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Original Research

What has Iran achieved in under-five mortality in terms of equity and efficiency in the past decades?

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ABSTRACT

Objective: Iran has made remarkable progress in reducing child mortality over the past few decades. However, this promising profile is mainly average driven, and inequalities are not counted in judgments about the progress. In the present study, we used an achievement index approach to combine average and inequalities to provide a better picture of Iran's achievement in under-five mortality over the last two decades.

Study design: The study had a cross-sectional design.

Methods: Data gathered in the two recent national demographic health surveys (DHSs) in 2000 and 2010 were used to conduct the analyses. Accordingly, 45,646 live births covered by DHS 2000 and 10,604 live births covered by DHS 2010 were investigated. An achievement index was constructed by incorporating some extensions to the concentration index, namely by incorporation of the average into the index.

Results: The standard concentration index showed that under-five mortality was unequally distributed, hurting the poor, across all provinces and Iran overall in 2000 (concentration index = −0.1311 [standard error {SE} = 0.0139]) and 2010 (−0.1367 [SE = 0.0381]). The achievement index revealed that Iran has had achievements in under-five mortality (relative change in the mean has decreased from 29.5% to 25.8%), but the achievement was mostly due to reductions in the average mortality and not in its unequal distribution. The same result applied to a considerable number of provinces, and only a few have made achievements in both inequality and average.

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Conclusions: Considering the lack of progress in the reduction of inequalities in under-five mortality over the past decades, equity-oriented policies should be of prime importance for Iran's healthcare system.

Introduction

Childhood mortality rates are among the most important health indices, representing the performance of societal health systems.[1] Globally, the under-five mortality rate has dropped from 93 deaths per 1000 live births in 1990 to 41 in 2016;[2] 5.6 million children died in 2016 before reaching their fifth birthday, 15,000 every day.[3] The under-five mortality rate is a key indicator of children's well-being, including the health and nutrition status.[4] It is also a key indicator of the extent of socio-economic development interventions that must be implemented for children's overall well-being.[5]

Since the 1980s, there has been a growing global call for nations to address health inequities.[6,7] Studies have shown that the pervasiveness of socio-economic inequalities in health both between and within countries at any stage of development significantly retards the progress toward the achievement of the Millennium Development Goals (MDGs).[8] Health inequalities refer to systematic and unjust differences in health (or the social determinants of health) between different social groups in societies. They are systematic as they systematically put some social groups, the disadvantaged ones, at further disadvantage by their poorer health. They are unjust as they can be reduced and eliminated by our current level of knowledge and technology. Therefore, the presence of health inequalities impose a normative and ethical challenge on healthcare systems and is required to be addressed and tackled by all means.[7] Different theoretical explanations are proposed in literature to explain the health inequalities. Material explanations resort to differences in distribution of material factors (e.g. food, shelter, pollution, and physical environment) between socio-economic groups and their effects on health to explain the inequalities in health. Psychosocial explanations point to negative health effects of feelings of discrimination, stress, low social support, and other psychological reactions to (negative) social experiences as the root causes of health inequalities. Behavioral explanations refer to differences in health behaviors (such as eating habits, smoking, and screening) between social groups to account for the unjust differences in health. And finally, biomedical explanations take the biological risk factors (e.g. specific genes) and their social pattering as contributors of health inequalities.[9]

Socio-economic inequalities in childhood mortality are a major public health problem in developing countries.[10] Childhood mortality is systematically and considerably higher among lower socio-economic groups within countries.[11] The reduction of regional and socio-economic inequalities in mortality within countries is a major objective of national governments and international organizations.[12,13] To achieve this goal, determinants of high mortality among disadvantaged people, communities, and regions need to be identified.[14]

The concentration index (CI) has proven to be a useful tool for measuring inequalities in the health sector.[15–20] However, the use of CI presents some important measurement problems. First, it is not clear from the index which socio-economic groups might benefit most from reductions in health inequalities.[21] Second, it is limited to the measurement of inequality and tells us nothing about the overall health averages.[22] From a health policy point of view, not only average of health in a society is an important matter but also inequality in its distribution matters. Nevertheless, policy-makers are likely to be willing to trade-off the equity and average, favoring the improvements in average. To prevent from this trade-off, Adam Wagstaff extends the CI and recommends the use of an 'achievement index' (AI) that simultaneously captures the average level of the health status and the socio-economic inequality in its distribution. Wagstaff, for the first time, implemented the AI approach to evaluate the status of 44 developing countries concerning three health variables for the under-five mortality levels, child malnutrition levels, and total fertility rates.[21] Since then, this approach has been applied in several studies, including Paul's study of self-perceived health in the Russian Federation,[23] Mezmur's study of maternal healthcare services in Ethiopia,[24] Biswas' study of chronic non-communicable diseases in Bangladesh,[25] Salvucci's study of child malnutrition in Mozambique,[26] and Morasae et al.'s study on mental health in Iran.[17]

However, we still lack such an approach to health in many countries, including Iran. Therefore, considering the importance of under-five children's mortality from socio-economic perspectives, we aimed to conduct the present study and investigate Iran's achievement over the past decades regarding children's health. To be exact, this study aimed to put the under-five mortality inequality and average together (by making some extensions to CI) to build an AI and then to reveal the provinces status in terms of their achievements. To the best of our knowledge, this report is one of the few studies on under-five mortality in the world using the AI approach. Specifically, it is of high importance for Iran where the achievements in under-five mortality are exclusively based on its averages.[27]

Methods

Data and measures

The required data were taken from Iran's demographic and health survey (DHS) conducted in 2000[28] and Iranian multiple indicators demographic and health survey (IrMIDHS)

conducted in 2010.[29] Stratified single-stage (equal size) cluster sampling (with unequal sampling probabilities) was used in DHS 2000. The sample included 2000 urban and 2000 rural households in each of the 28 provinces in the country plus 2000 households in Tehran. Overall, 113,957 households were sampled in the survey. Stratified multistage (equal size) cluster sampling (in which a minimum sample size was estimated to be 400 households in each province) was used in IrMIDHS. The sample included 31,300 households.[30]

The following questionnaires were used in both surveys: household information questionnaire, women's questionnaire, and under-five children's questionnaire. Questions related to women and children's questionnaires had very same items in DHS 2000 and IrMIDHS 2010. These two same questionnaires were used in the present study. However, the household information questionnaire had some differences in two surveys. Namely, in addition to the list of assets in 2000, some new assets (based on living standards in 2010) were added into the IrMIDHS 2010 asset list. Nonetheless, the comparability of the used data was checked by examining the discrepancies in questions and response options and removing duplicates and observations with wrong birth and death age records. Moreover, to make data sets comparable and have accurate estimates, three features of the sampling design, cluster sampling, and stratification (unequal selection probabilities) were considered in all the subsequent analyses.

Response rates for household questionnaires in 2000 and 2010 were 99.34% and 94.59%, respectively.[31] The sample size at provincial levels in both years (2000 and 2010) was shown to be adequate for robust (high power) statistical analyses on health indicators.[19,30]

Definition of variables

Under-five mortality (whether each of the live-born under-five children [under 4 years, 11 months, and 29 days] of the women interviewed were still alive or not) was our binary outcome variable. Owing to the relative scarcity of neonatal mortality, 1-year estimates were not adequately accurate[32] and could not ensure enough births to control for sampling error.[19,33] Therefore, the survival status of children was investigated during a 5-year observation period before the surveys in 2000 and 2010. Accordingly, 45,646 live births from 1995 to 2000 covered by DHS 2000 and 10,604 live births from 2005 to 2010 covered by MIDHS 2010 were investigated.

The household economic status was constructed using principal component analysis (PCA).[22,34] PCA constructs a wealth index and related quintiles from information on household's durable assets.[35] PCA is in fact a dimension-reduction method that reduces a large set of factors (asset variables) to a smaller set (wealth variable) that still contains most of the information in the larger set. The PCA comprised the four following steps in the present study. (1) Selection of the following assets to determine the economic status of households in 2000: the number of rooms per capita, access to piped drinking water, use of natural gas for heating and cooking, access to a heating system, and possession of bathroom, refrigerator, television, telephone, car, motorcycle, and bicycle. The assets selected for 2010 were as follows: the number of rooms per capita, access to piped drinking water, access to Internet, use of natural gas for cooking, access to a heating and cooling system, type of house ownership, and possession of bathroom, refrigerator, freezer, refrigerator freezer, color TV, LCD/LED/Plasma TV, landline, microwave, vacuum cleaner, personal computer/laptop, radio, cell phone, car, motorcycle, bicycle, and wrist watch. (2) Use of PCA command in STATA and retrieval of principal components that can explain a higher variance of the economic status (wealth status). The amount of variance explained by the first component in 2000 and 2010 was 29% and 22%, respectively. Therefore, the first principal component was adopted as the measure of the economic status in this study. (3) Estimation of factor (asset) scores in the components, especially in the first component. Factor scores show the importance of each asset in a given component. The higher score of a factor in a component points to its high importance for that component. It is expected to have only a few numbers of factors with high factor scores in each component, namely the first component. These few factors (assets) with high scores in the first component can then be used to construct the economic status index for each household, conditional to the presence of the assets for each given household. (4) Classification of households into five economic quintiles (poorest quintile, second poorest, middle, second richest, and richest) based on their economic status index that can then be used in the subsequent inequality measurements. More detail about construction of the economic status using PCA can be found elsewhere.[34]

Analysis

The following steps were consecutively followed to assess Iran's achievements in under-five mortality over the past two decades: construction of the economic status by PCA, calculation of standard CI, extension of the CI to make its implicit features explicit, and finally, calculation of AI. These steps were separately taken for each province and Iran as a whole in 2000 and 2010.

Concentration index

To measure inequalities in under-five mortality, the CI approach was used.[36,37] The standard CI is equal to

$$C = \frac{2}{n.\mu}\sum_{i=1}^{n} y_i R_i - 1 \quad (1)$$

where n is the sample size, y_i is the health indicator for person i, μ is the mean level of health, and R_i is the fractional rank of the wealth distribution of the ith person. The CI ranges between -1 and $+1$, and it is negative when the health variable is disproportionately concentrated among the poor and vice versa.[22] To make better sense of the index, we can rewrite Eq. (1):

$$C = 1 - \frac{2}{n.\mu}\sum_{i=1}^{n} y_i (1 - R_i) \quad (2)$$

$$C = 1 - \frac{2}{n.\mu}\sum_{i=1}^{n} y_i (1 - R_i)$$

where the quantity $(\frac{y_i}{n.\mu})$ is the share of health variable enjoyed (or suffered) by person i, which is weighted in the summation

by twice the complement of the person's fractional rank, that is, $2(1-R_i)$. As this shows, the CI is simply 1 minus the sum of these weighted health shares. The weights decline in a stepwise fashion, meaning that the poorest person's share of health is weighted by a number which is close to two and the richest person's health by a number which is close to zero. Clearly, the CI has an implicit view of the importance of different households in the distribution of health.[21]

In the first extension of the CI, different views regarding the importance of different households in the health distribution can be brought to the surface by accommodation of an inequality aversion parameter (υ):

$$C(\upsilon) = 1 - \frac{\upsilon}{n.\mu}\sum_{i=1}^{n} y_i(1-R_i)^{(\upsilon-1)} \quad \upsilon > 1 \tag{3}$$

Where the attached weight to the health share of i th person ($\frac{y_i}{n.\mu}$) equals $\upsilon(1-R_i)^{(\upsilon-1)}$ rather than $2(1-R_i)$. When $(\upsilon) = 2$, the weight is the same as in the standard CI. In contrast, when $(\upsilon) = 1$, the health of each subject is weighted equally. This is where the researcher is indifferent to inequality and the CI = 0 however unequal the distribution of health is across the wealth distribution. The weights, indeed, differ according to the degree of inequality aversion. As the value of (υ) increases above 1, the weight attached to the health of the poor households (lower wealth quintiles) increases and the weight attached to the health of the better-off households (higher wealth quintiles) decreases.[21,22] In higher values of (υ), for example $(\upsilon) = 6$ or 7, the weight attached to the health of households in the top half of the wealth distribution may equal zero.

The result of this extension to the CI would be valuable information about where in the wealth distribution (from poorest household to richest one or across the wealth quintiles) reductions in health inequality matter most. For example, suppose that our health outcome is a health disadvantage (e.g. under-five mortality) and is more concentrated among the poor households (negative standard CI). Also, suppose that we extend the CI and the extended CI $c(\upsilon)$ shows remarkable increases when the degree of the inequality aversion parameter increases. This result implies that the health of the poorest wealth quintile is much worse than that of the rest of the population and that improving the health of this group will make a significant difference in terms of reducing health (under-five mortality) inequality.

Achievement index

In the next extension of the CI, an AI is constructed that reflects both inequality and average. In the context of the extended CI, the AI can be imagined as the weighted average level of health in a given society in which greater weights are given to poorer people:[21]

$$I(\upsilon) = \frac{1}{n}\sum_{i=1}^{n} y_i\upsilon(1-R_i)^{(\upsilon-1)} \quad \upsilon > 1 \tag{4}$$

This index can also be written as

$$I(v) = \mu(1 - C(v)) \tag{5}$$

Once again, in a health disadvantage case (e.g. under-five mortality) that might be highly concentrated among the poor, the attached weight $(1 - C(\upsilon))$ will help to increase $I(\upsilon)$ beyond the mean, making achievement worse than it would appear if one were to look at the mean alone.[21,22]

Results

Tables 1 and 2 illustrate the mean and extended CIs (different degrees of inequality aversion) for under-five mortality across provinces of Iran in 2000 and 2010, respectively. The last column of the tables shows the difference between CI (2) and CI (5), an increase in the difference indicates higher rates of under-five mortality in the poorest quintile. As Table 1 shows, Isfahan and Kermanshah provinces had the highest and lowest differences between CI (2) and CI (5) in 2000, respectively. In contrast and according to Table 2, Zanjan and Markazi provinces had the highest and lowest differences between CI (2) and CI (5) in 2010. This matter shows that there have been some dynamics (progresses or regresses) in terms of the under-five mortality distribution across the provinces over the decades. Owing to space constraints, such dynamics of under-five mortality cannot be presented for every single province here. As a result, dynamics of the aforementioned provinces will be presented in the following as examples that can be applied for other provinces as well. Let us first take Isfahan and Zanjan, the places where there was a huge difference between CI (5) and CI (2), and the poorest people (quintile) had the worst profile in terms of under-five mortality compared with the richest economic quintiles in these provinces. Despite such a negative profile in 2000, the inequality decreased from −0.29 to −0.029 in the Isfahan province over the next decade, more than 90% decrease. More importantly, the difference between the richest and the poorest quintile (CI (5)−CI (2)) shrunk over the decade, and there was no such a huge difference between these two quintiles in 2010. The mean of mortality has also improved in this city, reaching from 0.026% in 2000 to 0.017% in 2010. In contrast, the inequality in Zanjan increased from −0.082 to −0.12 over the decade, around 30% increase. More importantly, the difference between the poorest and the richest quintiles (CI (5)−CI (2)) increased quite remarkably over the decade, indicating the deterioration of under-five child health in Zanjan over the decade. Quite surprisingly, the mean of under-five mortality decreased in this province in that decade (from 0.041 to 0.013), showing that the improvement was mostly enjoyed by the better-off people in Zanjan. In contrast to Zanjan and Isfahan, however, there was a little difference in under-five mortality between the poorest and the richest quintiles (CI (5)−CI (2)) in Kermanshah and Markazi provinces in 2000 and 2010, respectively. According to the findings, the inequality has increased in Kermanshah (from −0.069 to −0.273) over the decade, but the difference between the richest and the poorest quintiles was still less than most of other provinces in 2010. The case for Markazi is, however, very informing and interesting. This province has the least difference between the poorest and the richest quintiles in 2010 but has the highest inequality in that year among all the provinces (CI = −0.48). This matter is interesting as it shows that the under-five mortalities are mostly concentrated among the middle quintiles in this province, and the poorest quintile is in a better

Table 1 – The mean and extended concentration index (CI) values for under-five children mortality across provinces in Iran in 2000 (n = 45,646; no. of province = 28).

Provinces	Mean (SD)	R[b]	Extended concentration index (SE)					
			CI[a] (2)	CI (3)	CI (4)	CI (5)	R	CI (5)-CI (2)[c]
East Azerbaijan	0.0389(0.1933)	21	−0.1192(0.0728)	−0.1731(0.1120)	−0.2207(0.1414)	−0.2667(0.1658)	19	−0.1475
West Azerbaijan	0.0368(0.1883)	19	−0.0230(0.1328)	−0.0237(0.1553)	−0.0726(0.1057)	−0.0951(0.0693)	7	−0.0721
Ardabil	0.0430(0.2029)	26	−0.0370(0.0969)	−0.0450(0.1579)	−0.0580(0.2068)	−0.0750(0.2488)	3	−0.0380
Isfahan	0.0260(0.1592)	4	−0.2988(0.0895)	−0.4992(0.1400)	−0.6507(0.1784)	−0.7717(0.2105)	28	−0.4729
Ilam	0.0340(0.1812)	16	−0.1451(0.0743)	−0.2044(0.1158)	−0.2065(0.1474)	−0.2171(0.1737)	16	−0.0720
Bushehr	0.0299(0.1703)	8	−0.0773(0.1784)	−0.0785(0.1512)	−0.0885(0.1187)	−0.0915(0.0760)	5	−0.0142
Tehran	0.0271(0.1625)	5	−0.2222(0.0747)	−0.3671(0.1240)	−0.4660(0.1647)	−0.5329(0.2000)	26	−0.3107
Chaharmahal and Bakhtiari	0.0190(0.1366)	2	−0.1774(0.1015)	−0.2748(0.1559)	−0.3423(0.1967)	−0.3852(0.2305)	23	−0.2078
Khorasan	0.0336(0.1801)	14	−0.0116(0.0754)	−0.0594(0.1185)	−0.0842(0.1516)	−0.0923(0.1794)	6	−0.0807
Khuzestan	0.0401(0.1962)	22	−0.1912(0.0569)	−0.3043(0.0914)	−0.3846(0.1182)	−0.4462(0.1408)	25	−0.2550
Zanjan	0.0413(0.0050)	24	−0.0826(0.1577)	−0.1065(0.1343)	−0.1219(0.0686)	−0.1254(0.1061)	11	−0.0428
Semnan	0.0287(0.1670)	7	−0.1586(0.0928)	−0.2598(0.1484)	−0.3194(0.1918)	−0.3526(0.2283)	22	−0.1940
Sistan and Baluchestan	0.0548(0.2276)	28	−0.0950(0.0472)	−0.1285(0.0726)	−0.1535(0.0917)	−0.1795(0.1076)	13	−0.0845
Fars	0.0346(0.1828)	17	−0.1107(0.0789)	−0.1282(0.1900)	−0.1583(0.1602)	−0.1610(0.1247)	12	−0.0503
Qazvin	0.0306(0.1724)	9	−0.0710(0.0868)	−0.1591(0.1340)	−0.2419(0.1695)	−0.3176(0.1989)	21	−0.2466
Qom	0.0368(0.1614)	18	−0.0446(0.0900)	−0.0803(0.1523)	−0.0963(0.2492)	−0.0964(0.2041)	8	−0.0518
Kurdistan	0.0409(0.1980)	23	−0.1370(0.0696)	−0.1848(0.1087)	−0.1916(0.1631)	−0.1973(0.1383)	15	−0.0603
Kerman	0.0319(0.1756)	12	−0.2110(0.0818)	−0.3779(0.1271)	−0.4886(0.1615)	−0.5620(0.1907)	27	−0.3510
Kermanshah	0.0414(0.1993)	25	−0.0696(0.0788)	−0.0728(0.2187)	−0.0792(0.1803)	−0.0813(0.1351)	4	−0.0117
Kohkilooyeh and Boyer-Ahmad	0.0338(0.1807)	15	−0.0778(0.0766)	−0.1497(0.1158)	−0.2011(0.1447)	−0.2397(0.1687)	17	−0.1619
Golestan	0.0371(0.1889)	20	−0.1204(0.0695)	−0.2302(0.1082)	−0.3224(0.1375)	−0.3969(0.1620)	24	−0.2765
Gilan	0.0251(0.1565)	3	−0.0148(0.2425)	−00315(0.2069)	−0.0426(0.1066)	−0.0590(0.1640)	2	−0.0442
Lorestan	0.0324(0.1770)	13	−0.1412(0.0758)	−0.1818(0.1193)	−0.1931(0.1802)	−0.1940(0.1524)	14	−0.0528
Mazandaran	0.0170(01294)	1	−0.0210(0.1259)	−0.0874(0.1931)	−0.1180(0.2435)	−0.1199(0.2853)	10	−0.0989
Markazi	0.0277(0.1642)	6	−0.0262(0.2225)	−0.0728(0.1886)	−0.0825(0.0948)	−0.1005(0.1481)	9	−0.0743
Hormozgan	0.0309(0.1731)	11	−0.1336(0.0695)	−0.1972(0.1068)	−0.2321(0.1348)	−0.2537(0.1581)	18	−0.1201
Hamadan	0.0434(0.2039)	27	−0.1482(0.0700)	−0.2158(0.1084)	−0.2527(0.1374)	−0.2733(0.1615)	20	−0.1251
Yazd	0.0309(0.1730)	10	−0.0036(0.1807)	−0.0218(0.2132)	−0.0314(0.1418)	−0.0503(0.0905)	1	−0.0467
Total (Iran)	**0.0342(0.1817)**	–	−0.1311(0.0139)	−0.2121(0.0225)	−0.2629(0.0292)	−0.2954(0.0348)		−0.1643

SD, standard deviation; SE, standard error.
[a] Concentration index. The numbers in brackets are the degrees of inequality aversion parameter.
[b] R stands for the rank of the provinces.
[c] The larger the difference between CI (5) and CI (2), the higher the death rate in the poorest quintile.

situation. This finding is very interesting as it shows the value of extension to CI because this extension is able to reveal some details that standard CI fails to reveal.

However, such dynamics can also be better investigated and understood using the AI approach that combines the average with inequality. Tables 3 and 4 illustrate the value of AI for different degrees of inequality aversion across provinces in 2000 and 2010, respectively. The first column of the tables equals the mean of under-five mortality rate in each province. As under-five mortality is more concentrated among the poor, when the aversion degree rises above 1, the AI increases to values beyond the mean of mortality, making the achievement look more unacceptable in comparison to the only mean-focused achievements. To better illustrate such a matter, the penultimate column in these two tables shows the difference in ranking when (v) = 1 (mean) and when (v) = 5. The difference in ranking shows that the mean values cannot be our only tools for judgment and decision-making about under-five mortality achievements. Take the case of Isfahan in Table 3 and Zanjan in Table 4 as examples. Isfahan occupies rank 4 in terms of its achievement in low mean value for the under-five mortality. Zanjan stands in the 10th rank in this regard. But, by considering the inequality, aversion degree of 5, Isfahan's rank drops 14 steps and hits the 18th. Zanjan is even worse and drops 17 steps and reaches a very low rank of 27th. This matter clearly shows how misleading average values can be in judgments about achievements. As a result, the relative change in the mean, the last column in Tables 3 and 4, is devised to emphasize the significance of inequality in each province. The higher values of relative change show that inequality is of salience in the province and needs due attention. Let us take the case of Zanjan for example. This province had the highest difference between the poorest and the richest quintiles in terms of under-five mortality in 2010. When the extended CIs were multiplied by mortality mean in this province, the AI values considerably increased, going far beyond the mean (around 300% bigger) so that the province had the highest value in the relative change ({[AI (5) - AI (1)]/AI (1)}*100 = 311.36) among all the provinces. This matter shows the importance of attention to the inequality and to the poorest quintile in this province to improve the profile of under-five mortality. Interestingly, this was not the case for

Table 2 – The means and extended concentration index (CI) values for under-five children mortality across provinces in Iran in 2010 (n = 10,604; no. of province = 30).

Provinces	Mean (SD)	R[b]	Extended concentration index (SE)					
			CI[a] (2)	CI (3)	CI (4)	CI (5)	R	CI (5)–CI (2)[c]
East Azerbaijan	0.0268(0.1617)	21	−0.054(0.1530)	−0.1490(0.2367)	−0.2477 (0.2995)	−0.3366(0.3516)	15	−0.2826
West Azerbaijan	0.0348(0.1835)	25	−0.0774(0.1382)	−0.0909(0.2137)	−0.1410(0.2705)	−0.2090(0.3177)	19	−0.1316
Ardabil	0.0111(0.1075)	6	−0.1489(0.4093)	−0.1862(0.6306)	−02311(0.7965)	−0.4384(0.8329)	21	−0.2895
Isfahan	0.0178(0.1326)	14	−0.0299(0.1661)	−0.1554(0.2598)	−0.2954(0.3318)	−0.4373(0.3923)	27	−0.4074
Ilam	0.0132(01147)	10	−0.6057(0.4072)	−0.6114(0.5283)	−0.6189(0.4172)	−0.6233(0.5673)	9	−0.0176
Bushehr	0.0172(0.1305)	13	−0.0215(0.3354)	−0.1686(0.5168)	−0.3713(0.6530)	−0.5416(0.3685)	30	−0.5201
Tehran	0.0169(0.1292)	12	−0.1280(0.1119)	−0.1829(0.1737)	−0.2227(0.2205)	−0.2549(02594)	4	−0.1269
Chaharmahal and Bakhtiari	0.0241(0.1453)	19	−0.321(0.3338)	−0.3652(0.5119)	−0.5752(0.5441)	−0.6991(0.6425)	8	−0.3781
South Khorasan	0.0359(0.1866)	26	−0.4344(0.2297)	−0.6494(0.3534)	−0.7857(0.4462)	−0.8937(0.5231)	14	−0.4593
Razavi Khorasan	0.0113(0.0023)	7	−0.0991(0.1816)	−0.1458(0.2825)	−0.1945(0.3590)	−0.2488(0.4226)	10	−0.1497
North khorasan	0.0597(0.2377)	30	−0.0314(0.1707)	−0.0326(0.2630)	−0.0423(0.3319)	−0.0519(0.3885)	16	−0.0205
Khuzestan	0.0271(0.1626)	23	−0.0367(0.1306)	−0.0371(0.2023)	−0.0587(0.2563)	−0.1252(0.3011)	26	−0.0885
Zanjan	0.0131(0.1143)	9	−0.1278(0.4046)	−0.4560(0.6198)	−0.7182(0.7777)	−0.9042(0.8123)	29	−0.7764
Semnan	0.0178(0.1330)	15	−0.2359(0.4094)	−0.3175(0.6293)	−0.4862(0.7932)	−0.7809(0.8293)	11	−0.5450
Sistan and Baluchestan	0.0247(0.1553)	20	−0.1495(0.1524)	−0.2160(0.2364)	−0.2529(0.3000)	−0.2808(0.3528)	5	−0.1313
Fars	0.0205(0.1419)	16	−0.0185(0.1587)	−0.0387(0.2463)	−0.0798(0.3126)	−0.1182(0.3678)	3	−0.0997
Qazvin	0.0066(0.0811)	4	−0.5214(0.5825)	−0.6369(0.7001)	−0.6595(0.8135)	−0.6897(0.8176)	17	−0.1683
Qom	0.0062(0.0061)	3	−0.0601(0.1350)	−0.1478(0.3256)	−0.2386(0.3297)	−0.2875(0.3620)	18	−0.2274
Kurdistan	0.0268(0.1621)	22	−0.1557(0.2569)	−0.1675(0.3972)	−0.2210(0.5032)	−0.2281(0.5912)	6	−0.0724
Kerman	0.0138(0.1167)	11	−0.0181(0.2364)	−0.0695(0.3638)	−0.1144(0.4596)	−0.1300(0.5390)	1	−0.1119
Kermanshah	0.0209(0.1434)	17	−0.2734(0.2570)	−0.3012(0.2837)	−0.3206(0.2875)	−0.3505(0.3981)	24	−0.0771
Kohkilooyeh and Boyer-Ahmad	0.0388(0.1936)	28	−0.0189(0.2021)	−0.0704(0.3121)	−0.0850(0.3946)	−0.1618(0.4627)	2	−0.1429
Golestan	0.0285(0.1666)	24	−0.2730(0.2011)	−0.5019(0.3099)	−0.6371(0.3919)	−0.7198(0.4600)	28	−0.4468
Gilan	0.0374(0.1901)	27	−0.4604(0.1993)	−0.6768(0.3098)	−0.7864(0.3938)	−0.8547(0.4637)	20	−0.3943
Lorestan	0.0123(0.1104)	8	−0.2457(0.3359)	−0.4012(0.5192)	−0.4077(0.6573)	−0.4859(0.7718)	25	−0.2402
Mazandaran	0.0053(0.0030)	2	−0.1432(0.3993)	−0.2184(0.6151)	−0.2922(0.7763)	−0.3458(0.7090)	7	−0.2026
Markazi	0.0047(0.0683)	1	−0.4868(0.5827)	−0.6261(0.5973)	−0.6491(0.5034)	−0.5040(0.6748)	13	−0.0172
Hormozgan	0.0465(0.2109)	29	−0.0037(0.1639)	−0.0423(0.2526)	−0.0718(0.3192)	−0.0765(0.3742)	23	−0.0728
Hamadan	0.0088(0.0934)	5	−0.0578(0.4072)	−0.3162(0.4325)	−0.4769(0.7917)	−0.6479(0.8110)	22	−0.5901
Yazd	0.0240(0.1533)	18	−0.0508(0.2881)	−0.1028(0.4448)	−0.2509(0.5622)	−0.4331(0.6592)	12	−0.3823
Total (Iran)	**0.0209(0.1431)**		−0.1367(0.0381)	−0.2055(0.0593)	−0.2409(0.0754)	−0.2582(0.0888)		−0.1215

SD, standard deviation; SE, standard error.
[a] Concentration index. The numbers in brackets are the degree of inequality aversion parameter.
[b] R stands for the rank of provinces.
[c] The larger the difference between CI (5) and CI (2), the higher the death rate in the poorest quintile.

this province in 2000 as the difference between CI (5) and CI (2) was relatively low, indicating less difference between the poorest and the richest in terms of under-five mortality. Therefore, when extended CIs were multiplied by the mean, the AI values were not so higher than the mean, and the relative change was relatively small. The case for Isfahan was completely opposite of the Zanjan. As Isfahan had the highest difference between the poorest and richest quintiles in 2000 in terms of under-five mortality (CI (5)−CI (2)), the multiplication of the extended CIs with the mean of under-five mortality led to higher relative change so that Isfahan had the highest relative change value in 2000 (relative change = 77.31). But, as Isfahan saw improvements in the under-five mortality rate over the decade, the AI values for Isfahan in 2010 was relatively small, and the relative change was not high, comparatively (relative change = 43.58, one can compare it with 311 in Zanjan in the same year).

Fig. 1 also provides a clearer picture of the dynamics in achievements in under-five mortality rates across provinces over time (from 1995 to 2010). This figure shows the changes in the relative change from the mean for each province. Provinces in green have seen improvements in their relative change, i.e. had better achievements in under-five mortality rates considering both average and inequality. In contrast, the provinces in red have failed to see tangible achievements in their under-five mortality rate in the last decades.

However, taking all of Iran into account, the mean of under-five mortality has decreased over the period in the country (from 0.0342 [standard deviation {SD} = 0.1817] in 2000 to 0.0209 [SD = 0.1431] in 2010). But, the inequality has increased over the period (from −0.1311 [SD = 0.0139] in 2000 to −0.1367 [SD = 0.0381] in 2010).

Discussion

The present article aimed to use the AI approach to investigate the under-five mortality status across Iran's provinces over the past two decades. AI combines the average with inequality to prevent policymakers from trading off the inequality with

Table 3 – Achievement index values for different degrees of inequality aversion across provinces in Iran in 2000.

Provinces	Achievement index										Rank difference, R5–R1	Relative change[b] (%)
	V = 1 (mean)		V = 2		V = 3		V = 4		V = 5			
	I[a] (1)	R1	I (2)	R2	I (3)	R3	I (4)	R4	I (5)	R5		
East Azerbaijan	0.0389	21	0.0435	22	0.0456	21	0.0475	22	0.0492	22	1	26.48
West Azerbaijan	0.0368	19	0.0370	15	0.0377	13	0.0395	13	0.0403	13	−6	9.51
Ardabil	0.0430	26	0.0434	21	0.0465	24	0.0496	25	0.0505	24	−2	17.44
Isfahan	0.0260	4	0.0338	11	0.0390	16	0.0430	18	0.0461	18	14	77.31
Ilam	0.0340	17	0.0409	19	0.0410	18	0.0411	17	0.0414	15	−2	21.76
Bushehr	0.0299	9	0.0322	7	0.0322	7	0.0325	7	0.0326	7	−2	9.03
Tehran	0.0271	6	0.0332	9	0.0371	12	0.0398	14	0.0416	16	10	53.51
Chaharmahal and Bakhtiari	0.0190	2	0.0224	2	0.0243	2	0.0255	1	0.0264	1	−1	38.95
Khorasan	0.0336	15	0.0340	12	0.0356	9	0.0364	8	0.0367	8	−7	9.23
Khuzestan	0.0401	22	0.0478	26	0.0523	26	0.0556	27	0.0580	27	5	44.64
Zanjan	0.0413	24	0.0447	24	0.0457	23	0.0463	20	0.0465	19	−5	12.59
Semnan	0.0287	8	0.0333	10	0.0362	10	0.0379	9	0.0388	10	2	35.19
Sistan and Baluchestan	0.0548	28	0.0600	28	0.0619	28	0.0632	28	0.0646	28	0	17.88
Fars	0.0346	18	0.0384	17	0.0390	17	0.0401	15	0.0402	12	−6	16.18
Qazvin	0.0306	10	0.0328	8	0.0355	8	0.0381	10	0.0404	14	4	32.03
Qom	0.0268	5	0.0280	4	0.0289	4	0.0293	4	0.0293	3	−2	9.33
Kurdistan	0.0409	23	0.0465	25	0.0484	25	0.0487	23	0.0489	21	−2	19.56
Kerman	0.0319	13	0.0386	18	0.0439	19	0.0474	21	0.0474	20	7	48.59
Kermanshah	0.0414	25	0.0443	23	0.0447	20	0.0448	19	0.0500	23	−2	20.77
Kohkilooyeh and Boyer-Ahmad	0.0338	16	0.0364	14	0.0388	15	0.0406	16	0.0419	17	1	23.96
Golestan	0.0371	20	0.0415	20	0.0456	22	0.0490	24	0.0518	25	5	39.62
Gilan	0.0251	3	0.0259	3	0.0262	3	0.0266	2	0.0271	2	−1	7.97
Lorestan	0.0324	14	0.0370	16	0.0383	14	0.0386	12	0.0387	9	−5	19.44
Mazandaran	0.0170	1	0.0174	1	0.0196	1	0.0289	3	0.0301	4	3	77.06
Markazi	0.0277	7	0.0285	5	0.0298	5	0.0301	5	0.0305	5	−2	10.11
Hormozgan	0.0309	11	0.0351	13	0.0370	11	0.0381	11	0.0388	11	0	25.57
Hamadan	0.0434	27	0.0499	27	0.0528	27	0.0544	26	0.0553	26	−1	27.42
Yazd	0.0309	12	0.0302	6	0.0310	6	0.0318	6	0.0324	6	−6	4.85
Total (Iran)	0.0342	–	0.0387	–	0.0415	–	0.0432	–	0.0443	–	–	29.53

[a] Inequality aversion. The numbers in brackets are the degree of the inequality aversion parameter.
[b] Relative change from mean = {[I (5) - I (1)]/I (1)}*100.

the average. As a result, more to-the-point and precise policies regarding under-five mortality can be undertaken.

According to the findings, under-five mortality was unequally distributed, hurting the poor, in all provinces of Iran over the past decades. This finding is in line with a plethora of national and international studies.[10,11,20,38–43] Interestingly, when provinces' status in under-five mortality was separately investigated by average and inequality (provinces' rankings in Tables 1 and 3), a different picture was seen. For example, the rank of provinces in terms of average and inequality (CI (5)) was totally different, even sometimes contrasting with each other both in 2000 and 2010. In fact, there were some provinces (e.g. Isfahan, Tehran, Chaharmahal, and Semnan in 2000; Ardabil, Qazvin, Qom, and Hamedan in 2012) that were doing well in terms of average but were strangely lacking in terms of inequalities reduction. Moreover, in almost all the provinces, the poorest quintile was the victim of inequalities (moving from CI (2) to CI (5)), although they differed in terms of the degree of being such a victim. The AI, more interestingly, provided some new and helpful insights. Unfortunately, most of the Iranian provinces (18 of 30) did not experience remarkable achievements in under-five mortality over the past decades (Fig. 1). However, generally speaking, the entire country has experienced some achievements in under-five mortality as the value for relative change in mean has decreased from 1995 (relative change = 29.53%) to 2010 (relative change = 25.83%). This decline is mainly due to a decrease in the mean of the under-five mortality rate over the period. The reasons behind such progresses and regresses at the national and provincial level in terms of under-five mortality can be a topic for future investigations.

Nevertheless, one can use the current knowledge about socio-economic development at provincial level to explain the observed achievements. There have been several studies in Iran to examine and rank the provinces in terms of their socio-economic development (e.g. human development index) levels and access to social and health facilities. According to these studies, some of the provinces such as Tehran, Isfahan, East Azerbaijan, Semnan, Golestan, and Mazandaran are among the provinces with the high human development index and have the high access to facilities. In contrast, provinces such as Sistan, Lorestan, Ilam, and West Azerbaijan are at the bottom of the list of development indices and do suffer from deprivations. Other provinces such as Zanjan, Markazi, Kermanshah, and Khorasan are somewhere between those two extremes and are mediocre provinces.[44,45]

Table 4 – Achievement index values for different degrees of inequality aversion across provinces in Iran in 2010.

Provinces	Achievement index										Rank difference, R5–R1	Relative change[b] (%)
	V = 1 (mean)		V = 2		V = 3		V = 4		V = 5			
	I[a] (1)	R1	I (2)	R2	I (3)	R3	I (4)	R4	I (5)	R5		
East Azerbaijan	0.0268	21	0.0270	20	0.0272	17	0.0258	15	0.0287	15	−6	7.09
West Azerbaijan	0.0348	25	0.0352	25	0.0361	24	0.0376	23	0.0399	22	−3	14.66
Ardabil	0.0116	7	0.0181	10	0.0202	11	0.0208	10	0.0310	17	10	167.24
Isfahan	0.0179	14	0.0184	11	0.0207	12	0.0232	13	0.0257	12	−2	43.58
Ilam	0.0132	9	0.0213	14	0.0267	15	0.0309	18	0.0346	21	12	162.12
Bushehr	0.0172	13	0.0176	9	0.0179	8	0.0193	8	0.0243	11	−2	41.28
Tehran	0.0169	12	0.0191	12	0.0201	10	0.0208	11	0.0213	8	−4	26.04
Chaharmahal and Bakhtiari	0.0214	18	0.0283	21	0.0364	25	0.0441	25	0.0507	26	8	136.92
South Khorasan	0.0359	26	0.0515	28	0.0593	28	0.0642	28	0.0680	28	2	89.42
Razavi Khorasan	0.0114	6	0.0125	6	0.0130	5	0.0136	4	0.0142	4	−2	24.56
North khorasan	0.0598	30	0.0617	30	0.0619	29	0.0678	30	0.0742	30	30	24.08
Khuzestan	0.0271	23	0.0261	17	0.0270	16	0.0287	17	0.0305	16	−7	12.55
Zanjan	0.0132	10	0.0251	16	0.0358	23	0.0455	26	0.0543	27	17	311.36
Semnan	0.0179	15	0.0265	18	0.0318	22	0.0360	22	0.0399	23	8	122.91
Sistan and Baluchestan	0.0247	20	0.0284	22	0.0300	19	0.0309	19	0.0316	18	−2	27.94
Fars	0.0205	16	0.0209	13	0.0211	13	0.0222	12	0.0230	10	−6	12.20
Qazvin	0.0066	4	0.0068	3	0.0098	4	0.0154	6	0.0175	6	2	165.15
Qom	0.0062	3	0.0066	2	0.0077	3	0.0080	3	0.0088	3	0	41.94
Kurdistan	0.0269	22	0.0311	24	0.0314	20	0.0328	20	0.0330	19	−3	22.68
Kerman	0.0138	11	0.0122	5	0.0135	6	0.0148	5	0.0156	5	−6	13.04
Kermanshah	0.0209	17	0.0266	19	0.0276	18	0.0276	16	0.0283	14	−3	35.41
Kohgilooyeh and Boyer-Ahmad	0.0388	28	0.0389	26	0.0400	26	0.0406	24	0.0416	24	−4	7.22
Golestan	0.0285	24	0.0291	23	0.0316	21	0.0334	21	0.0336	20	−4	17.89
Gilan	0.0374	27	0.0546	29	0.0627	30	0.0668	29	0.0693	29	2	85.29
Lorestan	0.0123	8	0.0153	8	0.0172	7	0.0173	7	0.0183	7	−1	48.78
Mazandaran	0.0053	2	0.0061	1	0.0065	1	0.0069	1	0.0072	1	−1	35.85
Markazi	0.0047	1	0.0069	4	0.0070	2	0.0076	2	0.0077	2	1	63.83
Hormozgan	0.0465	29	0.0463	27	0.0485	27	0.0499	27	0.0501	25	25	7.74
Hamadan	0.0088	5	0.0145	7	0.0181	9	0.0203	9	0.0217	9	4	146.59
Yazd	0.0240	19	0.0242	15	0.0246	14	0.0253	14	0.0264	13	−6	10.00
Total (Iran)	0.0209	–	0.0238	–	0.0252	–	0.0260	–	0.0263	–	–	25.83

[a] Inequality aversion. The numbers in brackets are the degree of the inequality aversion parameter.
[b] Relative change from mean = {[I (5) - I (1)]/I (1)}*100.

Interestingly, the outline of provinces in terms of their under-five mortality achievements, shown in Fig. 1, does relatively correspond to the province's status in terms of development indices. In fact, the provinces with high development indices are doing well in terms of under-five child mortality achievements as well. However, against some studies that, using mean-based indices, report high under-five mortality achievements among mediocre provinces,[27] the present study showed that the mediocre provinces are not different from underdeveloped provinces when it comes to inequality in under-five mortality. More importantly, Iran's marked achievement to MDG 4 (to reduce child mortality by two-thirds from 1990 to 2015)[27] should be reassessed in terms of inequalities as well because such a mean-driven picture can be misleading and may prolong the unfavorable overlook of inequalities in decisions about child health in future.

To the best of our knowledge, there has been only one study using AI to investigate the under-five mortality status worldwide. Skaftun et al. investigated achievements of Ethiopia in some health-related variables, including under-five mortality, from 2000 to 2011.[43] Their study showed that Ethiopia had achieved lower rates of under-five mortality over the years, but the achievement, just like our study, was due to improvements in the mean of the mortality, and inequality increased over time. This matter shows that no policymaker should be allowed to make a trade-off between average and inequality and hide behind average-focused achievements as inequalities cannot be ignored in the long run.

Policy implications

One of the main features of the AI is that it can be used as a guide for policymaking. For example, if the index shows that a country is doing great in terms of average but lacking in inequalities, then it can direct the policies to redress the inequalities and vice versa. Therefore, using the AI in our study, especially using changes in the relative change in mean from 1995 to 2010, one can suggest the proper policy, equity based and efficiency based, for each province and the whole country as follows.

Efficiency-oriented policies

According to Table 5, the provinces that should scale up efficiency-oriented policies are as follows: Kohkilooyeh and

Fig. 1 – Provincial changes in relative difference from the mean since 2000 to 2010.

Hormozgan. Interestingly, Kohkilooyeh should take up these types of policies as inequality has decreased over the years in this province, but there was no change in the mean of the under-five mortality. Hormozgan should take up these policies as, surprisingly, the mean has increased over time in this province, but inequality has dropped dramatically. Efficiency-oriented policies are those policies that aim to reduce the rate of under-five mortality among the whole population, regardless of its delicate socio-economic distribution across the social groups. These policies, that are dominant in Iran's current child health programs, are somehow blind to the social patterning of under-five mortality.

Equity-oriented policies

According to Table 5, the following provinces should opt for equity-oriented policies: West Azerbaijan, Ardabil, Ilam, Bushehr, Zanjan, Semnan, Sistan, Qazvin, Qom, Kurdistan, Kermanshah, Gilan, Lorestan, Markazi, Hamedan, and Yazd. Mean of under-five mortality has considerably improved in almost all these provinces over the decades, but inequality has worsened. However, there have been some improvements in terms of inequality in provinces of Bushehr and Hamedan, but the rate is so meager that it cannot be counted as an achievement, and future efforts are needed.

Equity- and efficiency-oriented policies

There are some provinces that should focus both on equity and efficiency to have achievements in under-five mortality. Some of these provinces have seen meaningful achievements in both equity and efficiency over the years and need to continue the same route (East Azerbaijan, Isfahan, Tehran, Khuzestan, Fars, and Kerman). Some other provinces have sadly had increases in both inequalities and mean of the under-five mortality. These provinces, therefore, should focus on both policy orientations in their future policy and action routes.

Table 5 – Classification of provinces according to the policy type they need to scale up.

Provinces	Achievement	Inequality change	Mean change	Policy type
East Azerbaijan	**Yes**	Decrease	Decrease	Equity and efficiency
West Azerbaijan	No	Increase	Decrease	Equity
Ardabil	No	Increase	Decrease	Equity
Isfahan	**Yes**	Decrease	Decrease	Equity and efficiency
Ilam	No	Increase	Decrease	Equity
Bushehr	No	***Decrease***	Decrease	Equity
Tehran	**Yes**	Decrease	Decrease	Equity and efficiency
Chaharmahal and Bakhtiari	No	Increase	Increase	Equity and efficiency
Khorasan	No	Increase	Increase	Equity and efficiency
Khuzestan	**Yes**	Decrease	Decrease	Equity and efficiency
Zanjan	No	Increase	Decrease	Equity
Semnan	No	Increase	Decrease	Equity
Sistan and Baluchestan	No	Increase	Decrease	Equity
Fars	**Yes**	Decrease	Decrease	Equity and efficiency
Qazvin	No	Increase	Decrease	Equity
Qom	No	Increase	Decrease	Equity
Kurdistan	No	Increase	Decrease	Equity
Kerman	**Yes**	Decrease	Decrease	Equity and efficiency
Kermanshah	No	Increase	Decrease	Equity
Kohkilooyeh and Boyer-Ahmad	**Yes**	Decrease	Constant	Efficiency
Golestan	**Yes**	Increase	Decrease	Equity
Gilan	No	Increase	Increase	Equity and efficiency
Lorestan	No	Increase	Decrease	Equity
Mazandaran	**Yes**	Increase	Decrease	Equity
Markazi	No	Increase	Decrease	Equity
Hormozgan	**Yes**	Decrease	Increase	Efficiency
Hamadan	No	Decrease	Decrease	Equity
Yazd	No	Increase	Decrease	Equity
Total (Iran)	**Yes**	**Increase**	**Decrease**	**Equity**

Provinces in bold have seen improvements in their relative change, i.e. had better achievements in under-five mortality rates. In contrast, the provinces in italic have failed to see achievements in under-five mortality rates over time.

By equity-oriented policies, we mean those policies that aim at specific parts of the society that suffer from more social and health adversities. For example, there has been a growing concern about the increasing number of people living in urban slums and informal settlements in Iran in recent years.[46] This matter has stirred concerns about possible negative effects of such a trend on health achievements that Iran has experienced over the decades, especially in terms of rural and urban health.[47] Deployment of a family medicine program in rural areas (rural primary health care) has been one of the stark achievements of Iran's healthcare system in recent decades. This program has led to significant improvements in child and maternity health.[48] However, the progressive scale up of the family medicine program in urban setting (as part of an overall health system intervention called Health Sector Evolution Plan that began in 2014) and its specific focus on disadvantaged areas has raised the hopes to decrease the observed inequalities in under-five mortality in the coming years in Iran.[49] However, the assessment of such an effect will be only possible by the next DHS in Iran in 2020. We hope that our article's result can be a source of help and guidance in such an assessment.

Limitations

Although this study can be quite informative and useful in a couple of ways, there are some limitations that are worth mentioning. Iranian health authorities conduct a national health observatory survey every 10 years, so we will be lacking new information about under-five mortality until 2021 or 2022, when new national survey data become available. Nevertheless, our study can still be an informative torch to light the way for better policymaking for children's health in the near and even distant future.

Conclusion

The present study showed that Iran, nationally and provincially, has experienced some significant achievements in terms of reducing the under-five mortality rate over the past two decades, but still the disadvantaged are suffering from higher rates of under-five mortality, and inequalities are remarkable. Therefore, policymakers should give more focus to equity-oriented policies to achieve more equitable results in the future.

Author statements

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Ethical approval

This study received the required ethical approval from Tehran University of Medical Sciences Research Ethics Committee, Tehran, Iran, with ethical code No. 136890.

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Competing interests

Authors declare that they have no competing interests.

REFERENCES

1. You D, Hug L, Ejdemyr S, Idele P, Hogan D, Mathers C, et al. Global, regional, and national levels and trends in under-5 mortality between 1990 and 2015, with scenario-based projections to 2030: a systematic analysis by the UN Inter-agency Group for Child Mortality Estimation. *Lancet* 2015;**386**:2275–86.
2. UNICEF. *Under-five mortality*. 2017 [cited 2017]; Available from: https://data.unicef.org/topic/child-survival/under-five-mortality/.
3. WHO. *Under-five mortality*. 2017 [cited 2017]; Available from: http://www.who.int/gho/child_health/mortality/mortality_under_five_text/en/.
4. Bado AR, Susuman AS. Women's education and health inequalities in under-five mortality in selected sub-saharan African countries, 1990–2015. *PloS One* 2016;**11**, e0159186.
5. United-Nations-Children's-Fund. *Levels and trends in child mortality 2012: estimates developed by the UN inter-agency group for child morality estimationv. New York*. 2012.
6. Braveman P. Health disparities and health equity: concepts and measurement. *Annu Rev Public Health* 2006;**27**:167–94.
7. Braveman P, Gruskin S. Defining equity in health. *J Epidemiol Community Health* 2003;**57**:254–8.
8. Pathak PK, Singh A. Trends in malnutrition among children in India: growing inequalities across different economic groups. *Soc Sci Med* 2011;**73**:576–85.
9. Arcaya MCAA, Subramanian SV. Inequalities in health: definitions, concepts, and theories. *Global Health Action* 2015;**8**. https://doi.org/10.3402/gha.v8.27106.
10. Aristide Romaric B, Appunni SS. Decomposing wealth-based inequalities in under-five mortality in West Africa. *Iran J Public Health* 2015;**44**:920–30.
11. Houweling TA, Kunst AE. Socio-economic inequalities in childhood mortality in low-and middle-income countries: a review of the international evidence. *Br Med Bull* 2009;**93**:7–26.
12. Organization WH. *The world health report 2000: health systems: improving performance*. World Health Organization; 2000.
13. Braveman P, Gruskin S. Poverty, equity, human rights and health. *Bull World Health Organ* 2003;**81**:539–45.
14. Antai D. Regional inequalities in under-5 mortality in Nigeria: a population-based analysis of individual-and community-level determinants. *Popul Health Metrics* 2011;**9**:6.
15. Kavosi Z, Rashidian A, Pourreza A, Majdzadeh R, Pourmalek F, Hosseinpour AR, et al. Inequality in household catastrophic health care expenditure in a low-income society of Iran. *Health Pol Plann* 2012;**27**:613–23.
16. Hajizadeh M, Connelly LB. Equity of health care financing in Iran: the effect of extending health insurance to the uninsured. *Oxf Dev Stud* 2010;**38**:461–76.
17. Morasae EK, Forouzan AS, Asadi-Lari M, Majdzadeh R. Revealing mental health status in Iran's capital: putting equity and efficiency together. *Soc Sci Med* 2012;**75**:531–7.
18. Morasae EK, Forouzan AS, Majdzadeh R, Asadi-Lari M, Noorbala AA, Hosseinpoor AR. Understanding determinants of socioeconomic inequality in mental health in Iran's capital, Tehran: a concentration index decomposition approach. *Int J Equity Health* 2012;**11**:18.
19. Hosseinpoor 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**:837–44.
20. Hosseinpoor AR, Van Doorslaer E, Speybroeck N, Naghavi M, Mohammad K, Majdzadeh R, et al. Decomposing socioeconomic inequality in infant mortality in Iran. *Int J Epidemiol* 2006;**35**:1211–9.
21. Wagstaff A. Inequality aversion, health inequalities and health achievement. *J Health Econ* 2002;**21**:627–41.
22. O'Donnell O vDE, Wagstaff A, Lindelow M. *Analyzing health equity using household survey data*. Washington DC: The World Bank; 2008.
23. Paul P, Valtonen H. Health inequality in the Russian Federation: an examination of the changes in concentration and achievement indices from 1994 to 2013. *Int J Equity Health* 2016;**15**:36.
24. Mezmur M, Navaneetham K, Letamo G, Bariagaber H. Socioeconomic inequalities in the uptake of maternal healthcare services in Ethiopia. *BMC Health Serv Res* 2017;**17**:367.
25. Biswas T, Islam MS, Linton N, Rawal LB. Socio-economic inequality of chronic non-communicable diseases in Bangladesh. *PLoS One* 2016;**11**, e0167140.
26. Salvucci V. Determinants and trends of socioeconomic inequality in child malnutrition: the case of Mozambique, 1996–2011. *J Int Dev* 2016;**28**:857–75.
27. Mohammadi Y, Parsaeian M, Mehdipour P, Khosravi A, Larijani B, Sheidaei A. 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 Global Health* 2017;**5**:e537–44.
28. Education MoHaM. *Population and health in the Islamic Republic of Iran. Iran demographic and health survey report. Tehran*. 2000.
29. Rashidian AKA, Khabiri R, et al. *Islamic Republic of Iran's multiple indicator demograpphic and healh survey(IrMIDHS) 2010*. Ministry of Health and Medical Education; 2012.
30. Rashidian A, Karimi-Shahanjarini A, Khosravi A, Elahi E, Beheshtian M, Shakibazadeh E, et al. Iran's multiple indicator demographic and health survey - 2010: study protocol. *Int J Prev Med* 2014;**5**:632–42.
31. Rashidian AKA, Khabiri R, Khodayari-Moez E, Elahi E, Arab M, et al. *Islamic Republic of Iran's multiple indicator demograpphic and healh survey (IrMIDHS) 2010*. Tehran: Ministry of Health and Medical Education; 2012.
32. Kraft AD, Nguyen KH, Jimenez-Soto E, Hodge A. Stagnant neonatal mortality and persistent health inequality in middle-income countries: a case study of the Philippines. *PLoS One* 2013;**8**, e53696.
33. Anand SDF, Evans T, Shkolnikov VM, Wirth M. *Measuring disparities in health: methods and indicators. Challenging inequities in health: from ethics to action*. New York: Oxford University Press; 2001.

34. Vyas S, Kumaranayake L. Constructing socio-economic status indices: how to use principal components analysis. *Health Pol Plann* 2006;**21**:459–68.
35. Montgomery MR, Gragnolati M, Burke KA, Paredes E. Measuring living standards with proxy variables. *Demography* 2000;**37**:155–74.
36. Wagstaff A, Paci P, van Doorslaer E. On the measurement of inequalities in health. *Soc Sci Med* 1991;**33**:545–57.
37. Kakwani N, Wagstaff A, van Doorslaer E. Socioeconomic inequalities in health: measurement, computation, and statistical inference. *J Econom* 1997;**77**:87–103.
38. Ambel AA, Andrews C, Bakilana AM, Foster EM, Khan Q, Wang H. Examining changes in maternal and child health inequalities in Ethiopia. *Int J Equity Health* 2017;**16**:152.
39. Houweling TA, Caspar AE, Looman WN, Mackenbach JP. Determinants of under-5 mortality among the poor and the rich: a cross-national analysis of 43 developing countries. *Int J Epidemiol* 2005;**34**:1257–65.
40. Li Y, Zhang Y, Fang S, Liu S, Liu X, Li M, et al. Analysis of inequality in maternal and child health outcomes and mortality from 2000 to 2013 in China. *Int J Equity Health* 2017;**16**:66.
41. Moradi-Lakeh M, Bijari B, Namiranian N, Olyaeemanesh AR, Khosravi A. Geographical disparities in child mortality in the rural areas of Iran: 16-years trend. *J Epidemiol Community Health* 2013;**67**:346–9.
42. Van Malderen C, Van Oyen H, Speybroeck N. Contributing determinants of overall and wealth-related inequality in under-5 mortality in 13 African countries. *J Epidemiol Community Health* 2013;**67**:667–76.
43. Skaftun EK, Ali M, Norheim OF. Understanding inequalities in child health in Ethiopia: health achievements are improving in the period 2000-2011. *PLoS One* 2014;**9**, e106460.
44. Sadeghi H, Masaeli A, Basakha M, Kouhian M. The estimation of human development index for provinces. *Soc Welfare* 2010;**10**:129–53.
45. Sabermahani A, Barouni M, Seyedin H, Aryankhesal A. Provincial human development index, a guide for efficiency level analysis: the case of Iran. *Iran J Public Health* 2013;**42**:149–57.
46. Naghdi A, Khanian M, Rueentan M. *The urban dilemmas in Iran marginal urban area; A case study of Kermanshah city*. 2016.
47. Joulaei H, Bhuiyan AR, Sayadi M, Morady F, Afsar Kazerooni P. Slums' access to and coverage of primary health care services: a cross-sectional study in shiraz, a metropolis in southern Iran. *Iran J Med Sci* 2014;**39**:184–90.
48. Naderimagham S, Jamshidi H, Khajavi A, Pishgar F, Ardam A, Larijani B, et al. Impact of rural family physician program on child mortality rates in Iran: a time-series study. *Popul Health Metrics* 2017;**15**:21.
49. Moradi-Lakeh M. Health sector evolution plan in Iran. *Equity Sustain Concerns* 2015;**4**:637–40.