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Decomposing socioeconomic inequality in infant mortality in Iran

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Background Although measuring socioeconomic inequality in population health indicators like infant mortality is important, more interesting for policy purposes is to try to explain infant mortality inequality. The objective of this paper is to quantify for the first time the determinants' contributions of socioeconomic inequality in infant mortality in Iran.

Methods A nationally representative sample of 108 875 live births from October 1990 to September 1999 was selected. The data were taken from the Iranian Demographic and Health Survey (DHS) conducted in 2000. Households' socioeconomic status was measured using principal component analysis. The concentration index of infant mortality was used as our measure of socioeconomic inequality and decomposed into its determining factors.

Results The largest contributions to inequality in infant mortality were owing to household economic status (36.2%) and mother's education (20.9%). Residency in rural/urban areas (13.9%), birth interval (13.0%), and hygienic status of toilet (11.9%) also proved important contributors to the measured inequality.

Conclusions The findings indicate that socioeconomic inequality in infant mortality in Iran is determined not only by health system functions but also by factors beyond the scope of health authorities and care delivery system. This implies that in addition to reducing inequalities in wealth and education, investments in water and sanitation infrastructure and programmes (especially in rural areas) are necessary to realize improvements of inequality in infant mortality across society. These findings can be instrumental for the recent 5 year Economic, Social and Cultural Development Plan of Iran, which identified the reduction of inequalities in social determinants of health.

Keywords Socioeconomic inequality, decomposition, infant mortality, Iran

There seems to be broad agreement that many socioeconomic inequalities are unfair,[1] because they are the result of a division of labour in society that puts certain groups of people at a disadvantage, not only economically, socially, and politically but also in terms of their possibilities to be healthy.[2]

Evidence worldwide consistently shows that children belonging to households with a lower socioeconomic status have higher mortality rates.[3–9] Most of these deaths are from causes we know how to prevent and are, therefore, unnecessary and inequitable.[10] Measuring socioeconomic inequality, regular monitoring of inequities in child health, and use of the resulting information for education, advocacy, and increased accountability among the general public and decision makers is urgently needed. However, on their own these measures will not be sufficient to bring about sustainable change.[11] More effective for policy purposes is to unravel and quantify the contributions of infant mortality determinants to measured socioeconomic

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inequality in infant mortality. Such analysis would then indicate more specifically the type of policies and where resources should be directed to redress the root causes of inequality in infant mortality. Until now, few studies have been published on decomposing the concentration index of a health variable into its determining components. First, Wagstaff *et al.*[12] in 2003 proposed the decomposition method to analyse inequality in child malnutrition in Vietnam. In most of the subsequent literature, the health variables most often used are health care utilization[13,14] or self-assessed health in adults.[15–18]

From 1960 to 1995, Iran's human development index (HDI) values increased 0.452, moving the Islamic Republic of Iran from the group of countries considered to have low human development to join the ranks of those with medium human development.[19] In 2000, Iran's HDI had a value of ~0.72.[20] Improvement in Iranians' health status over the last 2 decades of the 20th century, has been one of the main reasons for the progress in human development in Iran. One of the most important factors leading to increased life expectancy in Iran, over the last decade of the 20th century was the decline in the mortality rate among infants from 63.5 per 1000 live births in 1988 to 30.7 per 1000 live births in 1997.[19] In spite of such a reduction in the average level of infant mortality, a recent study showed the existence of significant socioeconomic inequality in infant mortality in Iran.[21] The present study represents the first attempt to decompose socioeconomic inequality in infant mortality in Iran into its determinants.

Methods

Data and variable definitions

The data were taken from the Demographic and Health Survey (DHS) conducted in Iran in 2000. The sampling design was a stratified single stage (equal size) cluster sampling with unequal sampling probabilities.[22] The sample consists of 4000 households (2000 rural and 2000 urban) in each of Iran's 28 provinces, plus 2000 households in the capital city of Tehran[22], totalling more than 110 000 households overall. The number of all live births recorded from the interviews was over 300 000 and information on 108 875 live births during the period October 1990 to September 1999 (a 10 year period ending 1 year prior to the interview time, to avoid censoring effects) was analysed. The decision regarding selection of the observation period was based on a compromise that would provide recent estimates while ensuring sufficient births to reduce the effects of sampling error.[23]

A binary outcome variable was selected, namely whether or not each of the live born infants of the women interviewed was still alive or not in the 12 months following birth. Independent variables included: child sex, mother's age at the time of birth, the mother's history of stillbirth and abortion, risky birth interval ($<$24 months), index of household economic status, the mother's educational level, having a hygienic toilet in the house, location of residence (urban/rural), plus the specific province of residence.

Mother's age at the time of the child's birth was categorized into seven age groups ($<$15 years old; 15–19 years old; 20–24 years old; 25–29 years old; 30–34 years old; 35–39 years old, and $\geqslant$40 years old)

An index of economic status for each household was constructed using principal components analysis[24] based on data from 111 524 households. The following variables were used in principal components analysis: number of rooms per capita, having a car, having a motorcycle, having a bicycle, having a fridge, having a TV, having a telephone, and kind of heating device. From this the population economic status quintiles were calculated and used in the subsequent modelling. For the decomposition analysis, quintiles 1 and 2 and quintiles 3, 4, and 5 were grouped together, because of the similarity of the coefficients in the multivariate models. This produced a binary variable labelled 'low economic status', including households in the bottom 40% of economic status, which was used in the decomposition analysis.

Mother's education was considered as a categorical variable with the following four levels: illiterate, primary school, guidance/high school, university. For decomposition analysis, the categories primary school, guidance/high school, and university were grouped together—according to their coefficients in multivariate model—; so the mother's illiteracy—a binary variable—was used in decomposition analysis.

Residency in a rural area and province of residence were considered as geographically influencing variables and also as proxies for health care utilization.

Analysis

All analyses were performed in STATA software version 8.2.[25] The DHS stratification and the unequal sampling weights as well as household clustering effects were taken into account in the analysis. The concentration index was used as the measure of socioeconomic inequality in infant death[26.] It can be computed as twice the (weighted) covariance of the health variable and a person's relative rank in terms of economic status, divided by the variable mean according to Equation (1).[16,27] The value of the concentration index can vary between -1 and $+1$. Its negative values imply that a variable is concentrated among disadvantaged people while the opposite is true for its positive values. When there is no inequality, the concentration index will be zero.[26]

$$C = \frac{2}{\mu}\,\mathrm{cov}_w(y_i, R_i), \tag{1}$$

where y_i and R_i are, respectively, the health status of the ith individual and the fractional rank of the ith individual (for weighted data) in terms of *the index of household economic status*; μ is the (weighted) mean of the health of the sample and cov_w denotes the weighted covariance.

The method proposed by Wagstaff *et al.*[12] was used to decompose socioeconomic inequality in infant mortality into its determinants. A decomposition analysis allows one to estimate how determinants proportionally contribute to inequality (e.g. the gap between poor and rich) in a health variable. Wagstaff *et al.* showed that for any linear regression model linking the health variable of interest, y, to a set of k health determinants, x_k:

$$y_i = \alpha + \sum_k \beta_k x_{k_i} + \varepsilon_i, \tag{2}$$

where ε is an error term. Given the relationship between y_i and x_{ki} in Equation (2), the concentration index for y (C) can be written as:

$$C = \sum_k \left(\frac{\beta_k \bar{x}_k}{\mu}\right) C_k + \frac{GC_\varepsilon}{\mu} = C_{\hat{y}} + \frac{GC_\varepsilon}{\mu}, \quad (3)$$

where μ is the mean of y, $\bar{x}_k$ is the mean of x_k, C_k is the concentration index for x_k (defined analogously to C). In the last term (which can be computed as a residual), GC_ε is the generalized concentration index for ε_i.

Equation (3) shows that C can be thought of as being made up of two components. The first is the deterministic, or 'explained', component. This is equal to a weighted sum of the concentration indices of the regressors, where the weights are simply the elasticities [An elasticity is a unit-free measure of (partial) association, i.e. the % change in the dependent variable (health or infant mortality in this case) associated with a % change in the explanatory variable.] $(\beta_k \bar{x}_k/\mu)$ of y with respect to each x_k. The second is a residual, or 'unexplained', component. This reflects the inequality in health that cannot be explained by systematic variation in the x_k across socioeconomic groups.

To do a decomposition analysis, the following steps are required: (i) Regress the health variable against its determinants through an appropriate model. This results in finding the coefficients of the explanatory variables (β_k). (ii) Calculate the means of the health variable and each of its determinants (μ and $\bar{x}_k$). (iii) Calculate the concentration indices for the health variable and for the determinants (C and C_k) using Equation (1)—as well as the generalized concentration index of the error term (GC_ε). The concentration index of each determinant can be calculated using the Equation (1) where y_i and μ are now the value of that determinant for the ith individual and the determinant mean, respectively. At this stage, the values of all the variables included in Equation (3) are known. Finally, the pure contribution of each determinant included in the model to the inequality in the health variable can be quantified through the following steps: (iv) Calculate the *absolute* contribution of each determinant by multiplying the health variable elasticity with respect to that determinant and its concentration index $(\beta_k \bar{x}_k/\mu)C_k$ and (v) Calculate *percentage* contribution of each determinant simply through dividing its absolute contribution by the concentration index of the health variable $(\beta_k \bar{x}_k/\mu)C_k/C$.

In our analysis, infant mortality is measured as a binary variable taking the value of one or zero, depending on whether the infant survives or not in the 12 months following birth. Two standard models for binary variables are (i) the linear probability model (LPM) and (ii) the non-linear logit model. The LPM can yield estimates of the probability of infant death that are <0 or >1 and has heteroscedastic errors but has more easily interpretable results.

The *linktest* was used to choose between the LPM and the logit specifications.[28,29] All explanatory variables were included as categorical—dummy—variables. The linktest works as follows: after the initial fit of the LPM and the logit models, the predicted value and its square are generated for each model and entered as predictor variables into a new regression with the original dependent variable using the same specification (LPM, logit). If the model is correctly specified, the squared linear prediction should have no explanatory power.[28] The squared linear prediction term was insignificant using the logit, but still significant using the LPM, so a survey-specific logit model[25] was agreed as being preferable.

Since the logit model is intrinsically non-linear in the probability of death, but linear in the propensity to infant death (latent variable), i.e. the natural logarithm of the odds of infant death (rather than actual infant deaths), only the latter is appropriate to use for the linear decomposition method.

$$\text{Ln odds}_{\text{infant death}} = \alpha_i + \sum \beta_i x_i + \varepsilon_i \quad (4)$$

Moreover, since the inequality in *predicted* infant death will be described given the observed values of the X variable, attention is focused on the first term in the Decomposition equation, i.e. the predicted inequality as measured by $C\hat{y}$.

$$C_{\hat{y}} = \sum_k \left(\frac{\beta_k \bar{x}_k}{\mu}\right) C_k \quad (5)$$

Results

Table 1 shows the summary statistics of infant death and its determinants in Iran. It is important to note that the numbers in brackets are population-weighted percentages and, therefore, no surprise that, for example, the sampled live birth in the lowest wealth quintile is more than that in the highest wealth quintile, while its weighted percentage in the lowest wealth quintile of population is less than that in the highest wealth quintile of population. In addition, although the results show that the city of Tehran has the lowest sampled live births in comparison with correspondent values of the provinces, its weighted percentage is one of the highest.

The adjusted associations between infant mortality and its determinants in Iran are shown in Table 2. This provides the results of step (i). We can see that, as expected, the child being male, mother's delivery at either end of reproductive age, a history of mother's stillbirth/abortion, risky birth interval, and residency in a rural area all increase infant mortality risk, whereas being born into a family with higher socioeconomic status and having a mother with higher educational level show protective effects on infant mortality.

The means of the health variable ($\text{Ln odds}_{\text{infant death}}$) and of its determinants [the results of the step (ii)] and the concentration indices for the $\text{Ln odds}_{\text{infant death}}$ and for the determinants [the results of step (iii)] are shown in Table 3. The extent to which each of the explanatory variables is unequally distributed by economic status is reflected by their concentration index values. For example, mother's delivery at the two ends of reproductive age, mother's higher level of education and having a hygienic toilet in the house are all positively associated with economic status rank, i.e. concentrated among people of higher economic status, while the opposite is true, for example, for the mother's having a history of stillbirth and residence in a rural area.

The concentration index of the dependent variable based on logit model ($C\hat{y}$) shows the degree of inequality in the natural logarithm of the predicted odds of infant deaths. The $\text{Ln odds}_{\text{infant death}}$ has a negative mean, and the covariance between the $\text{Ln odds}_{\text{infant death}}$ and the economic status rank is also negative because the higher the economic status rank the lower the infant mortality. Therefore, the concentration index (0.0419) is positive, as it is made up by a division of these two entities [see Equation (1)]. That is why its interpretation is

Table 1 Summary statistics of the infant death and its determinants (Iran, 1990–1999)

Infant death	**3908 (3.33)**
Child sex	
Male	56126 (51.44)
Female	52749 (48.56)
Mother's age (at child birth)	
<15	692 (0.56)
15–19	16134 (14.78)
20–24	32549 (30.33)
25–29	27212 (25.58)
30–34	18897 (17.31)
35–39	10883 (9.48)
⩾40	2508 (2.05)
History of mother's stillbirth	7696 (6.50)
History of mother's abortion	22217 (21.46)
Risky birth interval	20002 (16.64)
Household economic status	
Quintile 1	25869 (19.01)
Quintile 2	22186 (17.33)
Quintile 3	23436 (22.30)
Quintile 4	19410 (20.32)
Quintile 5	17974 (21.03)
Mother's educational level	
Illiterate	44755 (35.24)
Primary school	38083 (33.23)
Guidance/high school	23355 (28.22)
University	2682 (3.31)
Having a hygienic toilet	46305 (49.95)
Location of residence	
Rural	60754 (44.70)
Urban	48121 (55.30)
Province of residence	
Markazi	3038 (1.95)
Gilan	2764 (3.35)
Mazandaran	2816 (3.80)
East Azerbaijan	3574 (5.46)
West Azerbaijan	4254 (4.58)
Kermanshah	2666 (1.77)
Khuzestan	5360 (7.56)
Fars	3447 (5.88)
Kerman	3705 (3.40)
Khorasan	3710 (11.13)
Isfahan	2905 (5.81)
Sistan and Baluchestan	5958 (4.07)
Kordestan	4191 (2.50)
Hamedan	3725 (3.00)
Chahar-Mahal and Bakhtiari	4249 (1.45)
Lorestan	4418 (2.91)
Ilam	4782 (0.91)
Kohgilooye and Boyer-Ahmad	5080 (1.14)
Bushehr	4441 (1.34)
Zanjan	3991 (1.66)
Semnan	2754 (0.74)
Yazd	2803 (1.15)
Hormozgan	4893 (2.29)
Tehran	3515 (6.25)
Ardebil	4198 (2.11)
Qom	3153 (1.33)
Ghazvin	3388 (1.57)
Golestan	4040 (2.60)
Tehran city	1057 (8.30)

Numbers outside and inside the brackets indicate sample counts and population-weighted percentages, respectively. (N = 108875).

slightly more complex than usual; i.e. this positive value means that Iranian infants belonging to households with lower economic status have a higher probability of mortality than those belonging to households with a higher economic status.

Table 3 also presents the results of decomposing the concentration index of the Ln odds $_{\text{infant death}}$ ($C\hat{y}$)—steps (iv) and (v). It combines the estimated logit coefficients with information on the means and concentration indices of the explanatory variables to compute the 'contributions' of each of the variables—or the sets of dummy variables—to the overall estimated socioeconomic inequality.

The different steps can be illustrated through using 'risky birth interval'. The results of steps i–iii, which are the risky birth interval coefficient, its mean, and its concentration index, are shown in columns 2–4, respectively. Step (iv) involves the calculation of the elasticity (−0.0378, not shown in the table) obtained by multiplying the risky birth interval mean (0.1664) and its coefficient (0.8028) and then dividing the result by the mean of Ln odds $_{\text{infant death}}$ (−3.534). The number in the 'Contribution to C' column (0.0054), is obtained by multiplying the elasticity (−0.0378) and the concentration index (−0.1426). The above-mentioned column shows the *absolute* contribution of each determinant like risky birth interval to the socioeconomic inequality in Ln odds $_{\text{infant death}}$. To quantify the corresponding *percentage* contribution of risky birth interval (13.04%), i.e. step (v), its absolute contribution (0.0054) is divided by the concentration index of the Ln odds $_{\text{infant death}}$ (0.0413).

This process was repeated for each of the other determinants. One could note that the concentration index of Ln odds $_{\text{infant death}}$ is additively decomposed, in a way that the sum of the column 'Contribution to C' equals the value of Ln odds $_{\text{infant death}}$, i.e. 0.0413. The last column of Table 3 shows the combined contribution for variables with several categories like mother's age and provinces.

Because the decomposition results based on both model specifications (LPM and logit) were very similar, we have only presented the ones based on the logit model in Table 3. The largest contributions to inequality in infant mortality were attributable to household economic status (36.2%) and mother's education (20.9%). Furthermore, residency in

Table 2 Adjusted associations between infant mortality and its determinants (Iran, 1990–1999)

	Coefficient	*P*-value	Adjusted odds ratio	95% confidence interval	
				Low	High
Child sex					
Male	0.15	0.001	1.16	1.06	1.27
Female			1		
Mother's age (at child birth)					
<15	1.19	<0.001	3.3	2.36	4.62
15–19	0.35	<0.001	1.43	1.23	1.65
20–24	0.07	0.28	1.08	0.94	1.23
25–29			1		
30–34	0.12	<0.139	1.12	0.96	1.31
35–39	0.39	<0.001	1.48	1.25	1.75
⩾40	0.55	<0.001	1.75	1.35	2.23
History of mother's stillbirth	0.56	<0.001	1.75	1.5	2.04
History of mother's abortion	0.13	0.027	1.14	1.02	1.28
Risky birth interval	0.8	<0.001	2.22	2.02	2.44
Household economic status					
Quintile 1			1		
Quintile 2	0.05	0.514	1.05	0.91	1.2
Quintile 3	−0.19	0.008	0.82	0.72	0.95
Quintile 4	−0.2	0.012	0.81	0.69	0.96
Quintile 5	−0.2	0.043	0.81	0.67	0.99
Mother's education					
Illiterate			1		
Primary school	−0.28	<0.001	0.75	0.67	0.85
Guidance/high school	−0.39	<0.001	0.68	0.56	0.81
University	−0.34	0.289	0.71	0.38	1.34
Having a hygienic toilet	−0.15	0.044	0.86	0.74	0.99
Location of residence					
Rural	0.16	0.005	1.17	1.05	1.31
Urban			1		
Province					
Markazi	0.04	0.878	1.04	0.61	1.78
Gilan	0.03	0.92	1.03	0.59	1.78
Mazandaran	−0.23	0.426	0.79	0.45	1.4
East Azerbaijan	0.31	0.245	1.37	0.8	2.34
West Azerbaijan	0.2	0.448	1.22	0.73	2.04
Kermanshah	0.25	0.365	1.27	0.75	2.17
Khuzestan	−0.16	0.549	0.85	0.51	1.44
Fars	−0.02	0.93	0.98	0.56	1.69
Kerman	−0.1	0.724	0.91	0.53	1.56
Khorasan	0.3	0.264	1.34	0.8	2.26
Isfahan	−0.05	0.858	0.95	0.54	1.67
Sistan and Baluchestan	0.25	0.352	1.28	0.76	2.15
Kordestan	0.27	0.309	1.3	0.78	2.18
Hamedan	0.02	0.928	1.02	0.61	1.73
Chahar-Mahal and Bakhtiari	0.01	0.973	1.01	0.6	1.7
Lorestan	−0.11	0.674	0.89	0.53	1.52

Table 2 continued

	Coefficient	*P*-value	Adjusted odds ratio	95% confidence interval	
				Low	High
Ilam	−0.08	0.783	0.93	0.54	1.58
Kohgilooye and Boyer-Ahmad	−0.19	0.487	0.83	0.49	1.4
Bushehr	−0.35	0.197	0.7	0.41	1.2
Zanjan	0.35	0.177	1.42	0.85	2.37
Semnan	0.38	0.161	1.46	0.86	2.48
Yazd	−0.01	0.985	0.99	0.57	1.73
Hormozgan	−0.05	0.845	0.95	0.56	1.6
Tehran	−0.01	0.966	0.99	0.58	1.68
Ardebil	0.28	0.283	1.32	0.79	2.21
Qom	0.09	0.749	1.09	0.63	1.9
Ghazvin	0.14	0.598	1.15	0.68	1.95
Golestan	0.36	0.177	1.43	0.85	2.4
Tehran city			1		

rural/urban areas (13.9%), birth interval (13.0%), and hygienic status of toilet (11.9%) show a considerable contribution to the measured inequality.

Discussion

To our knowledge, this is the first study on decomposing socioeconomic inequality in infant mortality into its determinants using the concentration index. This study on measuring socioeconomic inequality in child/infant mortality—like many others in different parts of the world—shows that children with a lower socioeconomic status are less likely to survive their first year of life. In the case of Iran, most determinants show a positive contribution to socioeconomic inequality in infant death. This means that the combined effect of the marginal effect of the explanatory variable on infant mortality and its distribution by economic status is to *raise* socioeconomic inequality in infant mortality such that infant mortality is greater among the poor. This effect may arise either because the particular determinant is more prevalent among people of lower economic status and is associated with a higher infant mortality risk or because the determinant in question is more prevalent among people of *higher* economic status and associated with a *lower* infant mortality risk. From the contributions expressed as percentages of overall socioeconomic inequality it is clear that most of the inequality is due to household economic status and mother's education. For instance, 36% of economic-status-related inequality in infant mortality is explained by economic status itself, and not by the other determinants *included in the regression model* and differentially distributed by economic status. Residency in rural/urban areas, birth interval, and the hygienic status of toilet take the next places of positive contribution. Mother's illiteracy, risky birth interval, and residency in rural areas are more prevalent among the low economic status ranks and associated with an increase in infant mortality risk. In contrast, having a hygienic toilet is more prevalent among those of higher economic status and is associated with a decrease in infant mortality risk.

Province of residence, history of mother's abortion, and gender have a *trivial* negative contribution to socioeconomic inequality in infant mortality. A negative contribution means that the combined effect of the marginal effect of the explanatory variable on infant mortality and its distribution by economic status is to *lower* socioeconomic inequality in infant mortality favouring the poor. History of mother's abortion and male gender both are somewhat more concentrated among the highest economic status ranks and associated with the increase in infant mortality risk. For province this might mean that—after controlling for other determinants of infant mortality—on average, the provinces with higher infant mortality risk are the ones with the lowest economic status (or vice versa).

We used regions (provinces) and urban/rural areas to control for, among other things, regional disparities in health services availability.[30] The Iranian DHS contains information on 'skilled birth attendants' and 'birth delivery location', but only for the last 2 years prior to survey, which is why those variables could not be included in our analysis, which encompasses a 10 year period. This problem also exists in other DHS surveys.

Some considerations on decomposition analysis

In simple terms, decomposition analysis links the concentration indices of the determinants of a health variable with the concentration index of that health variable via a regression model of the determinants. The following remarks should be taken into account when interpreting the results: Obviously, its strength is that it allows to establish which factors contribute to greater inequality and how, i.e. through the more unequal distribution of the determinant or through the greater effect on mortality. In other words, this method enables us to quantify the pure contribution of each determinant of a health variable—controlled for the other determinants—to socioeconomic inequality in that health variable. For instance, the contribution of the economic status variable itself (36%) represents the 'true effect', so that it is 'purged' of the confounding effects of the other variables examined. However, as the concentration index of a health variable can only be decomposed into the concentration indices of its determinants additively,[12] the usefulness of the method is limited to linear models not, for example, quadratic models. This is, of course, its

Table 3 Decomposition analysis of concentration index of infant mortality by economic status (Iran, 1990–1999)

	Coefficient	Mean	C	Contribution to C	Contribution to C (%)
Child sex (Male)	0.1506	0.5144	0.0031	−0.0001	−0.2
Mother's age					
<15	1.1978	0.0056	−0.2694	0.0005	
15–19	0.3496	0.1478	−0.0710	0.0010	
20–24	0.0713	0.3033	−0.0110	0.0001	
30–34	0.1205	0.1731	0.0524	−0.0003	
35–39	0.3971	0.0938	−0.0224	0.0002	
⩾40	0.5582	0.0205	−0.1266	0.0004	4.7
History of mother's stillbirth	0.5643	0.0650	−0.1001	0.0010	2.5
History of mother's abortion	0.1313	0.2146	0.0396	−0.0003	−0.8
Risky birth interval	0.8028	0.1664	−0.1426	0.0054	13.0
Low economic status	0.2287	0.3634	−0.6366	0.0150	36.2
Mother's illiteracy	0.3088	0.3524	−0.2803	0.0086	20.9
Having a hygienic toilet	−0.1700	0.2916	0.3503	0.0049	11.9
Residence in rural areas	0.1706	0.4470	−0.2663	0.0057	13.9
Province					
Markazi	0.0683	0.0195	0.1188	0.0000	
Gilan	0.0409	0.0335	0.0733	0.0000	
Mazandaran	−0.2124	0.0380	0.2695	0.0006	
East Azerbaijan	0.3453	0.0546	0.1087	−0.0006	
West Azerbaijan	0.2282	0.0458	0.0624	−0.0002	
Kermanshah	0.2719	0.0177	−0.2544	0.0003	
Khuzestan	−0.1357	0.0756	−0.3019	−0.0009	
Fars	−0.0026	0.0588	−0.2049	0.0000	
Kerman	−0.0730	0.0340	−0.1662	−0.0001	
Khorasan	0.3274	0.1113	0.0624	−0.0006	
Isfahan	−0.0274	0.0581	0.3555	0.0002	
Sistan and Baluchestan	0.2659	0.0407	−0.5569	0.0017	
Kordestan	0.2967	0.0250	−0.0751	0.0002	
Hamedan	0.0529	0.0300	−0.0077	0.0000	
Chahar-Mahal and Bakhtiari	0.0363	0.0145	0.0406	0.0000	
Lorestan	−0.0916	0.0291	−0.2522	−0.0002	
Ilam	−0.0475	0.0091	−0.4260	−0.0001	
Kohgilooye and Boyer-Ahmad	−0.1659	0.0114	−0.2741	−0.0001	
Bushehr	−0.3228	0.0134	−0.3393	−0.0004	
Zanjan	0.3775	0.0166	−0.0441	0.0001	
Semnan	0.4030	0.0074	0.2933	−0.0002	
Yazd	0.0293	0.0115	0.2952	0.0000	
Hormozgan	−0.0206	0.0229	−0.3417	0.0000	
Tehran	0.0089	0.0625	0.0082	0.0000	
Ardebil	0.3132	0.0211	−0.0431	0.0001	
Qom	0.1255	0.0133	0.2232	−0.0001	
Ghazvin	0.1668	0.0157	0.1553	−0.0001	
Golestan	0.3865	0.0260	0.0907	−0.0003	−2.3
Ln of odds of the infant death		−3.5341	0.0413	**0.0413 (total sum)**	

weakness strictly speaking. The grouping of the economic quintiles in our study was done in order to simplify the interpretation of the decomposition and allowed because of the similarity of regression coefficients between the quintiles 1 and 2 and also among the quintiles 3, 4, and 5 based on statistical grounds so that the decomposition results were not different from those using quintiles. Therefore, any other categorization could not be done as it may lead to different results. Of course the decomposition relies on the appropriate specification of the underlying model and any misspecification may affect the decomposition results. In our case, the results were fairly robust to the use of either an LPM or a logit model. Obviously, if important determinants of infant mortality (e.g. parity) that may also be patterned by economic status are not included, their effects could partly be attributed to the economic status. Finally, some caution is required in attributing a causal interpretation to the results of the analysis, because our estimates are derived from cross-section observational data and issues of causality might be better explored with longitudinal or experimental data.

Our study indicates that, in spite of the potential important role of the health system in reducing socioeconomic inequality in infant mortality, such inequality might also be related to factors beyond the scope of health authorities and the health care delivery system. The Human Development Report of the Islamic Republic of Iran has argued that the most important national socioeconomic policy goals are the development of an effective social security system and the acceleration of economic growth focused on expanding employment opportunity.[19] The unemployment rate, which had fallen significantly from 14.2 to 9.1% during 1986–96,[19] jumped back to 14.6% by 2001.[31] The national ratio of unemployed to employed people is high with 395 dependants for every 100 employed people.[20] This type of ratio has a profound effect on economic growth, standard of living, and the degree of economic equality and should be a priority target for reduction in future policy action. Other strategies for reducing economic inequality and raising the relative income of the poorest sections of the population would include (i) the development of relatively poor rural areas, (ii) spreading development to the poorest provinces, (iii) targeting subsidies on consumption, (iv) income and public service fees for those least able to pay, (v) identifying and tackling the demographic and socioeconomic characteristics of especially poor and vulnerable groups, and (vi) designing taxation and pricing policies to help redistribute income from rich to poor.[20] 'Poverty Reduction and Targeted Subsidies Plan' and 'Social Safety Net National Program' ratified by the Council of Ministers in 2005 are two examples of the Government's plans to reach the poor. From an educational equity point of view, Tehran and Sistan and Baluchestan had the highest and lowest adult literacy rate, respectively, with a 36.6% gap between them in 1996, and there were considerable disparities among provinces between these extremes.[19] Although the adult literacy rate for women rose from 46.3 to 67.0% from 1988 to 1997, a lower proportion of Iranian women than men were literate.[19] However, this situation has been changing in recent years. In 1999, primary education enrolment (ages 6–11) showed near equality: 92% of girls were enrolled compared with 93.4% of boys.[20] Recent increases in enrolment, a decrease in dropouts, and advancements in literacy have significantly advanced national goals towards universal literacy and universal primary education. A number of human development indicators are higher in urban areas than rural areas in Iran, as in many parts of the world.[20] Recently, the Health Services Utilization survey showed that people living in urban and main rural areas sought outpatient health care at a statistically significantly higher rate than those living in satellite and mobile rural areas.[32] Travel distance to care providers as one of the mentioned reasons for failure to seek care was much higher in satellite and mobile rural areas than in urban and main rural areas. This indicates that further expansion of rural health care facilities would answer a direct health need.[20] Taking another example, the DHS demonstrated that there was a much higher proportion of hygienic toilets in urban areas than in rural areas.[22] This could mean investments in water, sanitation, and housing infrastructure and programmes could directly influence the reduction of inequality of child mortality, particularly in rural areas. In addition to essential infrastructure investments, provision of appropriate support, which increases levels of health literacy, e.g. appropriate birth interval, is also required.

In conclusion, a universal approach linking the Ministry of Health and Medical Education with other ministries may speed up the reduction of inequalities in social determinants of infant mortality and, therefore, further advance equity in infant mortality.

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