Soc Indic Res (2018) 137:1185–1199
https://doi.org/10.1007/s11205-017-1631-3

Socioeconomic Inequalities in Infant Mortality in Egypt: Analyzing Trends Between 1995 and 2014

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Accepted: 10 April 2017 / Published online: 13 April 2017

Abstract This paper analyses the trend of the socioeconomic inequalities in infant mortality rates in Egypt over the period 1995–2014, using repeated cross-sectional data from the National Demographic and Health Survey. A multivariate logistic regression and concentration indices are used to examine the demographic and socioeconomic correlates of infant mortality, and how the degree of socioeconomic disparities in child mortality rates has evolved over time. We find a significant drop in infant mortality rates from 63 deaths per 1000 live births in 1995 to 22 deaths per 1000 live births in 2014. However, analyzing trends over the study period reveals no corresponding progress in narrowing the socioeconomic disparities in childhood mortality. Infant mortality rates remain higher in rural areas and among low-income families than the national average. Results show an inverse association between infant mortality rates and living standard measures, with the poor bearing the largest burden of early child mortality. Though the estimated concentration indices show a decline in the degree of socioeconomic inequality in child mortality rates over time, infant mortality rate among the poor remains twice the rate of the richest wealth quintile. Nonetheless, this decline in the degree of socioeconomic inequality in child mortality is not supported by the results of the multivariate logistic regression model. Results of the logistic model show higher odds of infant mortality among rural households, children who are twins, households with risky birth intervals. We find no statistically significant association between infant mortality and child's sex, access to safe water, mothers' work, and mothers' nutritional status. Infant mortality is negatively associated with household wealth and regular health care during pregnancy. Concerted effort and targeting intervention measures are still needed to reduce the degree of socioeconomic and regional inequalities in child health, including infant mortality, in Egypt.

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Keywords Infant mortality · Inequality · Trend analysis · Egypt

1 Introduction

According to the World Health Organization (WHO), 6.3 million children, under the age of five, died in 2013 worldwide (WHO 2014). More than half of these early child deaths are avoidable since medical interventions are available and widely known. As part of the global effort to curb early child mortality, the United Nations included the reduction in early child deaths by two-third, between 1990 and 2015, as one of the Millennium Development Goals (MDGs) (United Nations 2014). This goal was further enhanced by the introduction of the Sustainable Development Goals (SDGs) in 2015 which calls for ending preventable deaths of newborns and children under five years of age and reducing under-five mortality to at least as low as 25 per 1000 live births by 2030. Egypt along with several other developing countries has adopted the MDGs to be achieved by 2015. It has been documented that Egypt has made significant progress toward achieving the MDGs for health. Lozano (2011) tracked the progress toward the MDGs for health worldwide and considered Egypt as a top performing country. The under-five-mortality rate dropped from 85 deaths per 1000 live births in 1990 to 33 deaths by the year 2008. The progress has even continued after the dramatic political change that took place between 2011 and 2014, and the under-five-mortality rate dropped to 27 per 1000 live births (Ministry of Health and Population et al. 2015).

The progress toward achieving the MDGs may mask socio-economic disparities underneath, as the MDGs for health call for improvement in national averages, which may be attained either by improvement in the health of the poor, or the better-off. Accordingly, the improvement in national averages may result from an improvement in the health of the better-off, while the poor is lagging behind. Several previous studies which covered other low and middle-income countries show that the socioeconomic and regional inequalities in health did not narrow down over time despite the progress in national average indicators. For example, Nguyen et al. (2013) found that although there was a decline in child mortality rates at the national level in India, there were considerable inequalities across socioeconomic groups, ethnicities, districts, and wealth. While Subramanyam et al. (2010) pointed out that despite the stark economic growth and reduction in the overall prevalence of child malnutrition in India, social inequalities in child health were either widen or stayed the same between the years 1992 and 2005.

This raises the question as to what extent the poor in Egypt have benefited from the reduction in child mortality. Consequently, the objective of this paper is to examine the pattern of child mortality rates in Egypt, and as to whether the progress that took place in reducing the national mortality rates has been uniform by socio-economic status. To the best of our knowledge, and to date, no study has evaluated the trends in socio-economic inequalities in early child mortality in the Egyptian context.

The paper is organized as follows: Sect. 2 presents a brief review of the related empirical literature. Section 3 provides a description of the data, and Sect. 4 presents the empirical methodology. Section 5 discusses the results, and Sect. 6 concludes the paper.

2 Literature Review

A growing literature has emerged to study the trends of child mortality, and its determinants, in a wide range of countries (see for instance: Dallolio et al. 2012; Feng et al. 2012; Amouzou et al. 2012; Nattey et al. 2013; Nguyen et al. 2013). For example, Nguyen et al. (2013) estimated the change in child mortality rates in two of India's largest and poorest states over the period 1990–2007. They found that although there was a decline in child mortality rates at the national level, there were considerable disparities across socioeconomic groups, ethnicities, districts, and wealth. In a cross-sectional study, Nattey et al. (2013) investigated the relationship between household socio-economic status and under-five mortality and examined the risk factors associated with under-five mortality in Tanzania. The prevalence of the under-five mortality was found to be 26.9 per 1000 in the year 2005. They found evidence that household socio-economic inequality and maternal education are significantly associated with under-five mortality. The poorest were 2.4 times more likely to die compared to the least poor, indicating considerable health inequality. The least poor households had a 52% reduced mortality risk, and also children with mothers who had attained secondary education had a 70% reduced risk of dying compared to mothers with no education.

Using micro-data on 1.7 million births from 59 developing countries, Baird et al. (2011) found a robust negative association between per capita GDP and infant mortality. They found that on average, a 1% decrease in per capita GDP leads to an increase in infant mortality of between 0.24 and 0.40 per 1000 born children. They also found that female infant mortality is more sensitive than male infant mortality to negative economic shocks.

Gamper-Rabindran et al. (2010) examined the effect of piped water on infant mortality rate in Brazil, using a quantile regression with panel data. They found that the provision of piped water reduces infant mortality significantly more at the higher conditional quantiles of the infant mortality rate distribution than at the lower conditional quantiles (except for cases of extreme underdevelopment). These results imply that targeting piped water intervention toward areas in the upper quantiles of the conditional infant mortality rate distribution when accompanied by other basic public health inputs, can achieve greater reductions in infant mortality.

Several developing countries have achieved great progress in reducing the under-five-child mortality rates. Using data from Niger, Amouzou et al. (2012) reported a significant decline in child mortality rates from 226 deaths per 1000 live births in 1998, to 128 deaths in 2009, with an annual rate of decline of 5.1%. They then examined using the Lives Saved Tool, the factors that contributed to this reduction and found that about 59,000 lives were saved in children younger than five years in 2009. This reduction in infant mortality was attributed to three effective strategies (increase in access to child health services; use of mass campaigns; and programming for nutrition), operating together, that caused the greatest part of the reduction in child mortality.

Though extant literature is mostly dominated by studies covering low and middle-income countries, several studies have investigated the problem of child mortality in developed countries. For example, Dallolio et al. (2012) assessed the association between infant mortality and four key socio-economic determinants in 20 Italian regions. Infant mortality was positively correlated with income inequality, total unemployment rate, negatively associated with household income, and female educational attainment.

While a substantial number of studies have examined the determinants of child mortality in a wide range of countries, and during different periods of time, there is limited

evidence at the population level in Egypt. Since countries are likely to be heterogeneous with respect to their socio-economic conditions, and level of development, it is to be expected that the factors associated with child mortality could be country-specific and may differ from one country to another. Identifying the factors associated with child mortality at the country level will help guide effective intervention measures in Egypt.

3 Data

This paper uses repeated cross-sectional data from several rounds of the Egyptian Demographic and Health Survey (EDHS) over the period 1995–2014. EDHS is a cross-sectional survey of a nationally representative sample of the Egyptian households. The survey contains information on the health indicators of children and women, as well as a rich set of socio-demographic characteristics, maternity care, reproductive behavior, and housing characteristics. The US Agency for International Development funded the DHS surveys which have been conducted in over 90 countries.

To examine how the degree of the socio-economic inequalities in infant mortality rates has evolved over time, we utilize data from five rounds of the EDHS for the years 1995, 2000, 2005, 2008 and 2014 to compute the concentration indexes. The multivariate analysis of the demographic and socio-economic correlates of infant mortality is conducted using data on 9765 children from the 1995 round, 8406 children from the 2008 round, and 12,481 children from the 2014 round. The three samples are pooled together, generating an overall sample of 28,935 children where some observations are dropped due to missing data for some variables.

The unit of analysis in the regression model is the children born in the last five years preceding the survey. For households with multiple children, the analysis was clustered at the household level as well as at the primary sampling units (PSUs). In the EDHS, a list of shiakhas/towns constituted the primary sampling unit for urban areas and a list of villages served as the unit for rural areas. For the 1995 round of the EDHS, a total of 467 PSUs were selected, 204 of these units were in urban areas and 263 in rural areas. A total of 610 PSUs (275 shiakhas/towns and 335 villages) were selected for the 2008 EDHS sample, and 904 PSUs (481 shiakhas/towns and 423 villages) were chosen for the 2014 EDHS sample. A detailed description of the EDHS sample design and sample selection could be found in El-Zanaty et al. (1996), El-Zanaty and Way (2009) and Ministry of Health and Population et al. (2015).

3.1 Outcome Variable: Infant Mortality

Infant mortality estimates are calculated using data of the variables in the fertility history section of the mothers' questionnaire. The fertility history section contains data about the number of children residing with the mother and the number of children who died. It also has data on the birth history, gender, month and year of conception, survivorship status, and current age, or age at death, of each of the respondent's live births. This data is utilized to evaluate the infant mortality rates directly.

The incidence of infant mortality was represented by a dichotomous variable, taking the value of one if a household has experienced a mortality of a child less than one year, and equals zero otherwise.

3.2 Explanatory Variables

To examine the correlates of infant mortality, we use a standard set of socio-economic and demographic covariates that have been widely used in the literature. Child's size at birth is represented by five categories: very large (reference category), larger than average, average, smaller than average, and very small. A child's sex is represented by two categories: male (reference category), and female. Regional fixed effects are captured in two categories: urban (reference category), and rural. Household's economic status, captured by the wealth index, is represented by five categories: poorest (reference category), poorer, middle, richer, and richest. Access to safe water was represented by a dichotomous variable, with no access to safe water is used as the reference category. The effect of a regular health care during pregnancy was represented by two categories, with not receiving regular health care as the reference category.

As for the mother's characteristics, mother's education level is represented by four categories: no education (reference category), primary education, secondary education, and postsecondary. Working status of the mother is represented by a dummy variable, with two categories: unemployed (reference category), and employed. We also control for the mother's nutritional status by using the Body Mass Index (BMI) which is dichotomized into two categories: not malnourished (reference category), and malnourished ($BMI < 18.5$). The effect of the birth interval is represented by two categories: non-risky birth interval (reference category), and risky birth interval, defined as a birth-to-birth interval of less than 24 months.

4 Methodology

To get a descriptive indication of how the socio-economic inequalities in child mortality rates have evolved over time, we examine the Concentration Curve (CC) and the Concentration Index (CI) at different points of time. The CC and CI are two conventional measures of socio-economic disparities in health (Wagstaff 2000; Van Doorslaer et al. 2006; O'Donnell et al. 2008). The CC ranks households by their position in the income distribution and plots the cumulative percentage of deaths against cumulative percentage of households ranked in ascending order based on economic status. The CC lies above (below) the line of equality when child deaths are concentrated among households from lower (higher) socioeconomic status. The farther the CC is above (below) the equality line, the more concentrated the child deaths among poor (rich) households (O'Donnell et al. 2008).

On the other hand, the concentration index (CI) ranges between -1 and $+1$. The sign of the CI reflects the direction of the relation between the health variable of interest and household's position in the living standard distribution. A CI with a negative sign indicates that child mortality is concentrated among the poor, while a positive CI indicates that it is the better off who have a higher incidence of child mortality.

The magnitude of the CI, in absolute value, indicates the strength of the relation between the health variable of interest and economic status. Thus, the higher the value of the CI, the higher is the degree of concentration among the poor or the better off depending on the sign. Analogous to the Gini coefficient, a CI with zero value indicates perfect equality. The CI is computed as in Eq. 1 (O'Donnell et al. 2008).

$$CI = {}^{2}/_{\mu} Cov(H, W) \tag{1}$$

In which H is an indicator of the health variable and μ is its mean, while W is a measure of living standard, and *cov* is the covariance between H and W. The wealth index is used as a living standard measure. The EDHS team has developed the wealth index using a statistical method known as principal components analysis. The value of the wealth index depends on household's possession of chosen assets such as cars, floor type, access to water and sanitation, and materials used for housing construction. This index was used to stratify the interviewed households into five wealth quintiles.

The CI is computed for the survey years 1995, 2000, 2005, 2008 and 2014. By comparing the values of the concentration indexes over time, we could determine whether the degree of socioeconomic disparities in child mortality has declined over time. This is like a movie approach, where child health disparities are measured in each frame and the frames are rolled after each other (O'Donnell et al. 2008).

After measuring the disparities in child mortality rates using the concentration indexes over 1995–2014, we next examine the socioeconomic disparities of child mortality within a multivariate framework. Multiple logistic regression analysis is used to examine the odds of infant mortality associated with demographic and socioeconomic characteristics as in Eq. (2). The same approach has been used by Subramanyam et al. (2010) to analyze the trend of the socioeconomic inequalities in childhood under-nutrition in India between 1992 and 2005.

$$M_{ijt} = \alpha + \beta X_{ijt} + \tau H_{ijt} + \varepsilon_{ijt} \tag{2}$$

where M_{ijt} is an indicator variable that takes the value of 1 if child i in household j at year t died in the first year of life, and 0 otherwise;X_{ijt} is a vector of child characteristics such as child age, sex, birth order of the child. H_{ijt} is a vector of parental and household-level factors; ε_{ijt} is the error term.

To examine whether the degree of the socio-economic inequalities in infant mortality has declined over time, we interacted the households' wealth index, mothers' education level, and region of residence with the survey year dummies. The interaction term between the key explanatory variables and the survey year dummies capture the change in the effect of the explanatory variable over the period 1995–2014. A significant interaction term shows that the degree of association between family socioeconomic background and child health has changed over time, i.e. the level of socioeconomic disparities in health has changed. On the other hand, insignificant interaction term suggests no change in the degree of socioeconomic inequality over time.

The multivariate regression analysis and the descriptive statistics are population weighted using the EDHS survey weights to have population estimates and adjust for unequal probabilities of selection.

5 Result

Figure 1 displays the evolution of infant mortality rates over the period 1988–2014. Infant mortality rates show a declining trend, with a significant drop from 73 deaths per 1000 live births in 1988 to 22 deaths per 1000 live births in 2014.

Table 1 shows the infant mortality rates at different wealth quintiles. Infants born to poor households have a greater risk of mortality than infants born to rich households. There

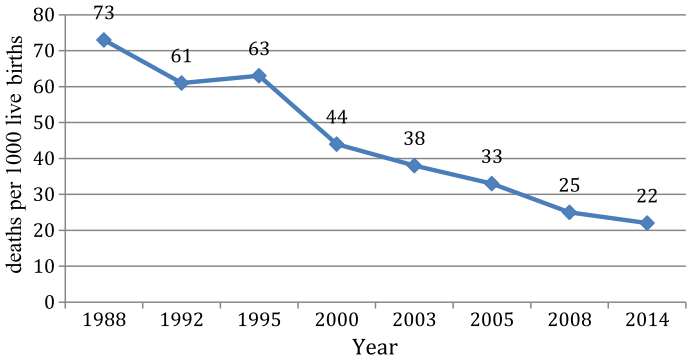

Fig. 1 Infant mortality rates in Egypt (1988–2014). *Source* Authors' calculation based on data from different rounds of the EDHS

Table 1 Infant mortality rates by socio-economic status in Egypt (1995–2014). *Source* Authors' calculation based on data from several rounds of the EDHS

	Q1	Q2	Q3	Q4	Q5	CI
1995	110	89	65	51	32	−0.2347
2000	76	64	54	44	30	−0.1763
2005	59	43	39	33	23	−0.1741
2008	42	31	26	25	17	−0.1654
2014	36	28	25	22	18	−0.1340

is a consistent inverse association between infant mortality rates and living standard measure across different rounds of the survey. The last column of Table 1 gives the CI for each round of the EDHS, where all have negative values. This suggests that the poor are bearing the largest burden of early child mortality.

Comparing the estimated CI over time suggests that the degree of socioeconomic disparities in child mortality rates has significantly declined, as CI is much smaller in 2014 than the values in 1995. Even among the poorest two quintiles, infant mortality rates have dropped substantially between 1995 and 2014. Despite this progress, it is important to stress that infant mortality rate among the poor remains twice the rate of the richest quintile.

Figure 2 plots the CC for infant mortality at two points of time, 1995 and 2014, which allows a visual assessment of socio-economic inequalities across time. It is evident that the CC is above the line of equality at the two points of time, which indicates persistence in the concentration of child deaths among the poor. However, the figure shows a decrease in the degree of disparity "inequality" in the incidence of infant mortality between the rich and the poor households over time. In particular, the CC for the year 2014 is closer to the line of equality than that for the year 1995. This indicates that socio-economic disparities in child mortality have narrowed over time.

Table 2 reports the result of the multiple logistic regression model, including the 95% Confidence Interval (CL) for the determinants of infant mortality. Results show no statistically significant difference, by sex, in the odds of infant mortality. For the year fixed

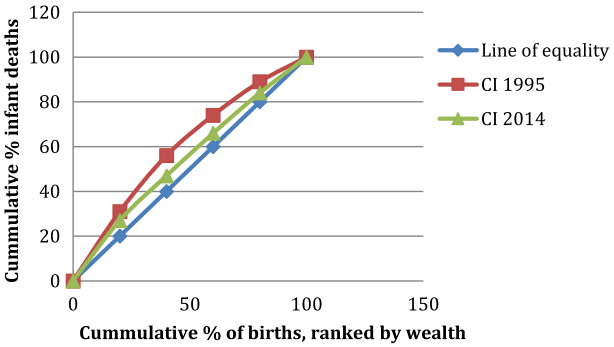

Fig. 2 Concentration curves for infant mortality. *Source* Authors' calculations based on data from several rounds of the EDHS

effects, the odds of infant mortality decreased over time. In particular, the odds of infant mortality are lower in the year 2008 (OR = 0.529; 95% CL = 0.309–0.905), and 2014 (OR = 0.436; 95% CL = 0.256–0.742) when compared with the year 1992. Consistent with several earlier studies (see for e.g. Luke and Brown 2007), we find that twin infants have higher odds of mortality (OR = 7.570; 95% CL = 6.195–9.250) compared to singletons. This could be explained by the inherent risks associated with multiple pregnancies. Being a twin increases the risk of sudden infant death syndrome, which is the unexplained death of a seemingly healthy baby. Twins are more likely than single births to be born prematurely, to have lower birth weight, congenital abnormalities, and complications during delivery. Accordingly, intensive care of multiple births during the neonatal period is vital.

Results also show that infants with risky birth interval have higher odds of mortality (OR = 3.307; 95% CL = 2.868–3.813) when compared with infants with a non-risky birth interval. Tackling this risk factor requires increasing people's awareness, through outreach campaigns, about its health implications, as well as increasing access to free or subsidized family planning services, and women's use of modern contraceptive methods to control the timing of their births.

Receiving a regular health care during pregnancy by mothers has a protective role against infant mortality. Infants whose mothers received regular health care during pregnancy have lower odds of mortality (OR = 0.815; 95% CL = 0.688–0.966) when compared to infants whose mother did not receive a regular health care during pregnancy. Though mothers' education was in general not significantly associated with infant mortality, mothers with postsecondary education have lower odds of infant mortality (OR = 0.443; 95% CL = 0.172–1.143) which was significant at 10%, when compared to mothers with less than primary education. Household economic status, as measured by the wealth index, has a statistically significant negative association with infant mortality. Lower odds of infant mortality is among households from the middle wealth group (OR = 0.585; 95% CL = 0.448–0.765), richer wealth group (OR = 0.490; 95% CL = 0.340–0.705), and richest wealth group (OR = 0.373; 95% CL = 0.237–0.588) when compared to the poorest households. Rural households have higher odds of infant mortality (OR = 1.239; 95% CL = 0.964–1.594) compared to urban households. No statistically significant association was found between access to safe water and infant mortality. Having more than two under-five children was negatively associated with infant mortality (OR = 0.370; 95% CL = 0.305–0.448) when compared with households with less than two under-5 children.

Table 2 Multiple logistics regression analyses of the socio-economic correlates of infant mortality

Variables	Odds ratio
Child sex	
Female	0.990
	(0.870–1.127)
Year fixed effect	
2008	0.529**
	(0.309–0.905)
2014	0.436***
	(0.256–0.742)
Wealth index	
Poorer	0.888
	(0.709–1.111)
Middle	0.585***
	(0.448–0.765)
Richer	0.490***
	(0.340–0.705)
Richest	0.373***
	(0.237–0.588)
Interaction term wealth index by year dummies	
Poorest × year 1995	1
	(1–1)
Poorest × year 2008	1
	(1–1)
Poorest × year 2014	1
	(1–1)
Poorer × year 1995	1
	(1–1)
Poorer × year 2008	1.010
	(0.641–1.592)
Poorer × year 2014	0.843
	(0.548–1.298)
Middle × year 1995	1
	(1–1)
Middle × year 2008	0.923
	(0.541–1.575)
Middle × year 2014	1.196
	(0.755–1.894)
Richer × year 1995	1
	(1–1)
Richer × year 2008	0.862
	(0.453–1.643)
Richer × year 2014	0.960
	(0.525–1.756)
Richest × year 1995	1
	(1–1)

Table 2 continued

Variables	Odds ratio
Richest × year 2008	0.681
	(0.293–1.580)
Richest × year 2014	1.550
	(0.745–3.228)
Rural versus urban	
Rural	1.239*
	(0.964–1.594)
Mother's education	
Primary	1.022
	(0.814–1.282)
Secondary	1.095
	(0.829–1.445)
Higher	0.443*
	(0.172–1.143)
Received regular care during pregnancy	
Yes	0.815**
	(0.688–0.966)
*Whether there are more than two under-fives in the household (*1–0*)*	
Yes	0.370***
	(0.305–0.448)
Risky birth interval	
Yes	3.307***
	(2.868–3.813)
Interaction term mother's education by year dummies	
No education × year 1995	1
	(1–1)
No education × year 2008	1
	(1–1)
No education × year 2014	1
	(1–1)
Primary education × year 1995	1
	(1–1)
Primary education × year 2008	1.244
	(0.719–2.152)
Primary education × year 2014	1.149
	(0.686–1.927)
Secondary education × year 1995	1
	(1–1)
Secondary education × year 2008	1.373
	(0.866–2.179)
Secondary education × year 2014	0.899
	(0.579–1.398)
Higher education × year 1995	1
	(1–1)

Table 2 continued

Variables	Odds ratio
Higher education × year 2008	2.275
	(0.668–7.747)
Higher education × year 2014	1.587
	(0.537–4.692)
Interaction term region (rural) by year dummies	
Urban × year 1995	1
	(1–1)
Urban × year 2008	1
	(1–1)
Urban × year 2014	1
	(1–1)
Rural × year 1995	1
	(1–1)
Rural × year 2008	0.559***
	(0.359–0.868)
Rural × year 2014	0.832
	(0.520–1.333)
Access to safe water	
Yes	1.001
	(0.772–1.297)
Mother is malnourished	
Yes	0.893
	(0.493–1.619)
Size of child at birth	
Very large	1
	(1–1)
Larger than average	0.663
	(0.266–1.654)
Average	0.454*
	(0.189–1.091)
Smaller than average	0.790
	(0.326–1.916)
Very small	1.439
	(0.585–3.541)
Mother is working	
Yes	0.922
	(0.755–1.126)
Child is twin	
Yes	7.570***
	(6.195–9.250)
Constant	0.116***
	(0.0444–0.305)
Observations	28,935

The provided coefficients are the adjusted odds ratios. Robust 95% confidence intervals are in parentheses

*** $P < 0.01$; ** $P < 0.05$; * $P < 0.1$. All estimations are weighted using the DHS sampling weights

To analyze the trend in the socioeconomic disparities in infant mortality and how it evolved over time, we assess whether the association between the socio-economic predictors and infant mortality varied by the survey year. By pooling data from the 1995, 2008, and 2014 rounds of the EDHS, we test for the significance of the interactions between the predictors of interest and the survey year dummies in the pooled dataset. In particular, the trend in the socio-economic disparities in infant mortality is assessed by interacting households' wealth index, mothers' education level, and region of residence with the survey year dummies.

Results show that none of the interaction terms for the households' wealth index and mothers' education level is statistically significant which suggests that socioeconomic disparities in child health have remained unchanged over the study period. The results also show that the disparity in infant mortality rates between rural and urban areas declined in 2008 compared to 1995, as the odds ratio of the interaction term of the 2008 year dummy with the region of residence is less than unity and is statistically significant (OR = 0.559; 95% CL = 0.359–0.868). However, Egypt's progress, which took place in 2008, in narrowing the gap in infant mortality rates between the rural and urban areas did not continue during the period following the political turmoil in 2011. This is reflected by the statistically insignificant odds ratio of the interaction of the 2014 year dummy with the region of residence.

These results indicate that, in general, the degree of inequalities in infant mortality rates by the socio-economic characteristics, as measured by households' wealth index, mothers' education level, and region of residence, has not decreased over time.

6 Discussion and Policy Implications

This study investigates the pattern and trend of the socioeconomic inequalities in infant mortality rates in Egypt over the period 1995–2014. The socioeconomic factors are measured by the households' economic status, maternal education, and urban/rural residence. A multivariate logistic regression and concentration index were used to examine how the trend of the socio-economic disparities in infant mortality rates has evolved over time. Aggregate statistics from the EDHS indicate that infant mortality rate, at the national level, has fallen remarkably in Egypt from 63 deaths per 1000 live births in 1995 to 22 deaths per 1000 live in 2014 (EI-Zanaty et al. 1996; Ministry of Health and Population et al. 2015). However, analyzing trends over the study period reveals no corresponding progress in narrowing the socioeconomic disparities in childhood mortality. Infant mortality rates remain higher in rural areas and among low-income families than the national average.

In fact, the urban health advantage has been underscored in several studies (see for e.g. Sharaf and Rashad 2015). This advantage is derived from the relatively well-equipped health facilities at urban areas with better geographical accessibility (Fotso 2007). In addition to the improved health system, urban residents enjoy better access to clean water, satisfactory sanitation and transportation facilities, which affects child health. Furthermore, the EDHS show that urban residents differ in a systematic manner from rural residents regarding their socioeconomic characteristics which contribute to their better health outcomes. According to the 2014 EDHS, 60% of the rural population are in the two lowest wealth index groups, compared with 6% of the urban population. On average, urban

women were more highly educated than those from rural areas (EI-Zanaty et al. 1996; Ministry of Health and Population et al. 2015).

To curb early childhood mortality, the Government of Egypt implemented several supply-side intervention measures over the period 1995–2014 which contributed to the decline in childhood mortality rate at the national level. For example, the number of maternal health care units that provide maternity care at low or no charge has increased substantially (Egypt Ministry of Economic Development 2010). Also, the Expanded Program on Immunization held a series of national immunization day campaigns which increased the percentage of fully immunized children from 67% in 1992 to 91% in 2014 (EI-Zanaty et al. 1996; El-Zanaty and Way 2009; Ministry of Health and Population et al. 2015).

However, these one size fits all policies were not effective in reducing socioeconomic inequalities in childhood mortality over the study period. Separate interventions, both demand and supply-side, that target the poor households as well as those in the rural and deprived areas are still needed.

Several interventions have been suggested in the literature to reduce the inequalities between the disadvantaged groups and the rest of the population. For instance, there is empirical evidence that welfare programs that offer benefits, conditional on investments in health and education, such as conditional cash transfers, improves children's health care utilization and health outcomes among the most deprived households (Shei et al. 2014; Zaky 2014). However, introducing new welfare programs in Egypt may not be feasible given the chronic budget deficit and the austerity measures currently in place. We, therefore, propose a new policy that takes into account the limited resources and could be a game changer for human development in Egypt. We suggest conditioning the present welfare programs, specifically the food subsidy program, on making regular visits to health clinics for prenatal care, postnatal care and child immunization at the regions where childhood mortality is the highest. The suggested policy provides parents with an additional incentive at a minimal administrative cost to fully immunize their children and uptake the necessary medical care. For example, the 2014 round of the EDHS shows that 78% of the newborns did not have a postnatal checkup at all.

Egypt has a generous food subsidy program that provides a monthly ration of cooking oil, rice, sugar, flour and tea at heavily subsidized prices to about 68% of the population. Mothers in regions where maternity care utilization rate is low can simply show their health or vaccination cards at the food distribution outlets to receive their food ration. This policy would maximize the return on public spending at a little extra cost. The program could be upgraded to include other human development targets such as sending children to school. The above-suggested policy is not totally new and has been implemented in other developing countries. Banerjee et al. (2010) have used randomized control trials in India to evaluate the efficacy of adding modest non-financial incentives (a kilo of raw lentils) on immunization rates. They found that such small incentives have a substantial positive impact on immunization rates.

Reducing socioeconomic inequalities in infant mortality could also be promoted by supply-side interventions such as mobile clinics to deprived and remote areas, training traditional birth attendant, and upgrading health facility infrastructure and equipment for health care, which requires additional investments in the health sector.

We find mothers with higher education level have lower odds of infant mortality when compared to mothers with less than primary education. Education plays a role in augmenting a woman's stock of health knowledge about contraceptive technologies, healthy pregnancy behaviors, nutrition, basic hygiene, and immunization, which are vital to

reducing the leading causes of child mortality. Also, Women with higher education tend to have smaller families, since education increases a woman's income stream, and fewer children in a family increase the likelihood that an infant will survive (McCrary and Royer, 2011). Given our finding that mothers with higher education level have lower odds of infant mortality, policies that enhance access to higher education would also contribute to reducing infant mortality rates in Egypt. Increasing women's enrollment in higher education would require policies that address the social as well as the economic obstacles that affect female enrollment and dropouts. Although Egypt has been adopting a system of free public education for decades now, higher education enrollment rates among women remain low, particularly among the poorest households and rural areas, especially in Upper Egypt governorates which are considered socially and culturally more conservative and protective toward allowing their daughters to join educational institutions in urban governorates. Given the social constraints, we propose launching online distance learning services and programs that offer accredited degrees and would boost the opportunities to access higher education for all.

The current study is not free from limitations. Even though we control for a wide set of variables, the usual caveats of causal inference using cross-sectional data hold for the current analysis. However, it does not affect the key finding of the study, which is the persistent socioeconomic inequality in infant mortality rates. Due to security issues, the 2014 round of the EDHS does not include data on North and South Sinai regions. However, they comprise less than 1% of Egypt's total population. Future research could investigate the inequality of opportunity in access to health services by different groups to help to narrow the health gap.

7 Conclusion

Saving young children's lives is among the Sustainable Development Goals (SDGs), which was developed by the United Nations. Goal number 3 in the SDGs calls for ending preventable deaths of newborns and children under five years of age and reducing under-five mortality to at least as low as 25 per 1000 live births by 2030. Egypt has achieved significant progress in fulfilling this goal. However, despite the stark reduction in early child mortality rates in Egypt over the period 1995–2014, the current study yields that this progress was not uniform across different socio-economic and regional groups. Concerted effort and targeted intervention measures are still needed to reduce the degree of the socioeconomic and regional inequalities in child health, including infant mortality, in Egypt.

Acknowledgements: We would like to thank the anonymous reviewers, and the academic editor of the journal for the invaluable comments and suggestions that substantially improved the manuscript. This work has benefited from a financial grant and intellectual support from the Economic Research Forum. The contents and recommendations do not necessarily reflect the views of the Economic Research Forum.

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