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Understanding determinants of unequal distribution of stillbirth in Tehran, Iran

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Abstract

Objective: To determine the economic inequality in history of stillbirth and understanding determinants of unequal distribution of stillbirth for the first time in Tehran, Iran.

Methods: A population-based cross-sectional study was conducted on 5170 pregnancies in Tehran, the capital of Iran since 2015. Principal component analysis was applied to measure the asset-based economic status. Concentration index was used to measure socioeconomic inequality in stillbirth, and then decomposed into its determinants.

Results: The Concentration index and its 95% confidence interval for stillbirth was -0.121 (-0.2351361 to -0.001628). Decomposition of the concentration index showed that economic status had the largest contribution (31%) to socioeconomic inequality in stillbirth. Mother education (30%), father occupation (25%) and mother occupation (23%) had the next high positive contribution to measured inequality in stillbirth history, respectively.

Conclusions: Stillbirth is unequally distributed among the Iranian women and is mostly concentrated among low economic status people. Although, economic status have most positive contribution and explained about one-third inequality in stillbirth history but remained inequality can be eliminated by managing the other studied determinants such as mother and father education, employment and etc.

Keywords: Stillbirth**,** Socioeconomic inequality, Concentration index, Decomposition, Tehran

Strengths and limitations of this study

- The present study measured economic status using more accurate (asset-based) method compared to other studies which used household income method. This method has fewer limitations compared to income method in developing countries [1, 2].
- Instead of using linear regression to decompose inequality in a non-linear setting, the present study applied a more proper method to perform its objective.
- Due to the cross-sectional design of the present study, causal interpretations of the findings should be done with caution and longitudinal studies are needed to evaluate the temporality of the presented associations.
- Also, it should be considered in interpreting the findings, a self-administered questionnaire was applied in this study and some information biases may be induced.

Introduction

A stillbirth is the death of a baby during or before delivery. Stillbirth is advance classified as either early (between 20 and 27 completed weeks of pregnancy), late (between 28 and 36 completed pregnancy weeks), or term (between 37 or more completed pregnancy weeks) [3]. Also, stillbirth is defined as fetal loss in the 3rd trimester (≥28 completed weeks of gestational age or ≥1000 g birth weight) [4].

Even with increasing concentration for maternal neonatal health, stillbirths remain as one of the mail health issue in worldwide. As a minimum 2.65 million stillbirths (range 2.08 million to 3.79 million) were estimated worldwide in 2008. The most cases (98%) of stillbirths occur in low and middle income countries. The lowest numbers were reported from Finland with (2 cases per 1000 total births) and the highest numbers were reported in Nigeria and Pakistan with more than 40 per 1000 total births [4]. Based on the report of World Health Organization, for every 1000 total births, 18.4 babies were stillborn, mostly in low income countries and middle income countries, worldwide in 2015 [5].

Numerous factors are related with stillbirth including maternal infections, non-communicable diseases, nutrition, lifestyle related factors, and maternal age. Fourteen percent of stillbirths contribute to prolonged pregnancies [6]. Behind of these factors, some studies showed economic status is considered as one of the main cause of prenatal outcomes especially stillbirth [7-10] and rate of stillbirth was more concentrated in low economic area.

The rates of preterm birth and stillbirth diverge in countries and by socio-demographic variables [11]. The highest stillbirth rate, neonatal mortality rate and intrapartum-related

mortality rates occurs in area with low socio economic status due to accessing care in rural area, emergency obstetric care, immediate postnatal and prenatal care, gaps in healthcare coverage during the prenatal, intrapartum, and postnatal periods skilled birth attendance [12, 13]. Disparities in these rates are obvious. Even in areas with high income, there are inequalities in stillbirth rates, for instance in the United Kingdom, black women are two times as likely to have a stillbirth as are white women [4, 14].

The cause of a large proportion of stillbirths is unknown and some studies are needed to determine the cause of unexplained stillbirth [15]. Therefore, this is the first study in Iran aimed to determine the economic inequality in history of stillbirth and understanding determinants of unequal distribution of stillbirth in Tehran, Iran.

Methods

This was a population based cross-sectional study, which was a part of large survey on twin and multiple pregnancies in Tehran, the capital of Iran. Data collected were related to 5170 deliveries between July 6 to 21 2015 in 103 hospitals. The data were gathered from medical centers which has obstetrics and gynaecology wards. All women regardless of the type of delivery (natural or caesarean section) and the pregnancy outcome (live birth, stillbirth, and spontaneous abortion) were included in the study.

Validity indices of questionnaire including face, relevancy, clarity, and comprehensiveness, and also inter-rater agreement (IRA) were reported above the acceptable level of 80%. The questionnaire was completed by 103 educated midwives as interviewers. If participants did not aware from variables studied, their medical records would be observed, or conducted interviews with obstetricians and nurses. The outcomes of interest were history of still birth, and economic status was considered an independent variable. Economic status of participants was measured based on “asset base method”, in which the pregnant women were asked about having some asset including vacuum cleaner, handicraft carpet, laptop, freezer, dish washing machines, private cars, touch mobile, three-dimensional TV, side by side refrigerator, a microwave, the number of rooms, and area of residence.

This study was approved by the Ethical Committee of Royan Institute. At the start of study, aims of the study were obviously presented for all participants. Eligible individuals were also assured regarding their confidentiality and anonymity, and they could withdraw at any phase of the study.

Methodology

Independent variables (determinants) that were entered into the study were as follows: mother and father's age, nationality (Iranian and non-Iranian), education, occupation, and household's economic status. Age was categorized into two groups of over and under 35 years old. There were three categories for education, i.e. under-diploma, diploma (end of high school), and academic levels. Father's occupation included following categories: professional, managerial and technical, skilled non-manual, skilled manual, partly-skilled, and unskilled occupations.

To measure economic status of households, Principal Component Analysis (PCA) method was used. PCA, basically, is a standard factor analysis method leading to reduction of a slew of variables into one variable, here economic status variable indicating the economic position of households in the sample in present study. Asset variables used in our study for PCA were as follows: number of rooms per person, area per capita, possession of automobile, carpet, microwave, dishwasher, TV, Freezer, refrigerator, vacuum cleaner, laptop, PC, washing machine, and cell phone.

Inequality in distribution of stillbirth history was measured by use of concentration index (C) [16-18]. C is constructed and defined through a Concentration Curve (CC). This curve depicts the distribution of a health variable (Y axis) against an economic variable (X axis). Economic variable is cumulatively ranked starting from the poorest person/household. This way the curve shows across what economic groups the health variable is mostly concentrated. If health variable is equally distributed across the economic groups, the curve will be a 45 degree line named "equality line". Otherwise, the curve will lie above or below the equality

line indicating existence of inequality in distribution of health variable. C equals the area between equality line and depicted CC. In case of complete equality, CC and equality line coincide and C equals zero. If CC lies above (below) the equality line, it denotes that health variable is mostly concentrated among people of lower (higher) economic status and C will take a negative (positive) value [17]. Value of C ranges from -1 to +1.

After depiction of CC and measurement of C, now one can go further and decompose C to reveal what variables contribute to the measured value of Inequality [18]. To do this, following Wagstaff et al. [18], one can assume that there is a regression model linking health variable of interest y to a set of k determinants (X_k):

$$\gamma i = \propto + \sum_k \beta_k x_{ki} + \varepsilon_i \quad (1)$$

Where i means i_{th} individual, b_k denotes the coefficients and ε_i is an error term. Given the relationship between y_i and X_{ki} in Equation (2), the C for y can be written as:

$$(2) C = \sum_k \left(\frac{\beta_k \bar{x}_k}{\mu} C_k + \frac{GC_\varepsilon}{\mu}\right) = C\gamma + \frac{GC_\varepsilon}{\mu}$$

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 exactly like C) and in the last term GC (residual) is the generalized C for ε_i.

Equation (2) is made up of two components: (1) a deterministic or explained component and (2) an unexplained component. The first component consists of two constituents: elasticity and a C of k regressors. The second component, the unexplained portion, is the part of the inequality that cannot be explained by systematic variation in the contributors (determinants) across economic groups. To

decompose, the values of the all of the included variables in Equation (2) should be computed. First, the coefficients (β_k) of the explanatory variables are calculated. To do this, we need to conduct a regression analysis using an appropriate regression model. In present study, taking binary nature of dependent variables (stillbirth history), logistic regression was used to calculate the coefficient of explanatory variables. In the second step, the means of health variable (μ) and each determinant ($\overline{x}_k$) are calculated. Now that all the variables in Equation (2) are calculated, one can reveal the contribution of each determinant to inequality by multiplying the elasticity of each determinant by its concentration index $(\frac{\beta k\, \bar{x}k}{\mu})C_k$. This is the absolute contribution of each determinant to the measured inequality. Taking the absolute contribution, one can note that the contribution to inequality is the result of two factors: (1) a marginal effect of each determinant to the health variable and (2) the distribution of the determinant based on economic status. In the last step, to calculate the percentage contribution, the absolute contribution of each determinant is divided by the C of the health variable $(\frac{\beta k\, \bar{x}k}{\mu})C_k$/C. The contribution of an X variable to the measured health inequality can be either positive or negative. Positive contribution means that the variable would add to the inequality in health variable and vice versa.

Results

Table 1 illustrates demographic features of subjects studied. As the table shows most of subjects, male or female, were under 35 years old, Iranian, and with diploma level education. In terms of occupation, majority of women were employed, and around 50% of men belonged to “partly-skilled” or “skilled non-manual” occupations. In terms of stillbirth history, around 2% of subjects had such a history.

Figure 1 depicts stillbirth history concentration curve. As the figure shows, the curve is above the equality line and indicates that still birth is more concentrated among lower economic status people in Tehran. This shows that there is inequality in distribution of stillbirth in Tehran and the inequality disfavours the poor. Size of the inequality that equals history of stillbirth concentration index equals -0.121 (95% Confidence Interval= -0.2351361 to -0.001628).

Table 2 shows the logistic regression analysis results for stillbirth history and its determinants. As the table shows, there is a significant relationship between lower economic status and odds of stillbirth history. However, there is no such a significant relationship between other variables and stillbirth history.

Interestingly, there was no significant inequality in distribution of pre-eclampsia -0.008 (95% Confidence Interval -0.078 to 0.060), abortion 0.021 (95% Confidence Interval -0.010 to 0.052), weight at birth (kg) for the last child -0.001 (95% Confidence Interval -0.004 to 0.0009), and stillbirth in the last pregnancy 0.103 (95% Confidence Interval -0.055 to 0.264) in Tehran.

There is one important point that should be noted here, that is as coefficients of occupations group were so close to each other, they were re-categorized into three groups of: professional (including professional, managerial, technical), skilled (including skilled non-manual and skilled manual), and unskilled (including partly-skilled and unskilled) occupations.

Table 3 illustrates the results for decomposition of inequality in stillbirth. As it can be seen from table, economic status (31%), mother education (30%), father occupation (25%), and mother occupation (23%) had the highest positive contribution to measured inequality in stillbirth history, respectively. Interestingly enough, being older than 35 years old, in both parents, and belonging to non-Iranian had negative contribution to inequality, i.e. they reduced from inequality size in stillbirth in Tehran.

Discussion

To the best of our knowledge, several studies have been conducted on the prevalence and risk factors affecting stillbirth, but few studies were done regarding socio-economic factors influencing the stillbirth rate. Among these few studies, even in developed countries, there was no research to investigate impact of socio-economic inequality quantitatively in stillbirth. In the present study, for the first time, we have attempted to explain the socioeconomic inequality in stillbirth in Iran's capital, Tehran, by adopting a CI decomposition approach. This approach can help us to find main causes of socioeconomic inequalities in stillbirth in our societies, which will be vital for policy makers in the prevention of this important phenomenon.

The stillbirth CI (of Ln odds $_{stillbirth}$) in our study revealed that stillbirth is unequally distributed among study subjects. In fact, the negative value of this CI indicates that stillbirth is disproportionately concentrated among people of lower socioeconomic status. This finding has been approved by some other studies in developed and developing countries[19, 20]. This pro-poor inequality not only exists within countries but also this pattern could be extrapolated to between countries; such that a global study found that 98% of all stillbirths occur in low-income and middle-income countries; 77% in south Asia and sub-Saharan Africa.

Moreover, decomposition of stillbirth inequality showed that all of the independent variables (except mother nationality, mother age and father age) have positive contributions to socioeconomic inequality in stillbirth. A positive contribution implies that the combined effect of the marginal effect of the desired determinant and its distribution based on economic status increases socioeconomic inequality in stillbirth. This can occur because

either the desired determinant is more prevalent among people of lower economic status (negative C_k) and is associated with a higher risk of stillbirth, or because the determinant is more prevalent among those of higher economic status (positive C_k) and is associated with a lower risk of stillbirth. Also, in this study, economic status accounted for most of the existing socio-economic inequality in the stillbirth among Tehran's women. Indeed, economic status alone is responsible for 31.18% of the socio-economic inequality in stillbirth history. The next determinants with relatively large positive contributions to socioeconomic inequality in stillbirth are mother education (30 %), father occupation (25%), mother occupation (23%) and father education (12%). Mother nationality, father age and mother age also show sight negative contribution to inequality.

The decomposition method helps to quantify the contributions of determinants to socioeconomic inequality in health-related problems [21, 22]. Although, analysis of studied determinants in this study show that 31.18 % of socio-economic inequality can be explained by economic status, but 68.82% of that can be eliminated by managing the other studied determinants such as mother and father education, employment and etc. Hence, decomposition is an important way to monitor and understand the determinants of inequality [21, 22].

When comparing the findings of the present study with other ones, we should consider the differences in the way of calculating economic status. Asset-based, consumption expenditure and income are the most popular measures for assessing the economic status. The asset-based method provides a rapid and simple method for collecting economic status data. The little interview time and questionnaire space is needed for this method. Whilst the essential principles of analysis with PCA are complicated, their application is easy in many

statistical packages. According to some evidence the asset index is a more lasting measure of economic status than consumption expenditure, changing less in response to variations in income and expenditure and being resistant to most economic shocks [23]. This may be particularly important in low and middle-income countries, which may have greater fluctuations in consumption patterns than high-income countries. On the other hand, asset index data is more available in many studies which make the comparative research more easy all over the world. However, as the asset index is a measure of relative economic status, the poorest category of one country could not be compared with corresponding category in other country [2].

It is obvious that no previous studies have tried to address the issue of stillbirth inequality in a manner similar to the present study. Our present study found that stillbirth is more concentrated among lower socio-economic status people in Tehran which is confirmed by some other studies. A systematic analysis on the national, regional, and worldwide estimates of stillbirth rates in 2015 shows that 98% of all stillbirths occur in low-income and middle-income countries; 77% in south Asia and sub-Saharan Africa [20]. Also, a review on the high-income countries found that, a woman living under adverse socioeconomic circumstances has twice the risk of having a stillborn child when compared to her more advantaged counterparts [24]. Also, another study on the trends in socioeconomic inequalities in risk of sudden infant death syndrome, other causes of infant mortality, and stillbirth in Scotland showed that there is significant negative association between the economic status and risk of stillbirths [25]. These findings is also confirmed by another study among Swedish primiparous women showed that low SES increases the risk of stillbirth [26].

In the present study, decomposing socio-economic inequality shows that although economic status per se is accounted for 31.18% of inequality in stillbirth history but the remained inequality is explained by some determinants including mother/father education and occupation which are modifiable to some extent. Mother education had the 2nd high positive contribution to measured inequality, such that Under-diploma and diploma educated mother are more intended to experience stillbirths compared to those have academic educations. A study by Savard et al. in 2013 has been reported that absolute educational inequality in stillbirth persisted and relative inequality increased over the past three decades, despite an overall decrease in stillbirth rates. The decrease in absolute inequality for placental abruption was countered by an increase for unspecified causes [27]. These finding is also confirmed by global and semi-global studies, too [14, 20, 24].

The present study was also showed that maternal age older than 35 years is protective factor for stillbirth and has negative contribution to explained inequality in stillbirth history. Contrary to our findings a systematic review on Maternal age and risk of stillbirth showed that Women with advanced maternal age have an increased risk of stillbirth. However, the magnitude and mechanisms of the increased risk are not clear, and prospective studies are warranted [28]. Other study on Iranian women showed that the odds of stillbirth is lower in women older than 38 years and higher in women aged 20-33 years old compared to those aged 34-37 years old; which shows that the odds of stillbirth is not increased linearly and interpretation of the findings should be cautious [29]. The current study was also showed that paternal age older than 35 years is protective factor for stillbirth and has negative contribution to explained inequality in stillbirth history. A multisite population-based case-control study conducted on American women found that the odds of stillbirth is higher among those that paternal age ≥35 years and <20 years compared to the subjects with

paternal age between 20-34 years old; which implies again the odds of stillbirth is not increased linearly and interpretation of the findings should be cautious [30]. As a relatively new finding, stillbirth among Iranian is more prevalent than Non-Iranian women. The reason for this issue is should be studied in future studies.

Conclusion

In conclusion, we can state that stillbirth is unequally distributed among the Iranian women and is mostly concentrated among low economic status people. Economic status have most positive contribution and explained about one-third inequality in stillbirth history.

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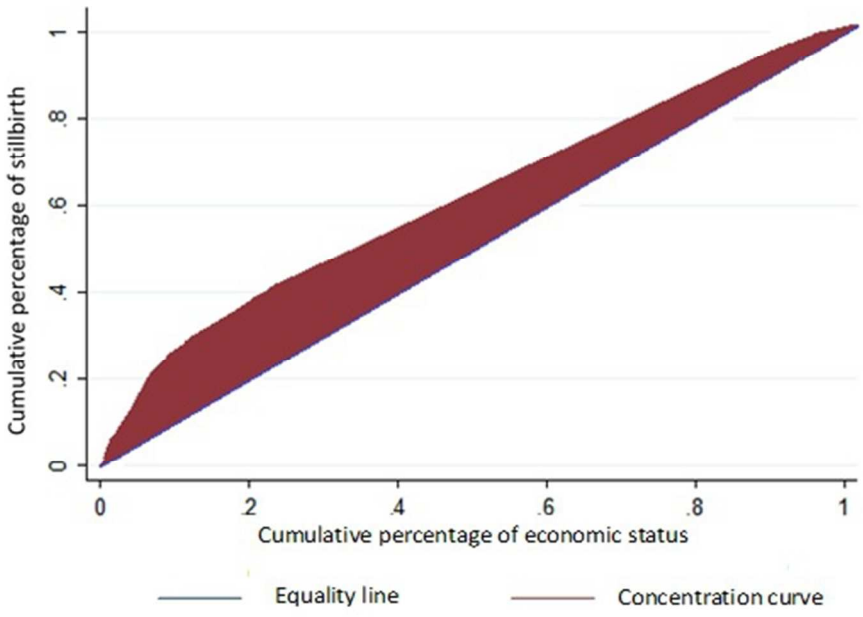

Figure 1. Concentration curve of stillbirth history in Tehran in 2014

156x110mm (96 x 96 DPI)

Table1. Demographic features of subjects participated in study in Tehran in 2014

Variable		Frequency	Percent (%)
Mother age	≥ 35	4501	87.06
	< 35	669	12.94
Father age	≥ 35	3377	65.32
	< 35	1793	34.68
Mother nationality	Iranian	4794	92.98
	Non-Iranian	362	7.02
Father nationality	Iranian	4773	92.91
	Non-Iranian	364	7.09
Mother education	Under-diploma	1416	27.52
	Diploma	2062	40.08
	Academic	1667	32.4
Father education	Under-diploma	1689	32.87
	Diploma	1825	35.52
	Academic	1624	31.61
Father occupation	Professional occupations	88	1.72
	Managerial and technical occupations	236	4.61
	Skilled non-manual occupations	1344	26.26
	Skilled manual occupations	865	16.9
	Partly-skilled occupations	1600	31.26
	Unskilled occupations	985	19.25
Mother occupation	Employed	4509	87.5
	Non-employed	644	12.5
Economic status	Quintile 1	1009	20.01
	Quintile 2	1011	20.05
	Quintile 3	1006	19.95
	Quintile 4	1008	19.99
	Quintile 5	1008	19.99
Stillbirth history	Yes	96	2
	No	5071	98
Pre-eclampsia history	Yes	252	4.88
	No	4914	95.12
Abortion history	Yes	1035	20.03
	No	4133	79.97
Stillbirth in the last pregnancy	Yes	53	1.04
	No	5024	98.96
Weight at birth for the last child (kg)	Mean (S.D)	4872	3188.6 (SD= 503.2)

Table 2. Logistic regression analysis results for stillbirth history and its regressors in Tehran

Variables		Coefficient	P-value	Adjusted odds ratio	95% confidence interval	
					Low	High
Mother age	≥ 35	-	-		-	-
	< 35	0.551	0.056	1.736	-0.013	1.116
Father age	≥ 35	-	-		-	-
	< 35	0.358	0.138	1.431	-0.115	0.833
Mother nationality	Iranian	-	-		-	-
	Non-Iranian	-0.604	0.788	0.546	-5.004	3.795
Father nationality	Iranian	-	-		-	-
	Non-Iranian	0.089	0.968	1.093	4.3	-4.478
Mother education	Under-diploma	0.467	0.246	1.596	-0.323	1.258
	Diploma	0.1	0.763	1.105	-0.552	0.753
	Academic	-	-	-	-	-
Father education	Under-diploma	0.178	0.652	1.195	-0.596	0.952
	Diploma	0.158	0.631	1.171	-0.487	0.803
	Academic	-	-	-	-	-
Father occupation	Professional	-	-	-	-	-
	Skilled	-0.119	0.652	0.887	-0.637	0.398
	Unskilled	-0.294	0.298	0.744	-0.85	0.263
Mother occupation	Employed	0.686	0.119	1.985	-0.176	1.548
	Non-employed	-	-	-	-	-
Economic status	Quintile 1	0.021	0.007	1.021	0.006	0.088
	Quintile 2	0.108	0.014	0.329	-1.99	-0.226
	Quintile 3	-0.532	0.166	0.587	1.285	-0.22
	Quintile 4	-0.585	0.118	0.556	-1.319	0.148
	Quintile 5	-	-	-	-	-

Table 3. Decomposition of inequalities in stillbirth history in Tehran 2014

Variable	Mean	Coefficient	Elasticity	C_k	Absolut contribution	Percent contribution
Poorest	0.199	0.021	-0.001	-0.800	0.001	
Poor	0.200	0.108	-0.005	-0.399	0.002	
Middle	0.200	-0.532	0.027	0.007	0.000	
Rich	0.201	-0.585	0.030	0.400	0.012	
Sum						**31.18**
Mother age > 35	0.124	0.551	-0.017	0.113	-0.002	**-4.03**
Father age > 35	0.341	0.358	-0.031	0.087	-0.003	**-5.54**
Mother nationality (non-Iranian)	0.070	-0.604	0.011	-0.675	-0.007	**-14.89**
Father nationality (non-Iranian)	0.070	0.089	-0.002	-0.662	0.001	**2.15**
Mother education (under-diploma)	0.272	0.467	-0.032	-0.448	0.014	
Mother education (diploma)	0.402	0.100	-0.010	-0.033	0.000	
Sum						**30.39**
Father education (under-diploma)	0.328	0.178	-0.015	-0.419	0.006	
Father education (diploma)	0.354	0.158	-0.014	0.011	0.000	
Sum						**12.44**
Father occupation (skilled)	0.431	-0.294	0.023	0.382	0.011	
Father occupation (unskilled)	0.505	-0.119	0.013	0.027	0.001	
Sum						**25.12**
Mother occupation (unemployed)	0.874	0.686	-0.151	-0.074	0.011	**23.16**
Ln of stillbirth	-3.966				0.048	100

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Understanding Determinants of Unequal Distribution of Stillbirth in Tehran, Iran

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Abstract

Objective: The present inquiry set to determine the economic inequality in history of stillbirth and understanding determinants of unequal distribution of stillbirth in Tehran, Iran. **Methods:** A population-based cross-sectional study was conducted on 5170 pregnancies in Tehran, Iran since 2015. Principal component analysis was applied to measure the asset-based economic status. Concentration index was used to measure socioeconomic inequality in stillbirth and then decomposed into its determinants. **Results:** The concentration index and its 95% confidence interval for stillbirth was -0.121 (-0.2351361 to -0.001628). Decomposition of the concentration index showed that mother education (50%), mother occupation (30%), economic status (26%), and father age (12%) had the highest positive contributions to measured inequality in stillbirth history in Tehran. Mother age (17%) had the highest negative contribution to inequality. **Conclusions:** Stillbirth is unequally distributed among Iranian women and is mostly concentrated among low economic status people. Mother-related factors had the highest positive and negative contributions to inequality, highlighting specific interventions for mothers to redress inequality.

Keywords: *stillbirth**,** socioeconomic inequality, concentration index, decomposition, tehran*

Strengths and limitations of the study

- The present study measured economic status using more accurate (asset-based) method compared to other studies which use household income method. This method has fewer limitations compared to income method in developing countries [1, 2].
- Instead of using linear regression to decompose inequality in a non-linear setting, the present study applied a more proper method to perform its objective.
- Due to the cross-sectional design of the study, causal interpretations of the findings were done with caution, and longitudinal studies were needed to evaluate the temporality of the presented associations.
- In addition, a self-administered questionnaire was applied, and some information biases were induced.
- The current socioeconomic status was used as proxy of socioeconomic status in the near past (during the stillbirth) which could be changed partially.

- **Introduction**

A stillbirth is defined as a baby born with no signs of life at or after 28 weeks' gestation [3]. Stillbirth is classified as either early (between 20 and 27 completed weeks of pregnancy), late (between 28 and 36 completed pregnancy weeks), or term (between 37 or more completed pregnancy weeks)[4]. Also, stillbirth is defined as fatal loss in the 3rd trimester (≥28 completed weeks of gestational age or ≥1000 g birth weight)[5].

Even with increasing concentration for maternal neonatal health, stillbirths remain as one of the main health issues worldwide. As a minimum, 2.65 million stillbirths (ranging 2.08 million to 3.79 million) were estimated worldwide in 2008. Most cases of stillbirths (98%) occur in low and middle income countries. The lowest numbers were reported from Finland (2 cases per 1000 total births), and the highest numbers were reported in Nigeria and Pakistan (more than 40 cases per 1000 total births) [5]. Based on the report of World Health Organization, for every 1000 total births, 18.4 babies were stillborn, mostly in low income countries and middle income countries worldwide in 2015 [6].

Numerous factors are related with stillbirth including maternal infections, non-communicable diseases, nutrition, lifestyle related factors, and maternal age. Fourteen percent of stillbirths contribute to prolonged pregnancies[7]. Some studies show that economic status is one of the main causes of prenatal outcomes especially stillbirth[8-11], and the rate of stillbirth was more concentrated in low economic area.

The rates of preterm birth and stillbirth diverge in countries and by socio-demographic variables [12]. The highest stillbirth rate, neonatal mortality rate, and intrapartum-related mortality rates occur in areas with low socio economic status due to accessing care in rural areas, emergency obstetric care, immediate postnatal and prenatal care, gaps in healthcare coverage during the prenatal, intrapartum, and postnatal periods skilled birth attendance [13, 14].

Disparities in these rates are obvious. Even in areas with high income, there are inequalities in stillbirth rates; for instance in the United Kingdom, black women are two times more prone to have a stillbirth as white women [5, 15].

Iran is a developing country located in Asia. Based on the 2010 report, 96.42% of deliveries were done in presence of skilled health workers, and maternity care coverage during pregnancy was reported 96.92%.

The cause of a large proportion of stillbirths is unknown, and some studies are needed to determine the cause of unexplained stillbirth [16]. Therefore, the present study aimed to determine the economic inequality in history of stillbirth and understanding determinants of unequal distribution of stillbirth in Tehran, Iran.

Methods

Although the methodology of this study was described elsewhere[17], here, more detailed information is reported on inequality analysis. A population based cross-sectional study was conducted, which was a part of large survey on twin and multiple pregnancies in Tehran Province, Iran. Data collected were related to 5170 deliveries between July 6 to July 21 2015 in 103 government, private, and military hospitals to ensure women with broad range of socioeconomic status. The data were gathered from medical centres with obstetrics and gynaecology wards. All women regardless of the type of delivery (natural or caesarean section) and pregnancy outcome (live birth, stillbirth, and spontaneous abortion) were included in the study. Also, the unstable women filled out the questionnaire after two or three days. The sampling procedure was carried out for two weeks.

Validity indices of questionnaire including face validity, relevancy, clarity, comprehensiveness, and inter-rater agreement (IRA) were reported above the acceptable level of 80%. One hundred and three educated midwives as interviewers completed the questionnaire. If participants had not been aware of variables studied, their medical records would have been observed, or would have conducted interviews with obstetricians and nurses. The outcomes of interest were history of stillbirth, and economic status was considered an independent variable. Economic status of participants was measured based on "asset base method", in which the pregnant women were asked about their assets including vacuum cleaner, handicraft carpet, laptop, freezer, dish washing machines, private cars, touch mobile, three-dimensional TV, side by side refrigerator, microwaves, number of rooms, and area of residence.

This study was approved in 2015 by the Ethical Committee of Royan Institute, Tehran, Iran (Ethical code: 91000357). At the beginning of the study, the study aims were clearly

presented for all participants. Confidentiality and anonymity of eligible individuals were assured; they could withdraw at any phase of the study. Verbal informed consent was obtained from all subjects before the study.

Methodology

Independent variables (determinants) of the study were as follows: mothers and father's age, nationality (Iranian and non-Iranian), education, occupation, and household economic status. Age was categorized into two groups: over and under 35 years old. There were three categories for education: under-diploma, diploma (end of high school), and academic degrees. Fathers' occupation included the following categories: professional, managerial, and technical, skilled non-manual, skilled manual, partly-skilled, and unskilled occupations. Unequal distribution of history of stillbirth was considered as a main outcome. Stillbirth was defined as a baby born with no signs of life at or after 28 weeks' gestation [1].

To measure the economic status of households, Principal Component Analysis (PCA) method was used. PCA, basically, is a standard factor analysis method leading to reduction of a slew of (asset) variables into one variable (i.e. economic status variable indicating the economic position of households). Asset variables used in the study for PCA were as follows: the number of rooms per person, area per capita, possession of automobile, carpet, microwave, dishwasher, TV, freezer, refrigerator, vacuum cleaner, laptop, PC, washing machine, and cell phone. Categorical variables should change to binary variables (have or not-have) before running a PCA. Numeric variables, however, do undergo no change (i.e. area per capita and the number of rooms per person). PCA result is a number of components on which asset variables are loaded. However, only the first component represents the economic status of the households as it can explain a remarkable part of variance (32% in our study) in economic status. In fact, economic status is the first component of PCA that is able to distinguish

between people in terms of their economic status. The asset variables that are loaded on the first component and give such a distinguishing ability to it were as follows: refrigerator, dishwasher, laptop, and microwave. An economic score was, finally, determined for each household by PCA. Then, the households were economically ranked, and economic quintiles were constructed to be used in the subsequent modeling [18].

Concentration curve and index were used to measure and decompose socioeconomic inequality in stillbirth history[19-21]. The two key variables constructing the concentration curve were the stillbirth history, its distribution, economic status variable, against which the distribution is assessed. Concentration curve plots the cumulative percentage of the stillbirth history (y-axis) against the cumulative percentage of the sample ranked by economic status, starting from the poorest (x-axis). If everyone, irrespective of his or her economic status, has exactly the same history of stillbirth, the concentration curve will be a 45-degree line, running from the bottom left-hand corner to the top right-hand corner. This is known as the line of equality. If, in contrast, stillbirth history takes higher values among poorer people, the concentration curve will lie above the line of equality and vice versa. Concentration index reports the distance between the concentration curve and the line of equality. Concentration index ranges from −1 to +1, with negative values indicating that the concentration curve lies above the line of equality and vice versa.

Wagstaff et al. (2003) demonstrated that a concentration index can be decomposed into contributions of different explanatory factors to inequality[19-21]. In fact, for any linear (regression) model of health, such as

$$yi = \propto + \sum_k \beta_k x_{ki} + \varepsilon_i \quad (1)$$

the concentration index (C) for y (stillbirth history) can be written as:

$$C = \sum_k \left(\frac{\beta_k \bar{x}_k}{\mu} C_k\right) + \frac{GC_\varepsilon}{\mu} = C_\gamma + \frac{GC_\varepsilon}{\mu} \quad (2)$$

where μ is the mean of y; $\bar{x}_k$ is the mean of factors; C_k is the concentration index for factors, and GC_ε is the generalized concentration index for the error term (ε).

However, as the health variable is a dichotomous variable in the present study and it has no linear probability distribution but only when it changes to natural logarithm (Ln), μ in the formula (2) will change to Ln of μ.

There are two parts in formula (2): GC_ε or residual component that reflects the part of inequality in stillbirth history that cannot be explained by systematic variation in the factors. Explained component (C_γ) that shows the contributions of explanatory factors to inequality. Each contribution is the product of sensitivity or relationship (elasticity) of stillbirth history with factor ($\frac{\beta_k \bar{x}_k}{\mu}$) and the degree of economic inequality in factor (C_k).

Results

Table 1 illustrates the demographic features of subjects studied. As the table shows, most of subjects, male or female, were under 35 years of age, Iranian, and had a diploma degree. In terms of occupation, 87.5% of women were housewives, and 50.51% of men belonged to "unskilled" and "partly-skilled" occupations. In terms of stillbirth history, 2% of subjects had such a history.

Table1. Demographic features of subjects participated in study in Tehran in 2014

Variable		Frequency	Percent (%)
Mother age	15-25	1344	26.25
	26-35	3457	61.66
	>36	619	12.09
Father age	15-25	332	6.52
	26-35	3045	59.83
	>36	1712	33.64
Mother nationality	Iranian	4794	92.98
	Non-Iranian	362	7.02
Father nationality	Iranian	4773	92.91
	Non-Iranian	364	7.09
Mother education	Under-diploma	1416	27.52
	Diploma	2062	40.08
	Academic	1667	32.4
Father education	Under-diploma	1689	32.87
	Diploma	1825	35.52
	Academic	1624	31.61
Father occupation	Professional occupations	88	1.72
	Managerial and technical occupations	236	4.61
	Skilled non-manual occupations	1344	26.26
	Skilled manual occupations	865	16.9
	Partly-skilled occupations	1600	31.26
	Unskilled occupations	985	19.25
Mother occupation	Housewife	4509	87.5
	Employed	644	12.5
Economic status	Most deprived	1009	20.01
	Quintile 2	1011	20.05
	Quintile 3	1006	19.95
	Quintile 4	1008	19.99

	Least deprived	1008	19.99
Stillbirth history	Yes	96	2
	No	5071	98
Pre-eclampsia history	Yes	252	4.88
	No	4914	95.12
Abortion history	Yes	1035	20.03
	No	4133	79.97
Stillbirth in the last pregnancy	Yes	53	1.04
	No	5024	98.96
Weight at birth for the last child (kg)	Mean (S.D)	4872	3188.6 (SD= 503.2)

Figure 1 depicts stillbirth history concentration curve; the curve is above the equality line and indicates that stillbirth is more concentrated among lower economic status people in Tehran. This shows that there is inequality in distribution of stillbirth in Tehran, and the inequality disfavours the poor. Size of the inequality that equals history of stillbirth concentration index equals -0.121 (95% Confidence Interval= -0.235 to -0.001).

Table 2 shows the logistic regression analysis results for stillbirth history and its determinants. As the table shows, there is a significant relationship between lower economic status, mother age (15-25), and odds of stillbirth history. However, there is no such a significant relationship between other variables and stillbirth history.

Table 2. Logistic regression analysis results for stillbirth history* and its regressors in Tehran

Variables		Coefficient	P-value	Adjusted odds ratio	95% confidence interval	
					Low	High
Mother age	15-25	-0.9	0.001	.221	0.09	.545
	26-35	-0.512	0.053	.599	.342	1.049
	>36 (reference)					
Father age	15-25	0.116	0.355	1.64	.574	4.701
	26-35	-0.099	0.427	.819	.501	1.33
	>36 (reference)					
Mother nationality	Iranian (reference)	-	-		-	-
	Non-Iranian	-0.315	0.883	.729	.011	2.417
Father nationality	Iranian (reference)	-	-		-	-
	Non-Iranian	-0.066	0.975	.936	.0143	2.99
	Under-diploma	0.589	0.149	1.8	.81	4.006

Mother education	Diploma	0.159	0.632	1.17	.61	2.25
	Academic (reference)	-	-	-	-	-
Father education	Under-diploma	0.071	0.880	1.07	.424	2.71
	Diploma	0.058	0.894	1.05	.451	2.48
	Academic (reference)	-	-	-	-	-
Father occupation	Professional (reference)	-	-	-	-	-
	Skilled	-0.066	0.863	.935	.44	1.98
	Unskilled	-0.018	0.954	.982	.539	1.79
Mother occupation	Housewife	0.685	0.113	2.004	.848	4.73
	Employed (reference)	-	-	-	-	-
Economic status	Most deprived	0.083	0.03	1.08	.509	2.31
	Quintile 2	-0.25	0.021	.358	.149	.858
	Quintile 3	-0.462	0.224	.629	.299	1.32
	Quintile 4	-0.564	0.130	.569	.274	1.18
	Least deprived (reference)	-	-	-	-	-

* It is worth noting that in the present paper we only measured and decomposed inequality in the "history of stillbirth" and not in the "stillbirth in the last (current) pregnancy". In fact, there was no inequality in the stillbirth in the current pregnancy (C=0.103, 95% CI= -0.055 – 0.264).

Interestingly, there was no significant inequality in distribution of pre-eclampsia -0.008 (95% Confidence Interval -0.078 to 0.060), abortion 0.021 (95% Confidence Interval -0.010 to 0.052), weight at birth (kg) for the last child -0.001 (95% Confidence Interval -0.004 to 0.0009), and stillbirth in the last pregnancy 0.103 (95% Confidence Interval -0.055 to 0.264) in Tehran.

Since coefficients of occupation groups were so close to each other, they were re-categorized into three occupation groups: professional (professional, managerial, and technical), skilled (skilled non-manual and skilled manual), and unskilled (partly-skilled and unskilled).

Table 3 illustrates the results for decomposition of inequality in stillbirth. Mother education (50%), mother occupation (30%), economic status (26%), and father age (12%) had the highest positive contribution to measured inequality in stillbirth history, respectively. Interestingly, mother age (17%), belonging to non-Iranian nationalities, had negative contribution to inequality, i.e. they decreased from inequality size in stillbirth in Tehran.

Table 3. Decomposition of inequalities in stillbirth history in Tehran 2014

Variable	Mean	Coefficient	Elasticity	C_k	Absolut contribution	Percent contribution
Most Deprived	0.199	0.083	-0.004	-0.800	0.003	
Quintile 2	0.200	-0.25	-0.013	-0.399	-0.005	
Quintile 3	0.200	-0.462	0.023	0.007	0.000	
Quintile 4	0.201	-0.564	0.029	0.4	0.011	
Sum						**26.6**
Mother age 15-25	0.263	-0.9	0.06	-0.171	-0.01	
Mother age 26-35	0.617	-0.512	0.08	0.048	0.004	
Sum						**-17.1**
Father age 15-25	0.652	0.116	-0.019	-0.264	0.005	
Father age 26-35	0.598	-0.099	0.015	-0.024	000	
Sum						**12.6**
Mother nationality (non-Iranian)	0.07	-0.315	0.006	-0.675	-0.004	**-10.1**
Father nationality (non-Iranian)	0.07	-0.066	0.001	-0.662	-0.001	**-2.1**
Mother education (under-diploma)	0.272	0.589	-0.04	-0.448	0.018	
Mother education (diploma)	0.402	0.159	-0.016	-0.033	0.001	
Sum						**50.1**
Father education (under-diploma)	0.328	0.071	-0.006	-0.419	0.002	
Father education (diploma)	0.354	0.058	-0.005	0.011	0.000	
Sum						**6.5**
Father occupation (skilled)	0.431	-0.066	0.007	0.191	0.001	
Father occupation (unskilled)	0.505	-0.018	0.002	-0.133	0.000	
Sum						**2.9**
Mother occupation (housewife)	0.874	0.685	-0.153	-0.074	0.011	**30.5**
Ln mean of stillbirth	**-3.966**			**0.037**		**100**

Discussion

To the best of our knowledge, several studies have been conducted on the prevalence and risk factors affecting stillbirth, but few studies were done regarding socio-economic factors influencing the stillbirth rate. Among these studies, even in developed countries, there are few researches on the impact of socio-economic inequality on stillbirth [22, 23]. In the present study, for the first time, the socioeconomic inequality in stillbirth in Iran's capital, Tehran, was explained via adopting a CI decomposition approach. This approach can help us to find the main causes of socioeconomic inequalities in stillbirth, which will be vital for policy makers in its prevention.

The stillbirth CI (of Ln odds $_{stillbirth}$) revealed that stillbirth is unequally distributed among study subjects. In fact, the negative value of CI indicates that stillbirth is disproportionately concentrated among people of lower socioeconomic status. This finding has been approved by some other studies in developed and developing countries[24, 25]. This pro-poor inequality not only exists within countries but also this pattern could be extrapolated between countries; a global study found that 98% of all stillbirths occur in low-income and middle-income countries, 77% in south Asia and sub-Saharan Africa.

Moreover, decomposition of stillbirth inequality showed that all independent variables (except mother nationality, mother age, and father age) have positive contributions to socioeconomic inequality in stillbirth. A positive contribution implies that the combined effect of the marginal effect of the desired determinant and its distribution based on economic status increase socioeconomic inequality in stillbirth. This can occur because either the desired determinant is more prevalent among people of lower economic status (negative C_k) and is associated with a higher risk of stillbirth or because the determinant is more prevalent among those of higher economic status (positive C_k) and is associated with a lower risk of

stillbirth. Also, mother education accounted for most of the socio-economic inequality in stillbirth among Tehran's women. Indeed, mother education alone is responsible for 50% of the socio-economic inequality in stillbirth history. The other determinants with relatively large positive contributions to socioeconomic inequality in stillbirth are mother occupation (30 %), economic status (26%), and father age (12%). Interestingly enough, mother age (17%), belonging to non-Iranian nationalities, had negative contribution to inequality, i.e. they decreased from inequality size in stillbirth in Tehran.

The decomposition method helps to quantify the contributions of determinants to socioeconomic inequality in health-related problems [26, 27]. Although, analysis of studied determinants in this study showed that 26 % of socio-economic inequality can be explained by economic status, but 74% can be eliminated by managing other determinants such as mother and father education, employment, etc. Hence, decomposition is an important way to monitor and understand the determinants of inequality [26, 27].

When comparing the findings with other findings, the differences in calculation of economic status should be considered. Asset-based, consumption expenditure, and income are the most popular measures for assessing the economic status. The asset-based method provides a rapid and simple method for collecting economic status data. Short interview time and questionnaire space are needed for this method. Whilst the essential principles of analysis with PCA are complicated, their application is easy in many statistical packages. According to some evidence, the asset index is a more lasting measure of economic status than consumption expenditure, changing less in response to variations in income and expenditure and being resistant to most economic shocks [28]. This may be particularly important in low and middle-income countries which may have greater fluctuations in consumption patterns than high-income countries. On the other hand, asset index data is more available in many studies that make the comparative research easier all over the world. However, as the asset

index is a measure of relative economic status, the poorest category of one country could not be compared with corresponding category in other country [2].

It is obvious that no previous studies have tried to address the issue of stillbirth inequality in a manner similar to the present study. The present study found that stillbirth is more concentrated among lower socio-economic status people in Tehran which is confirmed by some other studies. A systematic analysis on the national, regional, and worldwide estimates of stillbirth rates in 2015 shows that 98% of all stillbirths occur in low-income and middle-income countries; 77% in south Asia and sub-Saharan Africa [25]. Also, a review on the high-income countries found that a woman living under adverse socioeconomic circumstances has twice the risk of having a stillborn child when compared to her more advantaged counterparts [29]. Also, another study on the trends in socioeconomic inequalities concerning the risk of sudden infant death syndrome, other causes of infant mortality and stillbirth in Scotland showed a significant negative association between the economic status and risk of stillbirths [30]. These findings are also confirmed by another study on Swedish primiparous women, showing that low SES increases the risk of stillbirth [23].

In the present study, decomposing socio-economic inequality shows that although mother education per se is accounted for 50% of inequality in stillbirth history, but the remaining inequality is explained by some determinants including mother occupation and father age which are modifiable to some extent. Mother education had the first high positive contribution to measured inequality such that under-diploma and diploma educated mother were more likely to experience stillbirths compared to those having academic educations. A study by Savard et al. in 2013 reported that absolute educational inequality in stillbirth persisted, and relative inequality increased over the past three decades, despite an overall decrease in stillbirth rates. The decrease in absolute inequality for placental abruption was

countered by an increase for unspecified causes [31]. These finding are also confirmed by global and semi-global studies [15, 25, 29].

The present study also showed that maternal age older than 35 years is a protective factor for stillbirth and has negative contribution to the so-called inequality in stillbirth history. Contrary to the findings, a systematic review on maternal age and risk of stillbirth showed that women with advanced maternal age have an increased risk of stillbirth. However, the magnitude and mechanisms of the increased risk are not clear, and prospective studies are warranted [32]. Another study on Iranian women showed that the odds of stillbirth was lower in women older than 38 years and higher in women aged 20-33 years old compared to those aged 34-37 years old, which shows that the odds of stillbirth does not increase linearly, and interpretation of the findings should be cautious [33]. The current study also showed that paternal age older than 35 years is a protective factor for stillbirth and has negative contribution to the explained inequality in stillbirth history. As one of the limitations, the current socioeconomic status was measured as since it was believed that socioeconomic status could not be changed dramatically in the near past during stillbirth. A multisite population-based case-control study conducted on American women found the odds of stillbirth higher among those with paternal age ≥35 years and <20 years compared to the subjects with paternal age between 20-34 years old, implying that the odds of stillbirth does not increase linearly, and interpretation of the findings should be cautious [34]. As a relatively new finding, stillbirth among Iranian is more prevalent compared with non-Iranian women, the reason for which should be studied in future studies.

Conclusion

In conclusion, stillbirth is unequally distributed among Iranian women and is mostly concentrated among low economic status people. Mother-related factors had the highest positive and negative contributions to inequality. This matter calls for specific interventions for mothers to redress inequality. In other words, the mother-related factors are more modifiable than economic status to decrease socioeconomic inequality in stillbirth, and focusing on these factors would be more beneficial.

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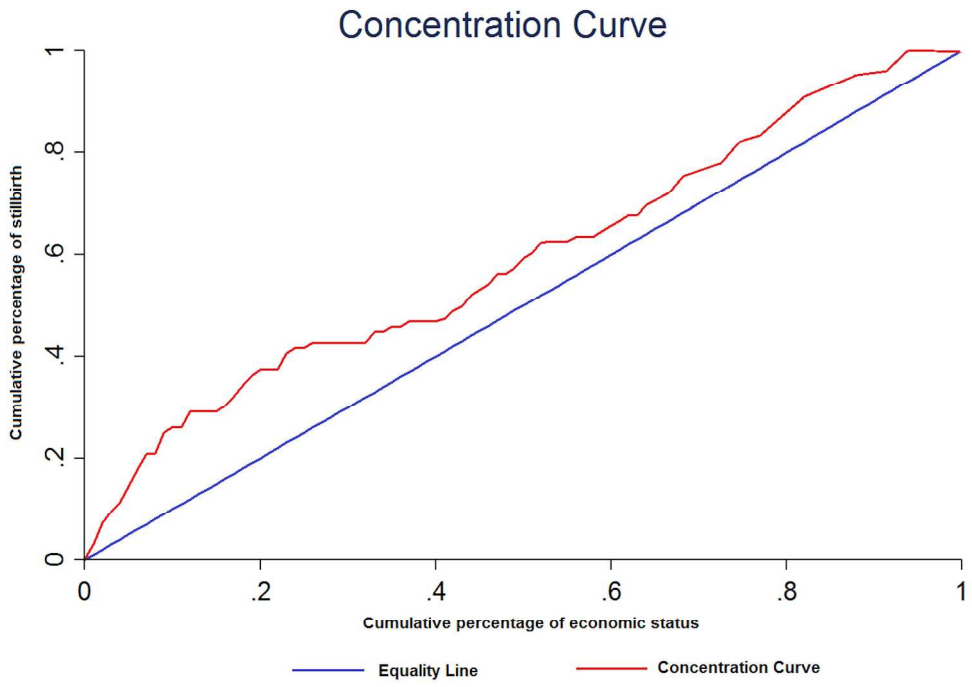

Figure 1. Concentration curve of stillbirth history in Tehran in 2014

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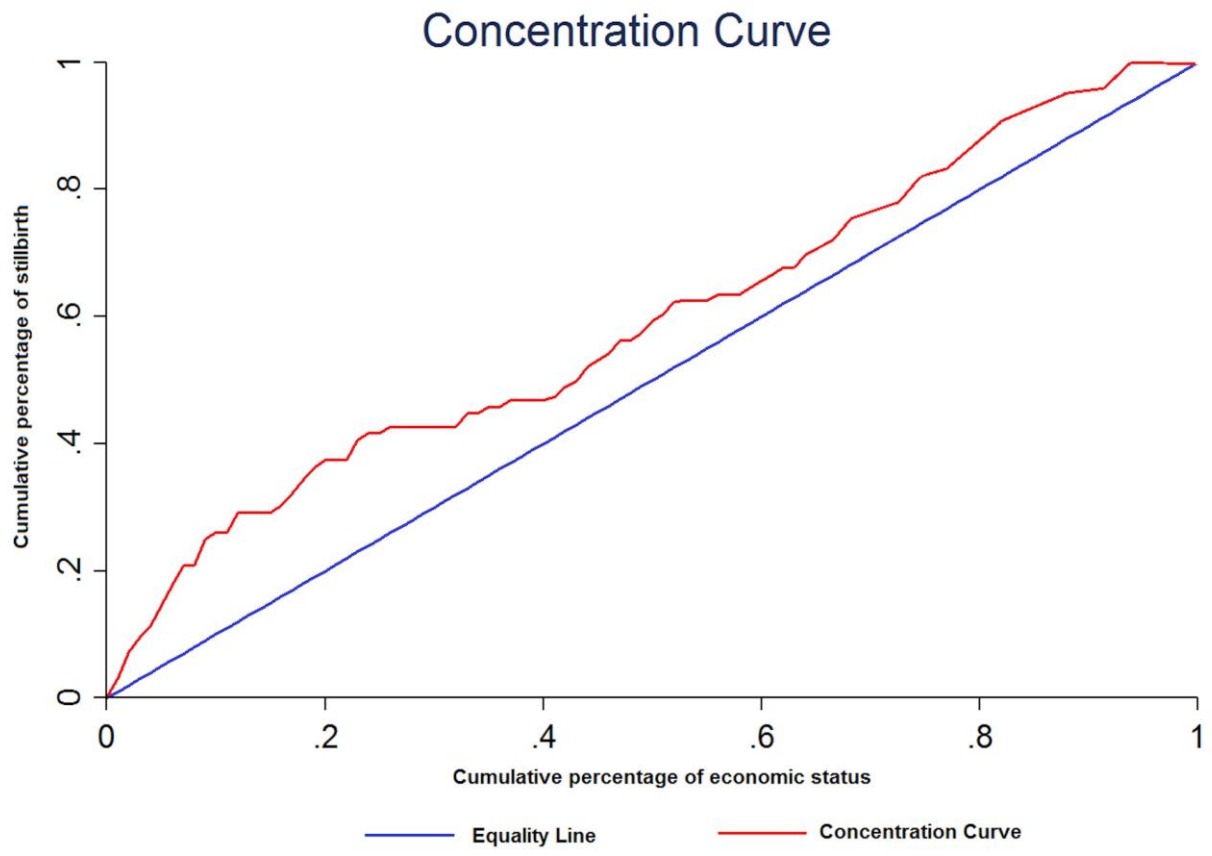

Figure 1. Concentration curve of stillbirth history in Tehran in 2014

* Concentration index is the area between equality line and concentration curve which in the present study equaled: -0.121

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Understanding Determinants of Unequal Distribution of Stillbirth in Tehran, Iran: a Concentration Index Decomposition Approach

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Understanding Determinants of Unequal Distribution of Stillbirth in Tehran, Iran: a Concentration Index Decomposition Approach

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Abstract

Objective: The present inquiry set to determine the economic inequality in history of stillbirth and understanding determinants of unequal distribution of stillbirth in Tehran, Iran. **Methods:** A population-based cross-sectional study was conducted on 5170 pregnancies in Tehran, Iran since 2015. Principal component analysis was applied to measure the asset-based economic status. Concentration index was used to measure socioeconomic inequality in stillbirth and then decomposed into its determinants. **Results:** The concentration index and its 95% confidence interval for stillbirth was -0.121 (-0.235 to -0.002). Decomposition of the concentration index showed that mother education (50%), mother occupation (30%), economic status (26%), and father age (12%) had the highest positive contributions to measured inequality in stillbirth history in Tehran. Mother age (17%) had the highest negative contribution to inequality. **Conclusions:** Stillbirth is unequally distributed among Iranian women and is mostly concentrated among low economic status people. Mother-related factors had the highest positive and negative contributions to inequality, highlighting specific interventions for mothers to redress inequality.

Keywords: *stillbirth, socioeconomic inequality, concentration index, decomposition, Tehran*

Strengths and limitations of the study

- The present study measured economic status using more accurate (asset-based) method compared to other studies which use household income method. This method has fewer limitations compared to income method in developing countries [1, 2].
- Instead of using linear regression to decompose inequality in a non-linear setting, the present study applied a more proper method to perform its objective.
- Due to the cross-sectional design of the study, causal interpretations of the findings were done with caution, and longitudinal studies were needed to evaluate the temporality of the presented associations.
- In addition, a self-administered questionnaire was applied, and some information biases were induced. Also due lack of data in some categories, especially for some combination of exposure and outcome levels, sparse data bias may have occurred [3].
- The current socioeconomic status was used as proxy of socioeconomic status in the near past (during the stillbirth) which could be changed partially.

Introduction

A stillbirth is defined as a baby born with no signs of life at or after 28 weeks' gestation [4]. Stillbirth is classified as either early (between 20 and 27 completed weeks of pregnancy), late (between 28 and 36 completed pregnancy weeks), or term (between 37 or more completed pregnancy weeks)[5]. Also, stillbirth is defined as fetal loss in the 3rd trimester (≥28 completed weeks of gestational age or ≥1000 g birth weight)[6].

Even with increasing concentration for maternal neonatal health, stillbirths remain as one of the main health issues worldwide. As a minimum, 2.65 million stillbirths (ranging 2.08 million to 3.79 million) were estimated worldwide in 2008. Most cases of stillbirths (98%) occur in low and middle income countries. The lowest numbers were reported from Finland (2 cases per 1000 total births), and the highest numbers were reported in Nigeria and Pakistan (more than 40 cases per 1000 total births) [6]. Based on the report of World Health Organization, for every 1000 total births, 18.4 babies were stillborn, mostly in low income countries and middle income countries worldwide in 2015 [7].

Numerous factors are related with stillbirth including maternal infections, non-communicable diseases, nutrition, lifestyle related factors, and maternal age. Fourteen percent of stillbirths contribute to prolonged pregnancies[8]. Some studies show that economic status is one of the main causes of prenatal outcomes especially stillbirth[9-12], and the rate of stillbirth was more concentrated in low economic area.

The rates of preterm birth and stillbirth diverge in countries and by socio-demographic variables [13]. The highest stillbirth rate, neonatal mortality rate, and intrapartum-related mortality rates occur in areas with low socio economic status due to accessing care in rural areas, emergency obstetric care, immediate postnatal and prenatal care, gaps in healthcare coverage during the prenatal, intrapartum, and postnatal periods skilled birth attendance [14, 15].

Disparities in these rates are obvious. Even in areas with high income, there are inequalities in stillbirth rates; for instance in the United Kingdom, black women are two times more prone to have a stillbirth as white women [6, 16].

Iran is a developing country located in Asia. Based on the 2010 report, 96.42% of deliveries were done in presence of skilled health workers, and maternity care coverage during pregnancy was reported 96.92%.

The cause of a large proportion of stillbirths is unknown, and some studies are needed to determine the cause of unexplained stillbirth [17]. Therefore, the present study aimed to determine the economic inequality in history of stillbirth and understanding determinants of unequal distribution of stillbirth in Tehran, Iran.

Method

Although the methodology of this study was described elsewhere[18], here, more detailed information is reported on inequality analysis. A population based cross-sectional study was conducted, which was a part of large survey on twin and multiple pregnancies in Tehran Province, Iran. Data collected were related to 5170 deliveries between July 6 to July 21 2015 in 103 government, private, and military hospitals to ensure women with broad range of socioeconomic status. The data were gathered from medical centres with obstetrics and gynaecology wards. All women regardless of the type of delivery (natural or caesarean section) and pregnancy outcome (live birth, stillbirth, and spontaneous abortion) were included in the study. Also, the unstable women filled out the questionnaire after two or three days. The sampling procedure was carried out for two weeks. This report was followed the STROBE guideline.

Validity indices of questionnaire including face validity, relevancy, clarity, comprehensiveness, and inter-rater agreement (IRA) were reported above the acceptable level

of 80%. One hundred and three educated midwives as interviewers completed the questionnaire. If participants had not been aware of variables studied, their medical records would have been observed, or would have conducted interviews with obstetricians and nurses. The outcomes of interest were history of stillbirth, and economic status was considered an independent variable. Economic status of participants was measured based on "asset base method", in which the pregnant women were asked about their assets including vacuum cleaner, handicraft carpet, laptop, freezer, dish washing machines, private cars, touch mobile, three-dimensional TV, side by side refrigerator, microwaves, number of rooms, and area of residence.

This study was approved in 2015 by the Ethical Committee of Royan Institute, Tehran, Iran (Ethical code: 91000357). At the beginning of the study, the study aims were clearly presented for all participants. Confidentiality and anonymity of eligible individuals were assured; they could withdraw at any phase of the study. Verbal informed consent was obtained from all subjects before the study.

Methodology

Independent variables (determinants) of the study were as follows: mothers and father's age, nationality (Iranian and non-Iranian), education, occupation, and household economic status. Age was categorized into two groups: over and under 35 years old. There were three categories for education: under-diploma, diploma (end of high school), and academic degrees. Fathers' occupation included the following categories: professional, managerial, and technical, skilled non-manual, skilled manual, partly-skilled, and unskilled occupations. Unequal distribution of history of stillbirth was considered as a main outcome. Stillbirth was defined as a baby born with no signs of life at or after 28 weeks' gestation [1].

To measure the economic status of households, Principal Component Analysis (PCA) method was used. PCA, basically, is a standard factor analysis method leading to reduction of a slew of (asset) variables into one variable (i.e. economic status variable indicating the economic position of households). Asset variables used in the study for PCA were as follows: the number of rooms per person, area per capita, possession of automobile, carpet, microwave, dishwasher, TV, freezer, refrigerator, vacuum cleaner, laptop, PC, washing machine, and cell phone. Categorical variables should change to binary variables (have or not-have) before running a PCA. Numeric variables, however, do undergo no change (i.e. area per capita and the number of rooms per person). PCA result is a number of components on which asset variables are loaded. However, only the first component represents the economic status of the households as it can explain a remarkable part of variance (32% in our study) in economic status. In fact, economic status is the first component of PCA that is able to distinguish between people in terms of their economic status. The asset variables that are loaded on the first component and give such a distinguishing ability to it were as follows: refrigerator, dishwasher, laptop, and microwave. An economic score was, finally, determined for each household by PCA. Then, the households were economically ranked, and economic quintiles were constructed to be used in the subsequent modeling [19].

Concentration curve and index were used to measure and decompose socioeconomic inequality in stillbirth history[20-22]. The two key variables constructing the concentration curve were the stillbirth history, its distribution, economic status variable, against which the distribution is assessed. Concentration curve plots the cumulative percentage of the stillbirth history (y-axis) against the cumulative percentage of the sample ranked by economic status, starting from the poorest (x-axis). If everyone, irrespective of his or her economic status, has exactly the same history of stillbirth, the concentration curve will be a 45-degree line, running from the bottom left-hand corner to the top right-hand corner. This is known as the line of

equality. If, in contrast, stillbirth history takes higher values among poorer people, the concentration curve will lie above the line of equality and vice versa. Concentration index reports the distance between the concentration curve and the line of equality. Concentration index ranges from −1 to +1, with negative values indicating that the concentration curve lies above the line of equality and vice versa.

Wagstaff et al. (2003) demonstrated that a concentration index can be decomposed into contributions of different explanatory factors to inequality[20-22]. In fact, for any linear (regression) model of health, such as

$$\gamma i = \propto + \sum_k \beta_k x_{ki} + \varepsilon_i \quad (1)$$

the concentration index (C) for y (stillbirth history) can be written as:

$$C = \sum_k \left(\frac{\beta_k \bar{x}_k}{\mu} C_k\right) + \frac{GC_\varepsilon}{\mu} = C_\gamma + \frac{GC_\varepsilon}{\mu} \quad (2)$$

where μ is the mean of y; $\bar{x}_k$ is the mean of factors; C_k is the concentration index for factors, and GC_ε is the generalized concentration index for the error term (ε).

However, as the health variable is a dichotomous variable in the present study and it has no linear probability distribution but only when it changes to natural logarithm (Ln), μ in the formula (2) will change to Ln of μ.

There are two parts in formula (2): GC_ε or residual component that reflects the part of inequality in stillbirth history that cannot be explained by systematic variation in the factors. Explained component (C_γ) that shows the contributions of explanatory factors to inequality. Each contribution is the product of sensitivity or relationship (elasticity) of stillbirth history with factor ($\frac{\beta_k \bar{x}_k}{\mu}$) and the degree of economic inequality in factor (C_k).

Results

Table 1 illustrates the demographic features of subjects studied. As the table shows, most of subjects, male or female, were under 35 years of age, Iranian, and had a diploma degree. In terms of occupation, 87.5% of women were housewives, and 50.51% of men belonged to "unskilled" and "partly-skilled" occupations. In terms of stillbirth history, 2% of subjects had such a history.

Table1. Demographic features of subjects participated in study in Tehran in 2014

Variable		Frequency	Percent (%)
Mother age	15-25	1344	26.25
	26-35	3457	61.66
	>36	619	12.09
Father age	15-25	332	6.52
	26-35	3045	59.83
	>36	1712	33.64
Mother nationality	Iranian	4794	92.98
	Non-Iranian	362	7.02
Father nationality	Iranian	4773	92.91
	Non-Iranian	364	7.09
Mother education	Under-diploma	1416	27.52
	Diploma	2062	40.08
	Academic	1667	32.4
Father education	Under-diploma	1689	32.87
	Diploma	1825	35.52
	Academic	1624	31.61
Father occupation	Professional occupations	88	1.72
	Managerial and technical occupations	236	4.61
	Skilled non-manual occupations	1344	26.26
	Skilled manual occupations	865	16.9
	Partly-skilled occupations	1600	31.26
	Unskilled occupations	985	19.25
Mother occupation	Housewife	4509	87.5
	Employed	644	12.5
Economic status	Most deprived	1009	20.01
	Quintile 2	1011	20.05
	Quintile 3	1006	19.95
	Quintile 4	1008	19.99
	Least deprived	1008	19.99
	Yes	96	2

Stillbirth history	No	5071	98
Pre-eclampsia history	Yes	252	4.88
	No	4914	95.12
Abortion history	Yes	1035	20.03
	No	4133	79.97
Stillbirth in the last pregnancy	Yes	53	1.04
	No	5024	98.96
Weight at birth for the last child (kg)	Mean (S.D)	4872	3188.6 (SD= 503.2)

Figure 1 depicts stillbirth history concentration curve; the curve is above the equality line and indicates that stillbirth is more concentrated among lower economic status people in Tehran. This shows that there is inequality in distribution of stillbirth in Tehran, and the inequality disfavours the poor. Size of the inequality that equals history of stillbirth concentration index equals -0.121 (95% Confidence Interval= -0.235 to -0.001).

Table 2 shows the logistic regression analysis results for stillbirth history and its determinants. As the table shows, there is a significant relationship between lower economic status, mother age (15-25), and odds of stillbirth history. However, there is no such a significant relationship between other variables and stillbirth history.

Table 2. Logistic regression analysis results for stillbirth history * and its regressors in Tehran

Variables		Exp (B)	P-value	Adjusted odds ratio	95% confidence interval	
					Low	High
Mother age	15-25	0.44	0.001	0.221	0.09	.545
	26-35	1.016	0.053	.599	.342	1.049
	>36 (reference)	2.295	-	-	-	-
Father age	15-25	0.97	0.355	1.64	.574	4.701
	26-35	0.583	0.427	.819	.501	1.33
	>36 (reference)	1.755				
Mother nationality	Iranian (reference)	0.959	-	-	-	-
	Non-Iranian	1.041	0.883	.729	.011	2.417
Father nationality	Iranian (reference)	0.958	-	-	-	-
	Non-Iranian	1.413	0.975	.936	.0143	2.99
Mother education	Under-diploma	1.909	0.149	1.8	.81	4.006
	Diploma	0.743	0.632	1.17	.61	2.25

	Academic (reference)	.069	-	-	-	-
Father education	Under-diploma	1.537	0.880	1.07	.424	2.71
	Diploma	0.862	0.894	1.05	.451	2.48
	Academic (reference)	0.716	-	-	-	-
Father occupation	Professional (reference)	1.395	-	-	-	-
	Skilled	0.767	0.863	.935	.44	1.98
	Unskilled	1.273	0.954	.982	.539	1.79
Mother occupation	Housewife	1.812	0.113	2.004	.848	4.73
	Employed (reference)	0.551	-	-	-	-
Economic status	Most deprived	2.338	0.03	1.08	.509	2.31
	Quintile 2	0.459	0.021	.358	.149	.858
	Quintile 3	0.798	0.224	.629	.299	1.32
	Quintile 4	0.621	0.130	.569	.274	1.18
	Least deprived (reference)	1.193	-	-	-	-

* It is worth noting that in the present paper we only measured and decomposed inequality in the "history of stillbirth" and not in the "stillbirth in the last (current) pregnancy". In fact, there was no inequality in the stillbirth in the current pregnancy (C=0.103, 95% CI= -0.055 – 0.264).

Interestingly, there was no significant inequality in distribution of pre-eclampsia -0.008 (95% Confidence Interval -0.078 to 0.060), abortion 0.021 (95% Confidence Interval -0.010 to 0.052), weight at birth (kg) for the last child -0.001 (95% Confidence Interval -0.004 to 0.0009), and stillbirth in the last pregnancy 0.103 (95% Confidence Interval -0.055 to 0.264) in Tehran.

Since coefficients of occupation groups were so close to each other, they were re-categorized into three occupation groups: professional (professional, managerial, and technical), skilled (skilled non-manual and skilled manual), and unskilled (partly-skilled and unskilled).

Table 3 illustrates the results for decomposition of inequality in stillbirth. Mother education (50%), mother occupation (30%), economic status (26%), and father age (12%) had the highest positive contribution to measured inequality in stillbirth history, respectively. Interestingly, mother age (17%), belonging to non-Iranian nationalities, had negative contribution to inequality, i.e. they decreased from inequality size in stillbirth in Tehran.

Table 3. Decomposition of inequalities in stillbirth history in Tehran 2014

Variable	Mean	Coefficient	Elasticity	C_k	Absolut contribution	Percent contribution
Most Deprived	0.199	0.083	-0.004	-0.800	0.003	
Quintile 2	0.200	-0.25	-0.013	-0.399	-0.005	
Quintile 3	0.200	-0.462	0.023	0.007	0.000	
Quintile 4	0.201	-0.564	0.029	0.4	0.011	
Sum						**26.6**
Mother age 15-25	0.263	-0.9	0.06	-0.171	-0.01	
Mother age 26-35	0.617	-0.512	0.08	0.048	0.004	
Sum						**-17.1**
Father age 15-25	0.652	0.116	-0.019	-0.264	0.005	
Father age 26-35	0.598	-0.099	0.015	-0.024	000	
Sum						**12.6**
Mother nationality (non-Iranian)	0.07	-0.315	0.006	-0.675	-0.004	**-10.1**
Father nationality (non-Iranian)	0.07	-0.066	0.001	-0.662	-0.001	**-2.1**
Mother education (under-diploma)	0.272	0.589	-0.04	-0.448	0.018	
Mother education (diploma)	0.402	0.159	-0.016	-0.033	0.001	
Sum						**50.1**
Father education (under-diploma)	0.328	0.071	-0.006	-0.419	0.002	
Father education (diploma)	0.354	0.058	-0.005	0.011	0.000	
Sum						**6.5**
Father occupation (skilled)	0.431	-0.066	0.007	0.191	0.001	
Father occupation (unskilled)	0.505	-0.018	0.002	-0.133	0.000	
Sum						**2.9**
Mother occupation (housewife)	0.874	0.685	-0.153	-0.074	0.011	**30.5**
Ln mean of stillbirth	**-3.966**			**0.037**		**100**

Discussion

To the best of our knowledge, several studies have been conducted on the prevalence and risk factors affecting stillbirth, but few studies were done regarding socio-economic factors influencing the stillbirth rate. Among these studies, even in developed countries, there are few researches on the impact of socio-economic inequality on stillbirth [23, 24]. In the present

study, for the first time, the socioeconomic inequality in stillbirth in Iran's capital, Tehran, was explained via adopting a CI decomposition approach. This approach can help us to find the main causes of socioeconomic inequalities in stillbirth, which will be vital for policy makers in its prevention.

The stillbirth CI (of Ln odds $_{stillbirth}$) revealed that stillbirth is unequally distributed among study subjects. In fact, the negative value of CI indicates that stillbirth is disproportionately concentrated among people of lower socioeconomic status. This finding has been approved by some other studies in developed and developing countries[25, 26]. This pro-poor inequality not only exists within countries but also this pattern could be extrapolated between countries; a global study found that 98% of all stillbirths occur in low-income and middle-income countries, 77% in south Asia and sub-Saharan Africa.

Moreover, decomposition of stillbirth inequality showed that all independent variables (except mother nationality, mother age, and father age) have positive contributions to socioeconomic inequality in stillbirth. A positive contribution implies that the combined effect of the marginal effect of the desired determinant and its distribution based on economic status increase socioeconomic inequality in stillbirth. This can occur because either the desired determinant is more prevalent among people of lower economic status (negative C_k) and is associated with a higher risk of stillbirth or because the determinant is more prevalent among those of higher economic status (positive C_k) and is associated with a lower risk of stillbirth. Also, mother education accounted for most of the socio-economic inequality in stillbirth among Tehran's women. Indeed, mother education alone is responsible for 50% of the socio-economic inequality in stillbirth history. The other determinants with relatively large positive contributions to socioeconomic inequality in stillbirth are mother occupation (30 %), economic status (26%), and father age (12%). Interestingly enough, mother age

(17%), belonging to non-Iranian nationalities, had negative contribution to inequality, i.e. they decreased from inequality size in stillbirth in Tehran.

The decomposition method helps to quantify the contributions of determinants to socioeconomic inequality in health-related problems [27, 28]. Although, analysis of studied determinants in this study showed that 26 % of socio-economic inequality can be explained by economic status, but 74% can be eliminated by managing other determinants such as mother and father education, employment, etc. Hence, decomposition is an important way to monitor and understand the determinants of inequality [27, 28].

When comparing the findings with other findings, the differences in calculation of economic status should be considered. Asset-based, consumption expenditure, and income are the most popular measures for assessing the economic status. The asset-based method provides a rapid and simple method for collecting economic status data. Short interview time and questionnaire space are needed for this method. Whilst the essential principles of analysis with PCA are complicated, their application is easy in many statistical packages. According to some evidence, the asset index is a more lasting measure of economic status than consumption expenditure, changing less in response to variations in income and expenditure and being resistant to most economic shocks [29]. This may be particularly important in low and middle-income countries which may have greater fluctuations in consumption patterns than high-income countries. On the other hand, asset index data is more available in many studies that make the comparative research easier all over the world. However, as the asset index is a measure of relative economic status, the poorest category of one country could not be compared with corresponding category in other country [2].

It is obvious that no previous studies have tried to address the issue of stillbirth inequality in a manner similar to the present study. The present study found that stillbirth is more

concentrated among lower socio-economic status people in Tehran which is confirmed by some other studies. A systematic analysis on the national, regional, and worldwide estimates of stillbirth rates in 2015 shows that 98% of all stillbirths occur in low-income and middle-income countries; 77% in south Asia and sub-Saharan Africa [26]. Also, a review on the high-income countries found that a woman living under adverse socioeconomic circumstances has twice the risk of having a stillborn child when compared to her more advantaged counterparts [30]. Also, another study on the trends in socioeconomic inequalities concerning the risk of sudden infant death syndrome, other causes of infant mortality and stillbirth in Scotland showed a significant negative association between the economic status and risk of stillbirths [31]. These findings are also confirmed by another study on Swedish primiparous women, showing that low SES increases the risk of stillbirth [24].

In the present study, decomposing socio-economic inequality shows that although mother education per se is accounted for 50% of inequality in stillbirth history, but the remaining inequality is explained by some determinants including mother occupation and father age which are modifiable to some extent. Mother education had the first high positive contribution to measured inequality such that under-diploma and diploma educated mother were more likely to experience stillbirths compared to those having academic educations. A study by Savard et al. in 2013 reported that absolute educational inequality in stillbirth persisted, and relative inequality increased over the past three decades, despite an overall decrease in stillbirth rates. The decrease in absolute inequality for placental abruption was countered by an increase for unspecified causes [32]. These finding are also confirmed by global and semi-global studies [16, 26, 30].

The present study also showed that maternal age older than 35 years is a protective factor for stillbirth and has negative contribution to the so-called inequality in stillbirth history. Contrary to the findings, a systematic review on maternal age and risk of stillbirth showed

that women with advanced maternal age have an increased risk of stillbirth. However, the magnitude and mechanisms of the increased risk are not clear, and prospective studies are warranted [33]. Another study on Iranian women showed that the odds of stillbirth was lower in women older than 38 years and higher in women aged 20-33 years old compared to those aged 34-37 years old, which shows that the odds of stillbirth does not increase linearly, and interpretation of the findings should be cautious [34]. The current study also showed that paternal age older than 35 years is a protective factor for stillbirth and has negative contribution to the explained inequality in stillbirth history. As one of the limitations, the current socioeconomic status was measured as since it was believed that socioeconomic status could not be changed dramatically in the near past during stillbirth. A multisite population-based case-control study conducted on American women found the odds of stillbirth higher among those with paternal age ≥35 years and <20 years compared to the subjects with paternal age between 20-34 years old, implying that the odds of stillbirth does not increase linearly, and interpretation of the findings should be cautious [35]. As a relatively new finding, stillbirth among Iranian is more prevalent compared with non-Iranian women, the reason for which should be studied in future studies.

Conclusion

In conclusion, stillbirth is unequally distributed among Iranian women and is mostly concentrated among low economic status people. Mother-related factors had the highest positive and negative contributions to inequality. This matter calls for specific interventions for mothers to redress inequality. In other words, the mother-related factors are more modifiable than economic status to decrease socioeconomic inequality in stillbirth, and focusing on these factors would be more beneficial.

Figure legend:

Figure 1: Concentration curve of stillbirth history in Tehran in 2014

* Concentration index is the area between equality line and concentration curve that in the present study equalled: -0.121

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Data sharing statement: No additional data are available.

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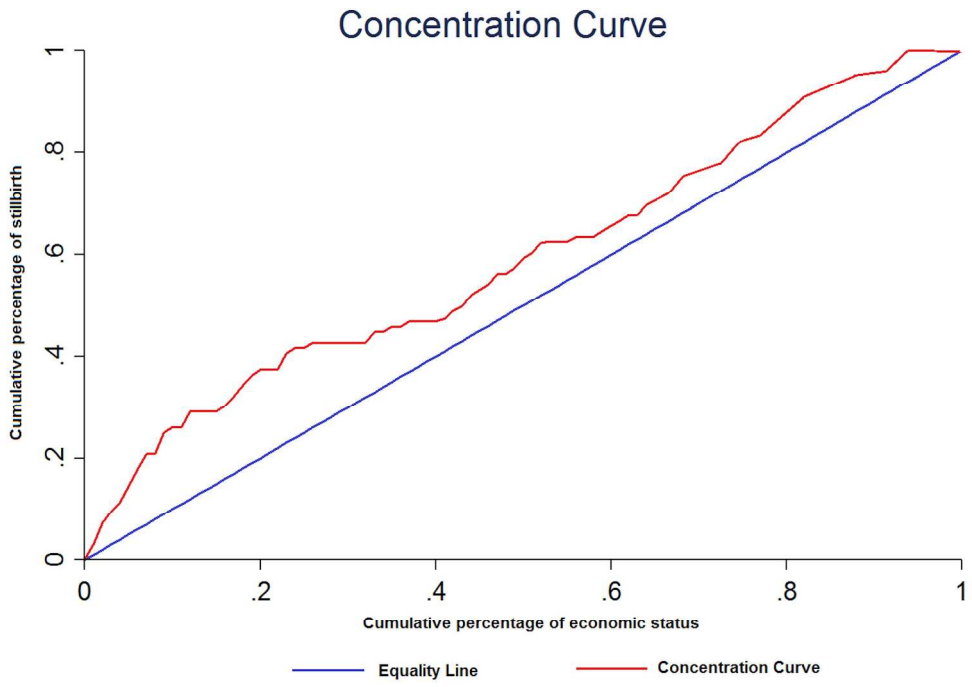

Figure 1. Concentration curve of stillbirth history in Tehran in 2014

1083x812mm (96 x 96 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation	Line
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1-2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	27-42
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	58-86
Objectives	3	State specific objectives, including any prespecified hypotheses	87-90
Methods			
Study design	4	Present key elements of study design early in the paper	92-101
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	92-101
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	92-101
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	119-126
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	92-101
Bias	9	Describe any efforts to address potential sources of bias	52-53
Study size	10	Explain how the study size was arrived at	92-101
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	119-143
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	119-172
		(*b*) Describe any methods used to examine subgroups and interactions	119-172
		(*c*) Explain how missing data were addressed	119-172
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	119-172
		(*e*) Describe any sensitivity analyses	NA

Continued on next page

Results			**Line**
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	174-178
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	174-181
		(b) Indicate number of participants with missing data for each variable of interest	174-181
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	*NA*
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	*NA*
		Cross-sectional study—Report numbers of outcome events or summary measures	*177-178*
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	182-211
		(*b*) Report category boundaries when continuous variables were categorized	182-211
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	223-225
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	223-307
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	223-307
Generalisability	21	Discuss the generalisability (external validity) of the study results	223-307
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	318

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.