

Original Article

Improved Population Health in Iran from 1979 to 2019; Decreasing Mortality Rates and Increasing Life Expectancy

Narges Ebrahimi, MSc¹; Parinaz Mehdipour, MSc¹; Farnam Mohebi, MD¹; Ali Ghanbari, MSc¹; Mehrdad Azmin, PhD¹; Farshad Farzadfar, MD^{1,2*}

¹Non-Communicable Diseases Research Center, Endocrinology and Metabolism Population Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran

²Endocrinology and Metabolism Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran

Abstract

Background: In this study, we seek to evaluate the population health improvements during the previous four decades in Iran. We have estimated the levels and trends of child and adult mortality in addition to life expectancy from 1979 to 2019 at national and sub-national levels using all the available data.

Methods: In this study, we used data from National and Sub-National Burden of Diseases study and employed Bayesian Averaging Model (BAM) to predict mortality rates and life expectancy from 1979 to 2019. By including all available data sources of death information of Iran, including national level data from the Institute for Health Metrics and Evaluation (IHME), national censuses, Demographic and Health Survey (DHS), and Death Registration System (DRS) and using Spatio-Temporal and Gaussian Process Regression (ST-GPR) models, we estimated mortality rates and life expectancy from 1990 to 2015. We also used a BAM to project our desired indices until 2019.

Results: Both child and adult mortality rates decreased dramatically over the period. At the national level in Iran, in 2019, child mortality rate (deaths per 1000 livebirths), was 16.0 (95%UI: 13.0–19.6), adult mortality rates [probability of death (%)] for females and males were 6.1 (5.4–6.8) and 11.5 (10.3–12.8), respectively. Also, life expectancy values for females and males were 81.6 (80.7–82.2) and 76.1 (75.3–76.6), respectively. The results were consistent for both sexes. Despite the total narrowing gaps among provinces, a difference can still be observed particularly for the border provinces regarding child mortality rates. However, the difference in the other measures are inconsiderable. From 1979 to 2019, the overall change percent in child mortality rate, adult mortality rate for females and males and life expectancy for females and males were -86.3% (-89.0%–83.1%), -52.5% (-60.9%–42.9%), -48.7% (-56.9%–39.6%), 25.3% (20.8%–31.5%), and 31.3% (25.5%–41.3%), respectively.

Conclusion: This study provides an overview of the previous 40 years of mortality rates (child and adult) and life expectancy. The provided framework of national and sub-national evaluation can be used by researchers to continue the path of providing information for prioritization and evaluation of programs and also performing cost-effectiveness analysis for proposing efficient strategies to policy makers.

Keywords: Adult mortality, Child mortality, Iran, Life expectancy

Cite this article as: Ebrahimi N, Mehdipour P, Mohebi F, Ghanbari A, Azmin M, Farzadfar F. Improved population health in Iran from 1979 to 2019; decreasing mortality rates and increasing life expectancy. Arch Iran Med. 2020;23(2):61–68.

Received: February 5, 2019, Accepted: October 21, 2019, ePublished: February 1, 2020

Introduction

The Iranian health system has gone through considerable changes during the past four decades. Improvements were made through implementing a set of policies and plans aimed at improving healthcare access and quality. Prominent examples of these changes include the establishment of the primary health care system, integration of medical education and health care systems, implementation of family physician and referral system, and, more recently, the Health System Transformation Plan.¹⁻³ Other factors impacting health such as increased literacy, especially among females, safer and more accessible transportation, in addition to overall sociopolitical changes and economic development, as well as global advances in life sciences can also not be ignored.⁴

However, health sector, as the most important factor contributing to mortality and life expectancy, should be evaluated and considered.⁵ Child mortality, adult mortality, and life expectancy are the indicators that could together show the impact of these changes on health care quality and efficiency improvements.⁶⁻¹⁰ In general, since 1990, child mortality and adult mortality rates have been decreasing in the North Africa and Middle East countries. However, adult mortality has gone through fluctuations in the recent years and increased from 158.61 deaths per 100000 in 2010 to 165 in 2017. The pattern of life-expectancy also followed equivalent changes and it increased in these years in this region. The patterns were the same for countries similar to Iran in Socio-Demographic Index, income, and region, particularly for child mortality.

*Corresponding Author: Farshad Farzadfar, MD, MPH, MHS, DSc; Non-Communicable Diseases Research Center, Endocrinology and Metabolism Population Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran. Second Floor, No.10, Jalal Al-e-Ahmad Highway, Tehran 1411713137, Iran. Tel: +98-21-88631293; Email: f.farzadfar@tums.ac.ir

Adult mortality, despite the general decrease, differed in details and fluctuations in this period of time.¹¹

This paper seeks to evaluate the population health improvements during the previous four decades in Iran. We have estimated the levels and trends of child and adult mortality in addition to life expectancy from 1979 to 2019 at national and sub-national levels using all the available data. The systematic description of levels and trends of death and life expectancy provides a basis for further evaluation of the effects of implemented intervention plans and policies.

Materials and Methods

In the present study, we have reported the all-cause mortality rate of adults and children under-5 and at-birth life expectancy at the national and provincial levels stratified by sex and year combinations.

Child mortality is the number of deaths in under-5 age group per 1000 live births. *Adult mortality* represents the probability of number of deaths in ages 15 to 60 years. *Life expectancy at birth* is the average number of years that a newborn is expected to live if current mortality rates continue to apply.

We identified all available data sources of death information in Iran, appraised their quality and validity. We consequently used the national censuses of 1986, 1996, 2006, and 2011, Demographic and Health Survey (DHS) of the year 2000, and Death Registration System (DRS). The DRS has death records at national and sub-national levels from 1995 to 2010. Population data was gathered from the Statistical Center of Iran (SCI). In the present study, we used estimated data extracted from National and Sub-National Burden of Diseases and Injuries (NASBOD) conducted in Iran.¹² This project estimated the level and trends of mortality rates considering the incompleteness of DRS using demographic and statistical methods, including Spatio-Temporal and Gaussian Process Regression (ST-GPR) models from 1990 to 2015.¹³ GPR is a Bayesian method that utilizes the mortality rates as input and in result, defines a flexible model with hierarchical priors for its parameters. In the Gaussian process regression, the mean and covariance are defined as the spatiotemporal model and the Matérn function, respectively. We used the Spatio-Temporal model to impute the missing values of

the time trend and also the central tendency of the final results based on the correlations of age, space, and time and also the information from other socio-economic status covariates of the model. The model improves mortality estimate compared to other available methods because it takes into account the information of neighboring age groups, provinces and nearby time points. Additionally, by considering the incompleteness of DRS in the estimates specific mortality rates and the corresponding 95% uncertainty intervals (UIs) at both national and provincial levels, the quality of estimations improves. To predict mortality rates and life expectancy beyond this time span, we used a Bayesian Averaging Model (BAM) to project our desired indices until 2019.¹⁴ This model used the number of deaths and population of previous years by sex, age group and location, and projected mortality rates and life expectancy by 2019. BAM combines 21 models for predicting mortality rates and synthesizes them based on each model performance.

Since the NASBOD study aimed at predicting death for 1990 onwards, we obtained the required data for the years 1979 to 1990 at national level from the Institute for Health Metrics and Evaluation (IHME) and used them as an extra data source for adult and life expectancy indices.

Results

Child Mortality Rate

At the national level, child mortality rate (deaths per 1000 livebirths) decreased by more than 7-folds from 117.2 (95% UI: 116.2–118.5) in 1979, to 16.0 (13.0–19.6) in 2019. In terms of percentage change, an 86.3% (-89.0 – -83.1) decrease was observed in child mortality rate at the national level in this period (Table 1). At the provincial level, child mortality ranged from 6.7 (5.0–9.3) in Mazandaran to 41.7 (30.8–64.1) in South Khorasan in 2019 (Figure 1, Table 2).

Adult Mortality Rate

The probability of death (%) of individuals aged between 15 and 60 years, was halved for both females [from 12.8 (11.9–13.8) to 6.1 (5.4–6.8)] and males [from 22.5 (21.2–23.9) to 11.5 (10.3–12.8)] between 1979 and 2019. Adult mortality rates for females and males decreased by 52.5% (-60.9–-42.9) and 48.7% (-56.9–-39.6), respectively

Table 1. Rate of Child and Adult Mortality as well as Life Expectancy at Birth of Iranian Population by Decade and their Percent Change from 1979 to 2019

Measure	Sex	Year					Δ% 1979 to 2019
		1979	1989	1999	2009	2019*	
Child mortality rate (per 1000 live births)	Both	117.2 (116.2–118.5)	67.1 (66.5–67.6)	40.6 (40.3–40.9)	25.9 (25.3–26.4)	16.0 (13.0–19.6)	-86.3 (-89.0–-83.1)
Adult mortality (probability of death %)	Male	22.5 (21.2–23.9)	18.6 (17.7–19.6)	15.5 (14.7–16.4)	13.4 (12.5–14.4)	11.5 (10.3–12.8)	-48.7 (-56.9– -39.6)
	Female	12.8 (11.9–13.8)	10.9 (10.3–11.4)	8.9 (8.4–9.4)	7.3 (6.8–7.7)	6.1 (5.4–6.8)	-52.5 (-60.9–-42.9)
Life expectancy at birth	Male	58.0 (54.2–60.0)	63.2 (63.0–63.2)	68.1 (68.0–68.1)	72.6 (72.6–72.7)	76.1 (75.3–76.6)	31.3 (25.5–41.3)
	Female	65.2 (62.5–66.8)	66.5 (66.3–66.5)	72.0 (72.0–72.1)	77.6 (77.5–77.64)	81.6 (80.7–82.2)	25.3 (20.8–31.5)

Data in parenthesis are 95% UI.

* The values in 2019 are predicted.

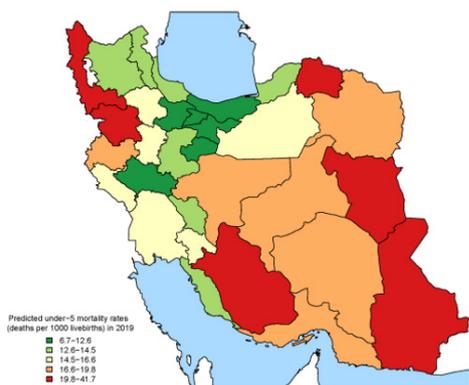


Figure 1. Provincial Distribution of Under-5 Mortality Rates in 2019.

(Table 1). Generally, in 2019, central provinces had a lower adult mortality for both females and males (Figure 2). In 2019, the difference between the highest and lowest adult mortality across provinces was 4.0 for females and 7.1 for males, respectively (Table 3).

At-Birth Life Expectancy

The results show that throughout the studied period, life

expectancy has increased for both females [from 65.2 (62.5–66.8) to 81.6 years (80.7–82.2)] and males [from 58.0 (54.2–60.0) to 76.1 years (75.3–76.6)]. The change in life expectancy in males is 2 years more than females. In terms of percent change, life expectancy has increased by 25.3% (20.8–31.5) and 31.3% (25.5–41.3) for females and males, respectively (Table 1). The greatest difference of life expectancies at birth between provinces in 2019 was 9.3 years for females and 11.0 years for males (Figure 3, Table 4).

Additionally, we calculated the three measures including child mortality, adult mortality, and life expectancy in years 1990 and 2019 to assess the probable differences and inequities among border and non-border provinces (Table 5). There are 16 border provinces out of 31 and we calculated the corresponding measure in those provinces using proportion of the population.

Discussion

This study aimed to evaluate the population health improvements in the past 40 years in Iran via estimating the levels and trends of child and adult mortality rates and

Table 2. Provincial Distribution of Under-5 Mortality Rates in 1990 and 2019 with Percent Change

Province	Year		Δ% 1990 to 2019
	1990	2019*	
Markazi	63.9 (62.3–65.7)	13.7 (10.3–18.0)	-78.6 (-84.3--71.1)
Gilan	47.8 (47.0–48.7)	12.6 (9.1–17.7)	-73.6 (-81.3--62.3)
Mazandaran	48.7 (47.6–49.8)	6.7 (5.0–9.3)	-86.2 (-90.0--80.5)
Azerbaijan, East	74.6 (73.2–76.5)	13.4 (10.4–17.2)	-82.0 (-86.4--76.5)
Azerbaijan, West	88.3 (85.7–92.3)	21.3 (16.1–29.5)	-75.9 (-82.6--65.6)
Kermanshah	63.3 (62.3–64.5)	19.5 (15.2–24.9)	-69.2 (-76.4--60.0)
Khuzestan	59.0 (57.8–60.2)	15.6 (11.6–21.1)	-73.6 (-80.7--63.5)
Fars	53.8 (52.1–55.8)	23.8 (17.8–32.5)	-55.8 (-68.1--37.6)
Kerman	64.5 (63.2–65.9)	16.9 (12.6–23.1)	-73.8 (-80.9--63.4)
Khorasan, Razavi	87.1 (84.1–88.8)	19.8 (15.8–25.3)	-77.3 (-82.2--69.9)
Isfahan	54.2 (52.8–55.4)	16.8 (13.5–23.2)	-69.0 (-75.6--56.1)
Sistan and Baluchistan	100.5 (99.3–101.8)	21.7 (16.4–29.4)	-78.4 (-83.9--70.4)
Kurdistan	112.2 (110.7–113.4)	24.9 (18.8–34.5)	-77.8 (-83.4--68.8)
Hamadan	63.9 (62.3–65.6)	16.3 (12.0–22.3)	-74.5 (-81.7--64.2)
Chahar Mahaal and Bakhtiari	62.6 (61.5–64.3)	13.5 (9.4–19.7)	-78.4 (-85.4--68.0)
Lorestan	71.0 (69.9–72.3)	12.4 (9.2–17.1)	-82.5 (-87.3--75.5)
Ilam	67.5 (65.5–69.6)	14.8 (10.4–21.2)	-78.1 (-85.1--67.6)
Kohgiluyeh and Boyer-Ahmad	65.2 (57.3–83.5)	16.6 (11.8–23.8)	-74.5 (-85.9--58.5)
Bushehr	64.0 (62.1–65.4)	14.5 (10.2–20.2)	-77.3 (-84.4--67.5)
Zanjan	95.6 (94.0–96.7)	16.6 (12.0–24.4)	-82.6 (-87.6--74.0)
Semnan	67.3 (66.5–68.1)	15.5 (10.7–22.4)	-77.0 (-84.3--66.3)
Yazd	52.7 (50.9–54.2)	18.1 (12.5–26.7)	-65.7 (-76.9--47.5)
Hormozgan	71.9 (70.2–73.7)	19.5 (14.1–26.3)	-72.9 (-80.9--62.5)
Tehran	56.8 (54.7–57.7)	12.0 (8.8–14.7)	-78.9 (-84.7--73.1)
Ardabil	82.9 (80.9–84.4)	14.2 (10.5–19.9)	-82.9 (-87.6--75.4)
Qom	56.3 (54.9–57.6)	9.4 (6.7–13.5)	-83.3 (-88.4--75.4)
Qazvin	66.8 (65.3–68.6)	11.8 (8.8–16.3)	-82.3 (-87.2--75.0)
Golestan	73.4 (72.4–76.2)	13.2 (10.2–18.4)	-82.0 (-86.6--74.6)
Khorasan, North	103.0 (100.6–106.1)	26.3 (19.6–39.9)	-74.5 (-81.5--60.3)
Khorasan, South	113.3 (106.9–116.0)	41.7 (30.8–64.1)	-63.2 (-73.4--40.0)
Alborz	57.2 (55.7–58.6)	9.5 (7.0–12.1)	-83.4 (-88.1--78.3)

Data are presented as rate per 1000 livebirths (95% UI).

* The values in 2019 are predicted.

Table 3. Provincial Distribution of Adult Mortality Rates by Sex in 1990 and 2019 with Percent Change

Province	Sex	Year		Δ% 1990 to 2019
		1990	2019*	
Markazi	Male	21.4 (19.5–23.4)	11.4 (9.4–13.8)	-46.7 (-59.8 – -29.2)
	Female	15.8 (14.1–17.6)	6.5 (5.3–7.8)	-58.9 (-69.9 – -44.7)
Gilan	Male	19.5 (17.8–21.3)	10.4 (8.6–12.6)	-46.7 (-59.6 – -29.2)
	Female	13.9 (12.6–15.3)	5.9 (4.9–7.1)	-57.6 (-68.0 – -43.7)
Mazandaran	Male	18.9 (17.3–20.7)	10.8 (8.9–13.0)	-42.9 (-57.0 – -24.9)
	Female	15.3 (13.4–17.5)	6.1 (5.0–7.4)	-60.1 (-71.4 – -44.8)
Azerbaijan, East	Male	19.8 (18.9–20.7)	10.7 (8.8–13.1)	-46.0 (-57.5 – -30.7)
	Female	14.7 (13.7–15.9)	6.1 (5.0–7.4)	-58.5 (-68.6 – -46.0)
Azerbaijan, West	Male	19.8 (18.4–21.4)	11.2 (9.2–13.7)	-43.4 (-57.0 – -25.5)
	Female	15.7 (14.6–16.9)	6.3 (5.2–7.7)	-59.9 (-69.2 – -47.3)
Kermanshah	Male	23.7 (20.0–28.1)	13.6 (11.2–16.5)	-42.6 (-60.1 – -17.5)
	Female	18.2 (17.3–21.1)	7.7 (6.3–9.3)	-57.7 (-70.1 – -40.8)
Khuzestan	Male	20.4 (19.0–21.9)	11.2 (9.2–13.6)	-45.1 (-58.0 – -28.4)
	Female	16.1 (15.5–16.7)	6.4 (5.2–7.7)	-60.2 (-68.9 – -50.3)
Fars	Male	21.4 (19.7–23.3)	11.1 (9.1–13.5)	-48.1 (-60.9 – -31.5)
	Female	14.2 (13.1–15.4)	6.3 (5.2–7.6)	-55.6 (-66.2 – -42.0)
Kerman	Male	24.9 (23.0–26.9)	12.5 (10.3–15.1)	-49.8 (-61.7 – -34.3)
	Female	15.7 (14.3–17.2)	7.1 (5.9–8.6)	-54.8 (-65.7 – -39.9)
Khorasan, Razavi	Male	24.9 (20.3–30.6)	12.9 (10.6–15.7)	-48.2 (-65.4 – -22.7)
	Female	16.7 (13.8–20.2)	7.3 (6.0–8.9)	-56.3 (-70.3 – -35.5)
Isfahan	Male	17.7 (15.6–20.1)	9.5 (7.9–11.6)	-46.3 (-60.7 – -25.6)
	Female	13.5 (11.9–15.3)	5.4 (4.4–6.5)	-60.0 (-71.2 – -45.4)
Sistan and Baluchistan	Male	25.7 (22.9–28.8)	14.1 (11.5–17)	-45.1 (-60.1 – -25.8)
	Female	17.4 (15.3–19.8)	8.0 (6.5–9.7)	-54.0 (-67.2 – -36.6)
Kurdistan	Male	20.7 (19.0–22.6)	12.2 (10.0–14.7)	-41.1 (-55.8 – -22.6)
	Female	19.0 (17.5–20.6)	6.9 (5.7–8.4)	-63.7 (-72.3 – -52.0)
Hamadan	Male	23.4 (20.7–26.3)	11.5 (9.5–14.0)	-50.9 (-63.9 – -32.4)
	Female	13.4 (11.9–15.1)	6.5 (5.3–7.9)	-51.5 (-64.9 – -33.6)
Chahar Mahaal and Bakhtiari	Male	17.2 (15.4–19.3)	9.3 (7.6–11.3)	-45.9 (-60.6 – -26.6)
	Female	13.2 (11.4–15.3)	5.2 (4.3–6.3)	-60.6 (-71.9 – -44.7)
Lorestan	Male	21.9 (19.5–24.6)	11.5 (9.5–14.0)	-47.5 (-61.4 – -28.2)
	Female	16.6 (15.4–17.8)	6.5 (5.4–7.9)	-60.8 (-69.7 – -48.7)
Ilam	Male	17.8 (16.0–19.8)	11.0 (9.0–13.3)	-38.2 (-54.5 – -16.9)
	Female	18.6 (16.2–21.3)	6.2 (5.1–7.5)	-66.7 (-76.1 – -53.7)
Kohgiluyeh and Boyer-Ahmad	Male	16.1 (14.4–17.9)	9.8 (8.1–11.9)	-39.1 (-54.7 – -17.4)
	Female	16.0 (13.6–18.7)	5.5 (4.5–6.7)	-65.6 (-75.9 – -50.7)
Bushehr	Male	17.6 (16.4–18.9)	9.9 (8.2–12.0)	-43.8 (-56.6 – -26.8)
	Female	14.3 (12.9–15.7)	5.6 (4.6–6.8)	-60.8 (-70.7 – -47.3)
Zanjan	Male	21.7 (20.0–23.4)	11.0 (9.0–13.4)	-49.3 (-61.5 – -33.0)
	Female	13.5 (12.3–14.9)	6.2 (5.1–7.5)	-54.1 (-65.8 – -39.0)
Semnan	Male	18.4 (16.7–20.4)	10.2 (8.4–12.4)	-44.6 (-58.8 – -25.7)
	Female	14.5 (12.5–16.9)	5.8 (4.7–7.0)	-60.0 (-72.2 – -44.0)
Yazd	Male	18.4 (16.4–20.6)	9.9 (8.1–12.0)	-46.2 (-60.7 – -26.8)
	Female	14.3 (12.8–16.1)	5.6 (4.6–6.8)	-60.8 (-71.4 – -46.9)
Hormozgan	Male	24.1 (22.1–26.1)	12.2 (10.1–14.8)	-49.4 (-61.3 – -33.0)
	Female	14.6 (13.2–16.2)	6.9 (5.7–8.4)	-52.7 (-64.8 – -36.4)
Tehran	Male	20.2 (19.0–21.5)	10.3 (8.4–12.5)	-49.0 (-60.9 – -34.2)
	Female	12.0 (11.3–12.8)	5.8 (4.8–7.1)	-51.7 (-62.5 – -37.2)
Ardabil	Male	18.9 (16.7–21.3)	10.3 (8.4–12.5)	-45.5 (-60.6 – -25.1)
	Female	14.8 (13.2–16.6)	5.8 (4.8–7.1)	-60.8 (-71.1 – -46.2)
Qom	Male	14.5 (14.1–14.9)	8.6 (7.1–10.4)	-40.7 (-52.3 – -26.2)
	Female	12.1 (11.1–13.2)	4.8 (4.0–5.8)	-60.3 (-69.7 – -47.7)
Qazvin	Male	24.2 (21.2–27.8)	11.6 (9.5–14.1)	-52.1 (-65.8 – -33.5)
	Female	14.9 (13.5–16.5)	6.6 (5.4–8.0)	-55.7 (-67.3 – -40.7)
Golestan	Male	24.5 (22.7–26.5)	13.5 (11.0–16.3)	-44.9 (-58.5 – -28.2)
	Female	16.8 (15.4–18.4)	7.6 (6.3–9.2)	-54.8 (-65.8 – -40.3)
Khorasan, North	Male	22.8 (20.2–25.8)	12.6 (10.5–15.3)	-44.7 (-59.3 – -24.3)
	Female	15.9 (14.0–18.1)	7.1 (5.9–8.7)	-55.3 (-67.4 – -37.9)
Khorasan, South	Male	17.5 (15.1–20.2)	10.2 (8.4–12.4)	-41.7 (-58.4 – -17.9)
	Female	12.8 (10.8–15.1)	5.8 (4.7–7.0)	-54.7 (-68.9 – -35.2)
Alborz	Male	11.6 (7.5–17.8)	7.0 (5.7–8.4)	-39.7 (-68.0 – 12.0)
	Female	10.1 (8.2–12.5)	4.0 (3.3–4.8)	-60.4 (-73.6 – -41.5)

Data are presented as probability of death (%) (95% UI).

* The values in 2019 are predicted.

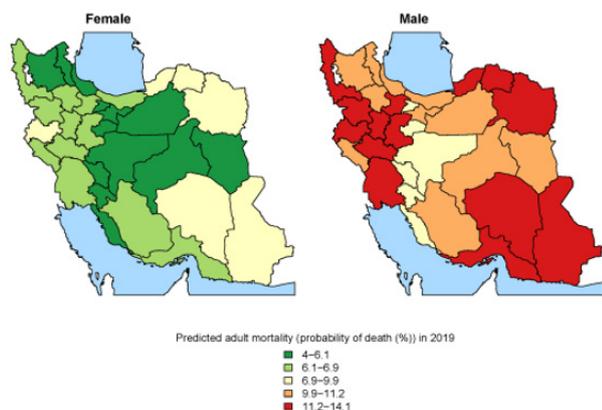


Figure 2. Provincial Distribution of Adult Mortality (Probability of Death) by Sex in 2019.

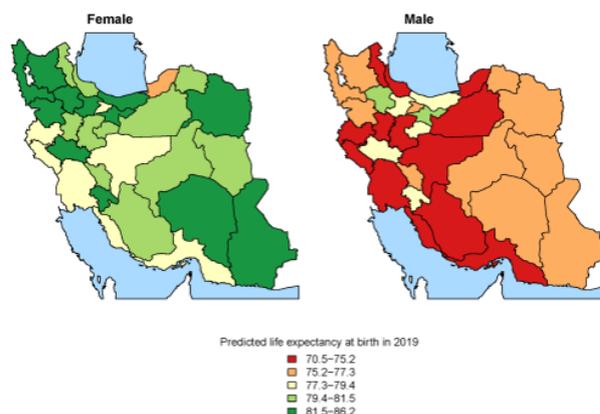


Figure 3. Provincial Distribution of Life Expectancy at Birth by Sex in 2019.

at-birth life expectancy from 1979 to 2019, nationally and sub-nationally. All three measure show significant improvements for both sexes. Child mortality rate has decreased by 86.3% and adult mortality rates for females and males have decreased by 52.5% and 48.7% respectively. In addition, life expectancy at birth has increased by 25.3% and 31.3% for females and males, with a slightly higher increase in males.

One of the most prominent findings was the sharpest decline that has occurred in under-5 mortality compared to other age groups (Figure 4). This is significant since this indicator is a direct reflection of health quality of a country.^{15,16} The findings of the current study, regarding child mortality, are in line with previous studies, suggesting that all the provinces in Iran have achieved the fourth goal of the Millennium Development Goals (MDGs) and most of the provinces have realized the third goal of the Sustainable Development Goals (SDGs).¹⁷ This decline in child mortality is owing to various reasons such as providing more areas with access to fundamental service packages for children and expanding healthcare networks in the 1980s by hiring low-paid primary health workers (*Behvarz*).¹⁸⁻²¹ In addition, urbanization, improvement in socioeconomic status, and education quality are also associated with this decreasing trend in child mortality rate.^{17,22} It should, however, be noted that although child mortality has decreased significantly in all the provinces over the past four decades, some border provinces still have relatively high child mortality rates (Figure 1). To illustrate, in the year 1990, we observed a statistically significant difference in child mortality comparing border and non-border provinces, whereas this difference has decreased appreciably as there is no significant difference in child mortality between these two categories. In other words, this measure could be a proxy of inequity and the observed inequity among border and non-border provinces has decreased in child mortality rate (Table 5).

Regarding adult mortality, we observed a descending trend for both female and male subjects throughout the

studied period. This is probably caused by improvements in socioeconomic status of the country as well as increased level of awareness and education and, consequently, better risk management.¹⁸⁻²⁰ One of the greatest contributing factors to the improved health of the Iranian population is the more equitable distribution of healthcare centers as the range of the mortality decreased between different provinces. Like child mortality, adult mortality rate was higher in border provinces (Figure 2). Yet, the difference is not statistically significant when we compare border and non-border provinces (Table 5).

Generally, males had a higher mortality rate than females in all years and the inter-gender gap stayed the same over the period (Figure 5). The higher mortality rate in males can be attributed to behavioral risk factors and lower healthcare seeking in addition to biological factors and transient shocks such as the Iran-Iraq war.²³⁻²⁵

Despite overall reduction in child and adult mortality rates and increase in life expectancy in Iran over the past four decades, our main concern has been inequality in these three indices across Iranian provinces. These inequalities might be due to social, environmental or economic factors including maternal education level, cost of healthcare, the extent of access to health services, and income per capita.²⁶⁻³¹ For adult mortality, global studies suggest that improvement in education and life-long learning, job creation and fair employment, ensuring a minimum income for a basic standard of living, and applying a social determinants approach to prevention can decrease these health inequalities.^{32,33} In addition, in terms of child mortality, improving maternal education and access to health care services in antenatal and postnatal periods can be effective in achieving equality in child health.^{17,34}

Like the previous studies investigating death and its related estimations, we encountered a few limitations: First of all, the death registration system in Iran has incomplete death records.³⁵ To overcome this problem, we used all the other available information of any existing source on death and estimated mortality rates, and eventually after using

Table 4. Provincial Distribution of Life Expectancy at Birth by Sex in 1990 and 2019 with Percent Change

Province	Sex	Year		Δ% 1990 to 2019
		1990	2019*	
Markazi	Male	67.1 (66.7–67.6)	74.7 (73.6–75.6)	11.3 (8.9–13.3)
	Female	71.3 (70.8–71.8)	80.1 (79.0–81.5)	12.3 (10.0–15.1)
Gilan	Male	64.3 (64.0–64.8)	74.2 (73.2–75.5)	15.4 (13.0–18.0)
	Female	68.6 (68.3–69.2)	80.9 (79.5–82.1)	17.9 (14.9–20.2)
Mazandaran	Male	64.8 (64.5–65.3)	78.6 (77.1–79.8)	21.3 (18.1–23.7)
	Female	66.7 (66.4–67.2)	82.8 (81.7–84.5)	24.1 (21.6–27.3)
Azerbaijan, East	Male	63.9 (63.5–64.1)	76.1 (74.8–76.9)	19.1 (16.7–21.1)
	Female	66.7 (66.3–66.9)	82.4 (81.1–83.6)	23.5 (21.2–26.1)
Azerbaijan, West	Male	62.2 (61.8–62.6)	77.3 (75.9–78.5)	24.3 (21.2–27.0)
	Female	64.9 (64.5–65.2)	86.2 (84.2–87.9)	32.8 (29.1–36.3)
Kermanshah	Male	62.6 (62.0–62.9)	71.6 (70.9–72.4)	14.4 (12.7–16.8)
	Female	67.7 (67.1–68.0)	78.7 (77.7–79.8)	16.2 (14.3–18.9)
Khuzestan	Male	67.7 (67.2–67.9)	73.7 (72.3–74.6)	8.9 (6.5–11.0)
	Female	71.9 (71.5–72.3)	78.5 (77.4–79.4)	9.2 (7.1–11.0)
Fars	Male	65.7 (65.4–66.0)	73.5 (72.3–74.2)	11.9 (9.5–13.5)
	Female	69.9 (69.5–70.1)	79.7 (78.6–80.6)	14.0 (12.1–16.0)
Kerman	Male	62.6 (62.2–63.0)	77.0 (75.8–78.0)	23.0 (20.3–25.4)
	Female	67.7 (67.4–68.1)	83.4 (82.1–84.7)	23.2 (20.6–25.7)
Khorasan, Razavi	Male	61.1 (60.7–61.4)	76.7 (75.8–77.3)	25.5 (23.5–27.3)
	Female	61.1 (60.6–61.8)	84.5 (83.1–86.3)	38.3 (34.5–42.4)
Isfahan	Male	69.2 (68.8–69.4)	74.0 (73.4–74.7)	6.9 (5.8–8.6)
	Female	71.5 (71.1–71.8)	78.2 (77.6–78.9)	9.4 (8.1–11.0)
Sistan and Baluchistan	Male	61.0 (60.6–61.7)	75.4 (74.1–76.5)	23.6 (20.1–26.2)
	Female	62.2 (61.7–62.7)	84.3 (82.7–86.5)	35.5 (31.9–40.2)
Kurdistan	Male	60.9 (60.5–61.4)	76.3 (75.5–77.3)	25.3 (23.0–27.8)
	Female	64.2 (63.8–64.7)	81.9 (81.1–83.4)	27.6 (25.3–30.7)
Hamadan	Male	65.8 (65.4–66.2)	72.9 (71.6–73.9)	10.8 (8.2–13.0)
	Female	70.2 (69.9–70.6)	81.5 (80.3–82.6)	16.1 (13.7–18.2)
Chahar Mahaal and Bakhtiari	Male	65.2 (64.5–66.0)	75.6 (74.0–77.0)	16.0 (12.1–19.4)
	Female	67.5 (66.9–68.4)	81.4 (79.5–83.3)	20.6 (16.2–24.5)
Lorestan	Male	59.7 (59.3–60.2)	79.0 (77.8–80.3)	32.3 (29.2–35.4)
	Female	66.1 (65.7–66.6)	84.7 (83.4–86.7)	28.1 (25.2–32.0)
Ilam	Male	66.2 (65.4–67.0)	75.2 (73.7–76.6)	13.6 (10.0–17.1)
	Female	68.2 (67.3–69.2)	78.8 (77.7–80.3)	15.5 (12.3–19.3)
Kohgiluyeh and Boyer-Ahmad	Male	65.8 (65.2–66.6)	77.4 (76.0–79.0)	17.6 (14.1–21.2)
	Female	67.1 (66.4–68.0)	83.2 (81.7–85.5)	24.0 (20.1–28.8)
Bushehr	Male	66.8 (66.0–67.3)	73.3 (71.9–74.3)	9.7 (6.8–12.6)
	Female	71.0 (70.3–71.5)	77.6 (76.4–78.8)	9.3 (6.9–12.1)
Zanjan	Male	56.6 (56.2–57.4)	79.6 (77.9–82.1)	40.6 (35.7–46.1)
	Female	59.5 (58.8–60.2)	86.0 (84.2–88.8)	44.5 (39.9–51.0)
Semnan	Male	67.0 (66.2–67.6)	74.6 (73.2–75.8)	11.3 (8.3–14.5)
	Female	67.4 (66.6–68.0)	80.0 (78.7–81.4)	18.7 (15.7–22.2)
Yazd	Male	66.5 (65.8–67.1)	76.3 (74.6–77.6)	14.7 (11.2–17.9)
	Female	71.0 (70.5–71.6)	80.7 (79.4–82.1)	13.7 (10.9–16.5)
Hormozgan	Male	69.5 (69.0–70.0)	70.9 (69.2–71.7)	2.0 (-1.1–3.9)
	Female	74.9 (74.3–75.6)	79.0 (77.0–80.3)	5.5 (1.9–8.1)
Tehran	Male	57.6 (57.2–57.9)	81.5 (80.0–83.2)	41.5 (38.2–45.5)
	Female	62.8 (62.4–63.7)	86.0 (84.0–87.4)	36.9 (31.9–40.1)
Ardabil	Male	63.3 (62.8–63.9)	75.0 (73.8–75.9)	18.5 (15.5–20.9)
	Female	65.7 (65.3–66.4)	80.1 (78.8–81.4)	21.9 (18.7–24.7)
Qom	Male	64.4 (63.8–64.9)	79.1 (77.6–80.5)	22.8 (19.6–26.2)
	Female	71.2 (70.7–71.7)	80.3 (79.5–81.9)	12.8 (10.9–15.8)
Qazvin	Male	61.8 (61.1–62.3)	77.5 (76.5–78.9)	25.4 (22.8–29.1)
	Female	65.6 (64.9–66.1)	81.6 (80.6–83.3)	24.4 (21.9–28.4)
Golestan	Male	64.5 (64.0–64.9)	70.5 (69.7–71.2)	9.3 (7.4–11.3)
	Female	66.8 (66.2–67.2)	76.9 (76.0–77.8)	15.1 (13.1–17.5)
Khorasan, North	Male	61.4 (60.9–61.9)	76.0 (74.9–77.2)	23.8 (21.0–26.8)
	Female	64.6 (64.2–65.1)	81.4 (80.1–82.8)	26.0 (23.0–29.0)
Khorasan, South	Male	64.6 (64.0–65.0)	75.2 (73.9–76.2)	16.4 (13.7–19.1)
	Female	68.5 (67.9–69.0)	80.7 (79.1–81.9)	17.8 (14.6–20.6)
Alborz	Male	71.0 (70.6–71.4)	75.5 (74.7–76.3)	6.3 (4.6–8.1)
	Female	75.0 (74.5–75.4)	77.9 (77.2–78.6)	3.9 (2.4–5.5)

Data are presented as life expectancy at birth (95% UI).

* The values in 2019 are predicted.

Table 5. Rate of Child and Adult Mortality as well as Life Expectancy at Birth of Iranian Population by Decade, Category of Border and Non-border Provinces and their Percent Change from 1979 to 2019

Measure	Sex	Borderline Provinces	Year		Δ% 1990 to 2019
			1990	2019*	
Child mortality rate (per 1000 live births)	Both	Yes	76.1 (74.3–77.9)	18.2 (13.8–24.7)	-76.1 (-82.2–66.8)
		No	60.6 (58.8–62.4)	15.0 (11.1–20.2)	-75.3 (-82.2–65.7)
Adult mortality (probability of death %)	Male	Yes	21.3 (19.1–23.9)	11.8 (9.7–14.3)	-44.6 (-59.4–25.1)
		No	20.0 (18.2–22.1)	10.3 (8.5–12.5)	-48.5 (-61.5–31.3)
	Female	Yes	15.9 (14.2–17.8)	6.7 (5.5–8.1)	-57.9 (-69.1–43.0)
		No	13.4 (12.2–14.8)	5.8 (4.8–7.1)	-56.7 (-67.6–41.8)
Life expectancy at birth	Male	Yes	64.1 (63.6–64.5)	74.8 (73.5–75.7)	16.7 (14.0–19.0)
		No	64.4 (63.9–64.9)	76.5 (75.3–77.8)	18.8 (16.0–21.8)
	Female	Yes	67.1 (66.6–67.6)	80.9 (79.6–82.3)	20.6 (17.8–23.6)
		No	68.3 (67.7–68.8)	81.6 (80.4–83.2)	19.5 (16.9–22.9)

Data in parenthesis are 95% UI.
 * The values in 2019 are predicted.

the ST-GPR method, which applies very well to missing values, we met the incompleteness of the death registration system in our analysis. However, the projections and extrapolations are subject to error. Secondly, we obtained adult mortality information from the IHME for the years

1979–1989 due to lack of death registration system data by sex and age before 1990. This information was only available at the national level. Despite improvements in death registration in recent years, the large incompleteness of death registration in starting years imposed bias on observed trends in early time intervals. Finally, the smoothed models over time, space, sex, and age groups, despite their high accuracy in estimating mortality rates, might have smoothed peaks and shocks.

In conclusion, taken together, this study provided a novel insight into the previous 40 years of Iranian population’s health and the outcome of the implemented health programs and policies. Both child and adult mortality rates decreased dramatically over the period. The at-birth life expectancy improved significantly. The results were consistent for both sexes. Despite the total narrowing gaps among provinces, a considerable difference can still be observed particularly for the border provinces regarding child mortality rates. However, the differences in other measures are inconsiderable. Moreover, the provided information identifies the populations that need extra attention while providing evidence for effective advocacy at legislative and policy making level. The provided framework of national and sub-national evaluation can be used by researchers to continue the path of providing information for prioritization and evaluation of programs and also performing cost-effectiveness analysis for proposing efficient strategies to policy makers.¹

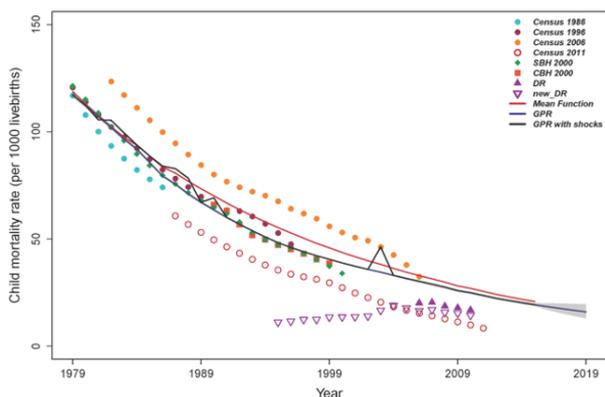


Figure 4. Time Trend of Under-5 Mortality Rates at National Level from 1979 to 2019.

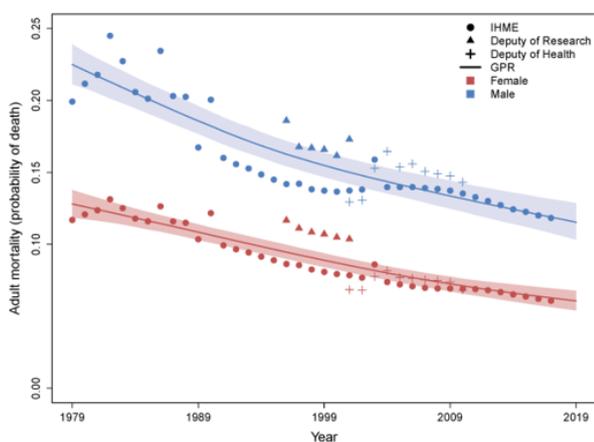


Figure 5. Time Trend of Adult Mortality (Probability of Death) by Sex at National Level from 1979 to 2019.

Authors’ Contribution

General design of study: FF, PM; Analysis of data and designing of graphs: NE, PM, AGH; Interpretation of data: NE, FF, PM, AGH; Writing primary draft: NE, FM, MA, PM; Manuscript critical revision: FF, MA, FM.

Conflict of Interest Disclosures

None.

Ethical Statement

The ethical committee of Tehran University of Medical Sciences

declared ethical approval for the current study.

References

- Marandi SA. The integration of medical education and health care services in the IR of Iran and its health impacts. *Iran J Publ Health*. 2009; 38(Suppl. 1):4-12.
- Olyaeemanesh A, Behzadifar M, Mousavinejhad N, Behzadifar M, Heydarvand S, Azari S, et al. Iran's Health System Transformation Plan: A SWOT analysis. *Med J Islam Repub Iran*. 2018;32:39. doi: 10.14196/mjiri.32.39.
- Zanganeh Baygi M, Seyadin SH, Rajabi Fard Mazrae No F, Kouhsari Khameneh A. Adaptation of goals and organizational structure in Iran's primary healthcare system, a systematic review. *Journal of Payavard Salamat*. 2016;9(5):446-58.
- Paya A, Raghfar H, Abdi A, Poor DM, Fadavi-Ardekani M. Social, economic, political, and intellectual changes in Iran since 1960s. In: Tiliouline H, Estes RJ, eds. *The State of Social Progress of Islamic Societies*. Switzerland: Springer; 2016. p. 211-35.
- Cutler D, Deaton A, Lleras-Muney A. The determinants of mortality. *Journal of Economic Perspectives*. 2006;20(3):97-120.
- Hunt SM, McEwen J. The development of a subjective health indicator. *Sociol Health Illn*. 1980;2(3):231-46.
- Robine JM, Romieu I, Cambois E. Health expectancy indicators. *Bull World Health Organ*. 1999;77(2):181-5.
- Ewbank DC, Gribble JN, Council NR. Trends in Mortality and Causes of Death in Africa. Effects of Health Programs on Child Mortality in Sub-Saharan Africa. Washington (DC): National Academies Press (US); 1993:11-25. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK236385/>
- World Development Indicators Washington, DC: World Bank; 2014. doi:10.1596/978-1-4648-0163-1. Available from: <http://documents.worldbank.org/curated/en/752121468182353172/World-development-indicators-201410>.
- Buajitti E, Chiodo S, Watson T, Kornas K, Bornbaum C, Henry D, Rosella LC. Ontario atlas of adult mortality, 1992-2015, Version 2.0: Trends in Public Health Units. Toronto, ON: Population Health Analytics Lab; 2018. Available from: <https://tspace.library.utoronto.ca/handle/1807/8283611>.
- Institute for Health Metrics and Evaluation. GBD Compare | Viz Hub 2017. Available from: <https://vizhub.healthdata.org/gbd-compare/>. Cited May 11, 2019.
- Farzadfar F, Delavari A, Malekzadeh R, Mesdaghinia A, Jamshidi HR, Sayyari A, et al. NASBOD 2013: design, definitions, and metrics. *Arch Iran Med*. 2014;17(1):7-15.
- Mehdipour P, Navidi I, Parsaeian M, Mohammadi Y, Moradi Lakeh M, Rezaei Darzi E, et al. Application of Gaussian Process Regression (GPR) in estimating under-five mortality levels and trends in Iran 1990-2013, study protocol. *Arch Iran Med*. 2014;17(3):189-92.
- Kontis V, Bennett JE, Mathers CD, Li G, Foreman K, Ezzati M. Future life expectancy in 35 industrialised countries: projections with a Bayesian model ensemble. *Lancet*. 2017;389(10076):1323-35. doi:10.1016/S0140-6736(16)32381-9.
- Malekzadeh R. Global burden of disease study 2010: a real advance in global descriptive epidemiology: perspective for developing countries. *Arch Iran Med*. 2014;17(5):302-303.
- Xi B, Zhou C, Zhang M, Wang Y, Xu L. Maternal and child mortality in China. *Lancet*. 2014;383(9921):953-4. doi: 10.1016/S0140-6736(14)60481-5.17.
- Mohammadi Y, Parsaeian M, Mehdipour P, Khosravi A, Larijani B, Sheidaei A, et al. Measuring Iran's success in achieving Millennium Development Goal 4: a systematic analysis of under-5 mortality at national and subnational levels from 1990 to 2015. *Lancet Glob Health*. 2017;5(5):e537-e544. doi: 10.1016/S2214-109X(17)30105-5
- Naghavi M, Shahrzad S, Sepanlou SG, BEsc PN, Pourmalek F, Lozano R, et al. Health transition in Iran toward chronic diseases based on results of Global Burden of Disease 2010. *Arch Iran Med*. 2014;17(5):321-35
- Rashidian A, Khosravi A, Khabiri R, Khodayari-Moez E, Elahi E, Arab M, et al. Islamic Republic of Iran's Multiple Indicator Demographic and Health Survey (IrMIDHS) 2010. Tehran: Ministry of Health and Medical Education; 2012. p. 83-6.
- Shadpour K. Primary health care networks in the Islamic Republic of Iran. *EMHJ - Eastern Mediterranean Health Journal*. 2000;6(4):822-5. Available from: <https://apps.who.int/iris/handle/10665/11893321>.
- Moradi-Lakeh M, Esteghamati A. National Immunization Program in Iran: why and why not. *Hum Vaccin Immunother*. 2013;9(1):112-4. doi: 10.4161/hv.22521.
- Bhandari N, Mazumder S, Taneja S, Sommerfelt H, Strand TA. Effect of implementation of Integrated Management of Neonatal and Childhood Illness (IMNCI) programme on neonatal and infant mortality: cluster randomised controlled trial. *BMJ*. 2012;344:e1634. doi: 10.1136/bmj.e1634.
- Rosella LC, Calzavara A, Frank JW, Fitzpatrick T, Donnelly PD, Henry D. Narrowing mortality gap between men and women over two decades: a registry-based study in Ontario, Canada. *BMJ Open*. 2016;6(11):e012564. doi: 10.1136/bmjopen-2016-012564.
- Pattison J, McPherson K, Blakemore C, Haberman S. Life expectancy: Past and future variations by gender in England & Wales. Longevity Science Advisory Panel; 2012. Available from: https://www.longevitypanel.co.uk/_files/life-expectancy-by-gender.pdf.
- Oksuzyan A, Juel K, Vaupel JW, Christensen K. Men: good health and high mortality. Sex differences in health and aging. *Aging Clin Exp Res*. 2008;20(2):91-102. doi: 10.1007/bf03324754.
- Hosseinpour AR, Mohammad K, Majdzadeh R, Naghavi M, Abolhassani F, Sousa A, et al. Socioeconomic inequality in infant mortality in Iran and across its provinces. *Bull World Health Organ*. 2005;83(11):837-44.
- Mújica OJ, Vázquez E, Duarte EC, Cortez-Escalante JJ, Molina J, Silva Junior JBd. Socioeconomic inequalities and mortality trends in BRICS, 1990? 2010. *Bull World Health Organ*. 2014;92(6):405-12. doi: 10.2471/BLT.13.127977.
- Mackenbach JP, Kulhánová I, Artnik B, Bopp M, Borrell C, Clemens T, et al. Changes in mortality inequalities over two decades: register based study of European countries. *BMJ*. 2016;353:i1732. doi: 10.1136/bmj.i1732.
- Heidarimoghadam R, Javaheri M, Nikravesh A, Mohammadi Y. Socio-economic determinants of inequality in child mortality rate among Iranian provinces: An ecological study. *Sri Lanka Journal of Child Health*. 2018;47(4):316-20.
- Kim JI, Kim G. Effects on inequality in life expectancy from a social ecology perspective. *BMC Public Health*. 2018;18(1):243. doi: 10.1186/s12889-018-5134-1.
- Khosravi A, Taylor R, Naghavi M, Lopez AD. Differential mortality in Iran. *Population Health Metrics*. 2007;5(1):7. doi: 10.1186/1478-7954-5-7.
- Marmot M. Global action on social determinants of health. *Bull World Health Organ*. 2011;89(10):702. doi: 10.2471/BLT.11.094862.
- Pappachan B, Choonara I. Inequalities in child health in India. *BMJ Paediatr Open*. 2017;1(1):e000054. doi: 10.1136/bmjpo-2017-000054.
- Boyle MH, Racine Y, Georgiades K, Snelling D, Hong S, Omariba W, et al. The influence of economic development level, household wealth and maternal education on child health in the developing world. *Soc Sci Med*. 2006;63(8):2242-54. doi: 10.1016/j.socscimed.2006.04.034.
- Khosravi A, Taylor R, Naghavi M, Lopez AD. Mortality in the Islamic Republic of Iran, 1964-2004. *Bull World Health Organ*. 2007;85(8):607-14. doi: 10.2471/blt.06.038802.