics of current deaths of the National Organization for Civil Registration in the period from October 2011 to September 2016 were used.

Step 2: Estimate the growth rates adjusting for migration and differential census coverage:

Equation 1:

$$ {}_5r_x = \frac{\ln({}_5N_x(t_2)/{}_5N_x(t_1))}{t_2 - t_1} - \frac{{}_5NM_x}{(t_2 - t_1)({}_5N_x(t_1) \times {}_5N_x(t_2))^{\frac{1}{2}}} + \delta $$

Where, 5Nx (t) is the population aged between x and x + 5 at time t, 5NMx is the net number of migrants (in- less out-migrants) aged between x and x + 5, and t1 and t2 are the times of the two censuses. Delta is the correction for the completeness of one census relative to the other.

Step 3: Estimate the life expectancy at age A, and at each five-year interval down to 65. It is derived from the data after applying the Generalized Growth Balance method.

Step 4: Estimate the number of people who turned x, and the number aged x to x+4 last birthday, from the reported deaths which are obtained by using the equations of numbers 2 and 3

Equation 2:

$$ \hat{N}_x = \hat{N}_{x+5}\exp(5{}_5r_x) + {}_5D_x \exp(2/5{}_5r_x) $$

Equation 3:

$$ \hat{N}_A = {}_\infty D_A \left(\exp({}_\infty r_A \times e_A) - ({}_\infty r_A \times eA)^2/6\right) $$

Where, A is the age at the start of the open interval, nrx is the annual population growth rate in the age group x to x+n's last birthday, and eA is the life expectancy at age A.

Step 5: Estimate the number of people aged x to x + 4's last birthday during the period between the two censuses, from the census populations:

Equation 4:

$$ {}_5N_x = (t_2 - t_1)({}_5N_x(t_1) \times 5Nx(t_2))^{\frac{1}{2}} $$

Step 6: Calculate the ratios of the estimates derived from deaths to those derived from the census populations:

Equation 5:

$$ {}_{A-x}\hat{N}_x = \sum_{a=x,5}^{A-5} 5\hat{N}x $$

Step 7: Estimate the completeness of death reports: Completeness is estimated from the quinquennial age group-specific ratios. In order to produce a robust estimate, it is calculated as the sum of 50 percent of the median, plus 25 percent of each of the 75th and 25th percentiles of these ratios (17).

Child mortality is estimated using the Brass method, which is based on the information about children ever born and children surviving. This paper uses used a version of the Brass method, known as the method of estimating child mortality between two surveys (18). Using two censuses in 2011 and 2016, an estimate of child mortality was obtained. After correcting the mortality data and calculating the death rates by age groups, life expectancy at birth was calculated using the standard life table technique. It should be noted that calculations were done using MortPak software, and data analysis was done by province.

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Results

According to the registered mortality statistics of the National Organization for Civil Registration of Iran, about 338 thousand deaths occurred in 2016 in the country. 198 thousand of them were men, and 140 thousand were women. Thus, the sex difference in deaths in Iran was 1.4, which means that for every 100 deaths for women, there are 140 deaths for men in 2016.Tehran province with about 53 thousand cases had the highest number of deaths, and Ilam province with about 2200 cases had the lowest number of deaths.

Table 1 shows the percentage of death registration in the country during the years 2011 to 2016. Nationwide, death registration was 8% more for men compared with women. This amount was calculated for men and women of the country to be 93% and 85%, respectively. These figures indicated that during 2011 to 2016, 15% of the deaths of women and 7% of the deaths of men were not registered by the National Organization for Civil Registration. Furthermore, at the provincial level, there are significant differences in the quality of death records. Markazi, Mazandaran, Zanjan, Qom, Gilan, Ardabil, Alborz and Kermanshah provinces were among the provinces where the death registration coverage for men was more than 95%. The coverage of women's deaths in Alborz, Zanjan and Qom provinces was higher than 90%. On the other hand, the registration of death data in Sistan and Baluchestan and Hormozgan provinces were of the lowest quality compared to other provinces; therefore, 72% and 75% of female deaths have been recorded respectively in Sistan and Baluchestan and Hormozgan provinces.

Table 1. Percentage of death registration coverage at national and provincial level by sex during 2011-2016

Province	Female	Male	Difference
East Azerbaijan	83	90	7
West Azerbaijan	82	92	10
Ardebil	89	95	6
Isfahan	84	94	10
Alborz	94	96	2
Ilam	76	90	14
Bushehr	81	86	5
Tehran	79	85	6
Chahar Mahaal and Bakhtiari	79	92	13
South Khorasan	80	90	10
Khorasan, Razavi	82	92	10
North Khorasan	82	88	6
Khuzestan	86	95	9
Zanjan	92	98	6
Semnan	84	89	5
Sistan and Baluchistan	72	85	13
Fars	83	93	10
Ghazvin	81	94	13
Qom	95	98	3
Kordestan	85	91	6
Kerman	80	90	10
Kermanshah	90	98	8
Kohgiluyeh and Boyer–Ahmad	79	85	6
Golestan	87	93	6
Gilan	92	97	5
Lorestan	78	91	13
Mazandaran	90	98	8
Markazi	89	98	9
Hormozgan	75	80	5
Hamadan	90	95	5
Yazd	81	89	8
National	85	93	8

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One of the most important demographic indicators is crude death rate, which can be easily calculated according to the availability of the number of deaths and the exposed population. Table 2 shows the death rates of the provinces of Iran by sex. After correcting the mortality data, the death rate for Iranian men and women in 2016 was estimated at 5.9 per thousand and 4.9 per thousand population, respectively. At the provincial level, as the national level, the death rate for men was higher than women. Furthermore, during the study period, the highest death rate regarding both women (6.2 per thousand) and men (7.6 per thousand) was related to Gilan province. The lowest death rate belonged to Alborz province with less than 4 per thousand population for men and women.

Table 2. Crude death rates (per thousand population) of Iran's provinces by sex 2011-16

Province	Female	Male
East Azarbaijan	5.9	6.8
West Azarbaijan	4.7	5.7
Ardebil	5.5	6.2
Isfahan	4.7	5.6
Alborz	3.1	3.6
Ilam	4.4	4.9
Bushehr	4.0	4.2
Tehran	4.6	5.9
Chahar Mahaal and Bakhtiari	5.7	4.5
South Khorasan	5.5	6.2
Khorasan, Razavi	5.0	5.8
North Khorasan	5.4	6.4
Khuzestan	4.1	5.0
Zanjan	4.8	6.0
Semnan	5.3	5.9
Sistan and Baluchistan	4.9	5.4
Fars	4.6	5.8
Ghazvin	4.6	5.3
Qom	4.4	4.9
Kordestan	4.6	5.8
Kerman	4.1	5.2
Kermanshah	5.3	6.8
Kohgiluyeh and Boyer–Ahmad	3.8	5.6
Golestan	4.6	5.7
Gilan	6.2	7.6
Lorestan	5.0	6.4
Mazandaran	5.3	6.0
Markazi	5.2	6.4
Hormozgan	3.8	5.4
Hamadan	5.4	6.9
Yazd	4.7	5.4
National	4.9	5.9

After modifying the mortality data and calculating the death rates by age groups, life expectancy at birth was calculated through the standard life table technique. The results are given in Table 3. Life expectancy at birth was estimated at 73.1 yearsfor men and 76 yearsfor women nationwide. Thus, women lived 2.9 years longer than men. At the provincial level, women had a longer life expectancy than men. For men, Alborz and Isfahan provinces had the highest life expectancy at 74.8 years. In addition, life expectancy at birth for men in Tehran, Mazandaran, Zanjan and Yazd provinces was over 74 years. In addition to these provinces, the life expectancy of Bushehr, Chaharmahal and Bakhtiari, Semnan, Fars, Qom and Markazi provinces was higher than the national level. Life expectancy at birth for men in other provinces, except for Sistan and Baluchestan, was more than 70 years. Life expectancy at birth for men in Sistan and Baluchestan province was 69.2 years.

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Table 3. Life expectancy at birth in Iran and provinces by sex, 2011-16

Province	Female	Male	Difference
East Azarbaijan	75.5	72.9	2.6
Weat Azarbaijan	75.6	72.8	2.8
Ardebil	74.9	72.2	2.7
Isfahan	77.9	74.8	3.1
Alborz	78.0	74.8	3.2
Ilam	73.6	71.1	2.5
Bushehr	75.5	73.1	2.4
Tehran	77.7	74.3	3.4
Chahar Mahaal and Bakhtiari	75.9	73.2	2.7
South Khorasan	75.0	72.6	2.4
Khorasan, Razavi	75.1	71.٧	3.٤
North Khorasan	73.8	71.8	2.0
Khuzestan	74.8	72.2	2.6
Zanjan	77.1	74.0	2.9
Semnan	76.9	73.8	3.1
Sistan and Baluchistan	70.4	69.2	1.2
Fars	76.5	73.4	3.1
Ghazvin	76.6	74.0	2.6
Qom	76.1	73.8	2.3
Kordestan	75.8	73.4	2.4
Kerman	76.0	72.7	3.3
Kermanshah	74.9	71.4	3.5
Kohgiluyeh and Boyer–Ahmad	75.2	72.2	3.0
Golestan	74.2	71.4	2.8
Gilan	77.0	73.5	3.5
Lorestan	74.8	71.7	3.1
Mazandaran	77.1	74.6	2.5
Markazi	77.5	73.9	3.6
Hormozgan	73.9	70.9	3.0
Hamadan	76.0	7٢.9	٣.1
Yazd	77.2	74.3	2.9
National	76.0	73.1	2.9

Regarding women in Iran, life expectancy at birth in Alborz (78 years), Isfahan (77.9 years), Tehran (77.7 years), Markazi (77.5 years) Zanjan (77.4 years), Yazd (77.2 years) and Mazandaran (77.1) were over 77 years. Life expectancy at birth for women in Fars, Semnan, Qazvin and Qom provinces was also higher than the national level. Women's life expectancy in all provinces was calculated to be over 70 years. The lowest life expectancy of women was related to the provinces of Sitan and Baluchistan (70.4 years), Ilam (73.6), North Khorasan (73.8) and Hormozgan (73.9 years). Sex difference in life expectancy at birth for the provinces of Iran shows that this difference in Hamadan, Markazi, Gilan, Lorestan, Kermanshah, Kerman, Fars, Semnan, Zanjan, Isfahan, Alborz , Tehran and Khorasan Razavi was more than 3 years and in other provinces was 3 years or lower. The lowest sex difference was related to Sistan and Baluchestan province which was 1.2 years.

Discussion

This study was an attempt to estimate life expectancy at birth in the provinces of Iran during 2011-16 through the secondary analysis of data from the National Organization for Civil Registration. The results showed that death registration in Iran was 85% for women and 93% for men, with significant differences between these figures in the provinces of Iran. Alborz and Isfahan provinces had the highest and Sistan and Baluchestan province had the lowest life expectancy at birth. Also, the life expectancy of

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Iranian men and women was estimated at 76 and 73.1 years, respectively.

Until the early 2000s, there was no data to study the age-sex pattern of mortality in Iran. Mortality studies was done based on mortality rate or life expectancy (usually life expectancy at birth), and then, extracting the life table from standard patterns (19). Today, This was proved to be in no way consistent with the sex-age pattern of mortality in Iran. However, detailed death information was gradually produced and made available to researchers through vital registration systems (the National Organization for Civil Registration) and the health registration (Ministry of Health and Medical Education). Despite the data generated by the demographic registration system, the coverage of this information still is not enough to calculate mortality rates with confidence and without any evaluation and correction (12). In this study, all the data used were evaluated before calculating the death rate and building the life table, and were applied after the required correction. Adult mortality data were corrected using SEG method. Although this method has fewer limitations than other methods, it offers only one correction factor for all ages. However, it is obvious that the accuracy and error of death registration in Iran is a function of both gender and age. The results demonstrated that in 2011-16, the current registration of death in Iran was about 90%. Comparison of these figures with death registration coverage in the same period before 2006-2011 shows improvement for men and women (19).

Findings related to estimating life expectancy at birth at the national and provincial levels can be summarized and discussed in 3 cases:

First, the findings of this study showed that in 2016, the life expectancy of men and women in the country was 73.1 and 76 years, respectively. The calculated life expectancy is consistent with the results of other studies in the country. Koosheshi (2018) estimated the life expectancy at birth to be 73.2 years for men and 76.2 years for women (19). Furthermore, the estimates of the Statistics Center of Iran for life expectancy in Iran for men and women of the country were 72.5 years and 75.5 years, respectively (13). The slight difference between the findings of this study and the estimates of the Statistics Center of Iran was due to a different method correcting the low mortality record. It is also noteworthy that life expectancy in Iran is significantly higher than in developing countries. Life expectancy in developing countries in 2015 was 67 and 70 years for men and women, respectively. In addition, the life expectancy of men and women is significantly higher than Asian countries (20). It can also be said that life expectancy at birth in Iran was somewhat similar to upper-middle-income countries (21)

Second, the index of life expectancy at birth is one of the indicators that shows the level of development in a society. According to the findings of studies conducted in Iran, the provinces of Tehran, Alborz, Isfahan, and Semnan were among the provinces with the highest level of development (22, 23). According to the findings of this study, these more developed provinces had the highest level of life expectancy. This is while Sistan and Baluchestan and Ilam were among the provinces with the lowest level of development with the lowest life expectancy at birth (22). It should be noted that life expectancy at birth in some provinces such as Isfahan, Alborz, and Semnan for men and women were about 5 years more than the less developed countries. The difference for men was about 1 year and for women, it was about 4 years (6, 21).

Third, in all development groups and major areas, women showed higher life expectancy than men. Worldwide, women, on average, lived 4.4 years longer than men in 2016 (7). In the more developed regions, life expectancy was 6.8 years more for women compared to men. This is while in the less developed regions women's life expectancy 3.7 years more. In the least developed countries, the difference by sex was less, e.g. 2.6 years (21, 24, 25). According to this research, the provinces with higher life expectancy showed a greater sex difference in life expectancy. Thus, the lowest sex difference in life expectancy was related to Sistan and Baluchestan, and the highest

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sex difference belonged to Tehran and Markazi provinces.

Continuous studies regarding estimation of mortality are necessary for more accurate planning, maintenance and promotion of health in any society. Calculating mortality rates and differences in different geographical locations provides the basis for development-oriented programs for policymakers. Efforts by policymakers to distribute welfare and health facilities more equally at the geographical level can significantly help reduce these gaps and. In addition to improving the situation of the provinces, the health indicators and the whole country will also be developed. In this regard, improving the quality of data at smaller geographical levels such as provinces and cities is essential for better analysis of demographic and epidemiological transitions and reduction of mortality.

It should be noted that this study also had some limitations. The method used to correct mortality data over 5 years (synthetic extinct generations), despite its advantages over other methods, offers only one correction factor for all ages. This is while the accuracy and error of death registration in Iran is a function of both age and age.

Conclusion

There are important differences in life expectancy at birth between the provinces of Iran. Considering that the process of increasing life expectancy in the country has slowed down over the past two or three decades, examining the differences in life expectancy, and finally, identifying the potentials to increase life expectancy in the country can help improve life expectancy with proper planning.

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Conflict of interest

The authors declared no conflict of interest.

Authors' contributions

All stages of article writing and analysis were done by M.S.

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