Socio-economic inequalities in infant health: evidence from Colombia between 1981 and 2010

DRAFT VERSION

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Abstract. This paper studies why and how infant mortality is related to socio-economic inequalities over time. Using a sample of 40.541 children from DHS data between 1986 and 2010, survival models capture the mechanisms through which SES (socio-economic status) influences infant mortality over time. The findings confirm the relationship between SES and health measured by infant mortality and indicate that parental income has a direct and stable impact on infant health, regardless of controls. In contrast, education works mainly through maternal biological factors; social class has an effect on infant health, but works through other variables not captured here such as race or time preferences. Surprisingly, duration of breastfeeding as a proxy for nutrition appears as an independent factor in explaining the link between SES and infant mortality. Finally, the decline in infant mortality is a story of mild success, but inequalities persist and relative risks across SES groups are still strikingly high despite the rising education and living standards. Hence unless we link SES inequalities in mortality to regional inequalities in poverty with the aim to prioritize investments in health care and public education, understand how nutrition (e.g. duration of breastfeeding) relates to SES, and what changes in the social structure and living standards are still needed to improve the odds of survival for the more disadvantaged groups, infant mortality in Colombia will not converge to developed-country standards in the near future.

Keywords: infant mortality, SES gradient, social class, income/wealth, education, relative index of inequality, Mosley and Chen framework, personal illness care, MDG.

Introduction

Infant mortality is an efficient indicator of average population health in developing countries (UNICEF, 2001; IMF, 2000). It has declined steadily in the developing world during the second half of the 20th century (Soares, 2007). Although there have been improvements in infant health, the mortality distribution is still intrinsically related to socio-economic inequalities (Jasper et al, 2011; Meara, 2001; Wagstaff, 2000; Adler et al, 1994). Hence the question why and how health relates to SES has gained weight as the current slow improvement in health outcomes (e.g. life expectancy or infant mortality) is associated with rising income inequality or social stratification in the developed and developing world alike (Deaton, 2003; Cornia et al, 2004). Furthermore, if this is the case, the question whether these health inequalities are rising in tandem with income inequality has opened a window to advocate for redistribution on the grounds of health.

The notion that mortality is inversely related to socio-economic status (SES) has been extensively documented (Wilkinson and Pritchett, 2006; Cutler et al, 2010). Among the main hypotheses to explain this relationship are the access and use of health care services combined with class-related health habits (Grossman, 1972; Townsend and Davidson, 1982; Adler and Ostrove, 1999; Deaton and Paxson, 1999) and one´s relative position in the income distribution (Wilkinson, 1996; Marmot, 1991; 2004; Wagstaff and Van Doorslaer, 2000). These explanations have been tested mostly in low mortality developed countries rather than high mortality low income countries (Wagstaff, 2000; Macassa et al, 2003).

Latin America, the most unequal region in the world, is no exception to the trend of mortality decline (UNDP, 2010). Yet, infant mortality seems to have stagnated in recent decades despite rising living standards and the introduction of health care reforms in the 1990´s for improving the health among the poorest groups. So far only five countries in the region (Nicaragua, Ecuador, Grenada, Perú and Cuba) are expected to fulfill their commitment to the Millenium Development Goals of reducing their infant mortality rates by 2/3 by 2015 (UN-ECLAC, United Nations- Economic Commission for Latin America and the Caribbean report, 2010).

The aim of this paper is to contribute to this area of research by studying why and how the effect of socio-economic inequalities (social class, income and education) upon infant mortality changes in the context of a developing country with high economic inequality over time. Certainly, these three dimensions of socio-economic status (SES) may capture different features of the structure and social context that may cause disease and mortality. In this line, Colombia provides a good example of a middle-income country which has experienced dramatic changes in infant mortality, educational advancement, falling fertility (Miller, 2005) and a pioneering and well regarded health care reform (2000 WHO Report[1]; Miller et al, 2009), yet the highest and persistent income inequality in the Americas (UNDP, 2010). Income inequality measured by the Gini coefficient has fluctuated between 55 and 60 % during the last four decades, which is expected to have an enduring effect upon average health despite the social and institutional advances of recent decades.

This paper differs from previous health/mortality studies in many ways. First, individual studies assessing SES inequalities in health for longer periods of time are scant, specially for Latin American countries. Second, it relates three objective measures of SES to the decline in infant mortality rather than estimating the effect of the Mosley and Chen proxy determinants per se. Third, it takes advantage of the trend of inequality in infant mortality as an indirect way to measure the impact of health care reform on the relative well-being of the Colombian population in a developing setting; the universal health insurance prioritized children and

[1]The WHO framework identified three social goals: to improve the health of the population (level and distribution); to improve responsiveness (level and distribution) to the legitimate expectations of the population; and to ensure fairness in financial contributions to health.

women from its onset and has widened in the last decade to cover more than 90% of the population by 2010 from a low of 20% in 1990´s.

Colombia has the longest series of Demographic and Health Surveys (DHS) in Latin America, representative at the national level, and this data can be used to assess SES inequalities in infant health between the most and the least advantaged children over time. The DHS data is based on a pooled sample covering infants born five years before the survey and during the period between 1981 and 2010, which captures the decline in infant mortality rates across surveys despite the acknowledged status of under-reporting. The census and the vital statistics suffer the same limitation.

Given that there is ambiguous evidence whether the health care reforms of 1990´s have been effective in flattening out the SES gradient in infant health (Homedes and Ugaldes, 2005), the paper uses the Mosley and Chen framework to test which mechanisms influence the relationship between infant mortality and SES over time. Hence the main hypotheses is that SES (social class, income and education) creates inequalities in health through environment, consumption and personal illness care (health habits and medical services). Using survival models, my findings confirm 1) the relationship between SES and health measured by infant mortality 2) income has a direct and strong effect despite the health institutional advances of recent decades 3) education seems to play a second role as a main determinant of the SES gradient in infant mortality and works mainly through maternal factors, namely parity 4) social class has a small effect on infant mortality and works through other variables not captured here 5) duration of breastfeeding as a proxy for nutrition is an independent factor in explaining the link between SES and infant mortality 6) while the trend of inequality in infant mortality appears to be declining, the relative risks across income groups remain strikingly high over time.

In sum, not enough has been done to flatten out the SES gradient in infant mortality; unless SES inequalities in mortality are linked to regional inequalities in poverty with the aim to prioritize investments in health care and public education, an understanding of how nutrition (e.g. duration of breastfeeding) relates to SES arises, and what changes in the social structure and living standards are still missing to improve survival for the more disadvantaged groups, the odds to reduce infant mortality by two thirds as the Millennium Development Goals (MDG) prescribed are low.

Finally, the paper is structured as follows: the first section reviews previous research of health inequalities. The second section deals with the theoretical framework of Mosley and Chen to link infant mortality to SES. The third section turns to the data and the statistical methods with the aim to identify the relative importance of the mechanisms linking SES and infant mortality. The fourth section presents the results. The final section discusses the results and presents the conclusions.

1. Previous research

There is a wide consensus of the existence of a global positive relationship between socio-economic status (SES) and health, regardless of the choice of indicators (Goldman, 2001; Singh-Manoux et al, 2005). Yet, the question why and how health relates to SES is still open for several reasons. First, there is no consensus around the causes behind the social gradient neither in historical nor contemporary populations (Bengtsson and Van Poppel, 2011). While some argue that income is the main determinant of health inequalities, others blame public health and access to medical knowledge; recently, health habits (smoking, drinking, ect.) and social position have gained more weight in the discussion (Adler and Ostrove, 1999; Wilkinson, 1996).

Second, the direction of causality and the choice of indicators constrain what we observe and therefore our explanations (Cutler et al, 2010). The evidence so far supports the effect coming from health towards SES in adult population, but clarifies that the chain of causality continues back into early childhood. This suggests that poor infant health leads to lower schooling achievement and therefore lower potential earnings and status (Case et al, 2002). Hence some argue that infant and child health provide an opportunity to attenuate the reverse causation between SES and health (Meara, 2001).

Certainly, even though causality may be settled, the mechanisms are nonetheless difficult to disentangle because the concept of SES simplified to the use of income neglects the role of other social markers and the validity or their potential mechanisms. Furthermore, theories about the third factor variable suggest that time preferences by social class (Kaplan et al, 1996), the role of stress in very stratified societies (Lorgelly & Linhead, 2008), genetics (Schultz, 1984) or even the macro-economic context (Kawachi & Kennedy, 1997), impede us to observe a causal relationship between SES indicators and health (Meara, 2001; Cutler and Lleras-Muney, 2007). In sum, the third factor variables may bias the effect of the variables we mean to manipulate.

Third, while some researchers argue that the health inequalities are constant (Phelan and Link, 1995), others claim them to be rising in the three last decades (Marmot, 2004). This prompts the issue whether the continuous improvements in average health are accompanied with an increasing or decreasing variance across social groups. This concern appears to be validated in many studies for developed (Deaton, 2003; Mackenback et al, 2003) and developing countries alike (Minujin and Demonica, 2004; Jasper et al, 2011). Nevertheless, Phelan and Link (1995) argue that the effect from SES to health has to be socially contextualized rather than focusing only on the individual risk factors and behavior towards disease.

True, the individual risk factors matter, but they are shaped by the social and economic forces around and upon the individual. For instance, a poor educated person who feels humiliated

because of the lower social status may be more vulnerable to sickness. The question then is what are the mechanisms through which the setting influences health over time. Hence, in developed countries, lower status may lead to illness through stress associated behavior, while in developing countries a combination of low status (habits) and low income (poverty) may be lethal.

2. Theoretical framework for infant and child mortality

A first advantage of using infant mortality is that it is a widely recognized indicator of average population health and living standards. Second, the related literature on health production functions has followed the Mosley-Chen framework to study inequalities in child mortality in developing countries (Schultz, 1983; Wagstaff, 2000). Hence this literature has tested a set of mechanisms to link health and SES. Furthermore, the direction of causality is straightforward, given that all studies confirm the protective role of SES indicators (Caldwell, 1979; Hobcraft, 1993; Case et al, 2002). Yet, we still have to single out the mechanisms for different measures of SES even though some coincide as in the case of income and education with health care (Schnittker, 2004). A third advantage is the immediacy of response of health inputs in infant health compared to adult health (Meara, 2001).

The main idea of the Mosley and Chen framework is that the social context and socio-economic status are the underlying causes in supporting the persistence of health inequalities through a set of mechanisms that may change disappear and reappear with time. Broadly, the social context affects the values of socio-economic variables, which work through biological mechanisms to influence morbidity and therefore mortality; for instance, poverty may contribute to the onset and persistence of infectious and respiratory diseases and, finally, of mortality. High levels of violence affect the accumulation of wealth and education, which in turn affect infant and maternal health. Migration may change the social context and therefore influence infant health through greater exposure to disease and psychological stress.

In a narrow sense, the framework provides a set of proximate determinants or mechanisms, which mediate the relationship between parental socio-economic status and infant health:

- maternal biological factors (i.e. age, parity, firstborn/birth intervals) are likely to be important because they capture the notion that children born to young or older mothers face a higher mortality risk than those in the middle of the age distribution; that the number of living children and the duration of birth intervals affect the perception of risk
- and other demographic features (sex and marital status) capture the risk of being treated differently because of gender and being born to a single mother.
- environmental contamination (air, food, water, fingers, insect vectors) is important because living in urban or rural areas or in certain neighborhoods, communities or regions affect infant health.

- nutrition (breastfeeding, diet, vitamins, proteins and minerals) is important for health, regardless of age, and interacts with disease, making them more difficult to cope with.
- personal illness care (personal preventive measures; medical treatment) is important because health habits and the access to medical services reduce the negative consequences of disease.
- and injury (accidental and unintentional) is important because intra-family violence and overall violence tends to influence maternal and infant health, and it may be more common in developing countries because of political and economic instability;

All these proximate risks may capture the consequences of social stratification, with an unequal effect depending on social class, income or knowledge.

Figure 1: An extended version of the Mosley and Chen framework

In sum, the relationship between SES and health is mediated in many ways. The framework singles out the measures of SES at three different levels and identifies the mechanisms through which SES measures are expected to operate. This implies that mothers or families with similar overall SES may experience different risks of infant mortality, depending on which proxy determinants mediate this relationship and at what level. The question then is whether a SES gradient in infant mortality emerges as a regularity, regardless of the control variables. Thus I will examine the potential mechanisms through which measures of SES (occupational class, income and knowledge) may influence infant mortality.

Social Class

There is a long tradition in British studies to use father´s occupational class as a proxy for social class and link SES and infant health (Townsend and Davidson, 1982; Pamuk, 1985; Marmot, 1991; 2004). A modern explanation to use father´s rather than mother´s occupational class is that women are off the labor market, at least temporarily, after delivering. Thus, by grouping children and mothers by father´s occupation, this measure of SES captures his working conditions and the way of life associated with their social class over time.

In developing countries, father´s occupational class influences infant health through the epidemiological environment. For instance, the work place may be related to catching contagious diseases and bringing it home, which coincides with the fact that infectious respiratory diseases are still today on the top ten more common causes of infant and child mortality in the developing world (WHO, 2008; UN-ECLAC, 2010). Likewise, occupational class may affect health through the difficulty in finding time to take children for preventive and medical treatment while holding down multiple low paying jobs (Deaton, 2011).

Miller and Urdinola (2010) explored this idea on a case study for Colombia and concluded that the relative price of health rises with booms and led to higher infant and child mortality rates; this implies that during seasonal work rural employees have less time to either provide the relatively inexpensive drugs and cures for their children or carry them children long

distances to health care centers. Furthermore, in developing countries with dysfunctional labor markets, time availability becomes more problematic for those working in the informal labor market because parental leaves do not exist (see Ruhm, 2000, about parental leave in the US). Indeed, the United Nations - ECLAC[2] (2010) report states that 8 of out 10 work in the informal labor market in Latin America.

On the other hand, the social context may unravel another aspect of occupational class: social prestige. Social prestige is more and less how society regards the contribution of one´s occupational position in terms of degree of skill, authority or control of capital (Davies, 1953; Treiman, 2008). Yet, social prestige may be attenuated by the persistence of other forms of inequality such as segmentation by gender or race in the labor market (Grusky, 2008). This suggests that gender and race may confine certain groups to certain occupations, and this discrimination may affect the use and quality of medical services, too (Deaton and Lubotsky, 2003;Bravemann et al, 2005). Given that pregnant women and infants tend to be prioritized in access to medical services, the mechanism may be related to occupational status, race or a combination of both.

In sum, that health declines with lower occupational class has been forcefully advocated in health studies. Lower occupational class rises infant mortality through the environmental exposure to disease, the relative price of health in terms of time preferences or differential access to medical services and thus creates inequalities in infant mortality.

Income

Health demand theory predicts that inequalities in health stem roughly from inequalities in income rather than in health care utilization (Grossman, 1972; Townsend and Davies, 1982; Wagstaff, 1995; 2002). Assuming that health is produced by inputs such as medical services and consumption, two individuals with different levels of income would not share the same indifference curve. Thus, the allocation of income to medical services and consumption will not render the same production function of health. This has served as the basis to use income-transfer programs to supplement the incomes of those on lower incomes and equalize health outcomes.

True, subsidies or universal coverage reduce the price of health and ought to benefit largely the poor rather than the rich. Yet, the evidence so far indicates that neither public funded nor private health systems have eradicated health inequalities (Deaton, 2003); while some argue that concept of SES simplified to the use of income neglects the role of other social markers and their potential mechanisms, others indicate that subsidized insurance expansions may not improve outcomes unless health habits or life styles, which are intrinsically related to income inequalities, are changed (Case and Paxson, 2002).

[2]UN- ECLAC : Economic Commission for Latin America and the Caribbean

Still, others qualify this assertion by claiming that relative income rather than absolute income explain health inequalities. This belief is inspired by the empirical observation that countries with low income inequality tend to have higher life expectancy relative to the high income inequality ones (Preston, 1975). In this line, Wilkinson (1996) hypothesized that the social environment (i.e. economic inequality and its consequences) per se is a hazard to individual health through stress-related illnesses rather than material deprivation in developed countries. Yet, the relative income hypothesis (RIH) has severe limitations: first, the choice of group of reference is arbitrary; is it one´s position in the community or in the national income distribution, or the community ranking in the national population. Second, the evidence so far rejects the relative income hypothesis in developed and developing countries alike (Deaton, 2003; Lorgelly and Lindley, 2008).

Another line of research stresses out that in circumstances of low levels or lack of labor income, wealth should capture the ability to use and pay for medical knowledge; certainly, income and wealth have separate effects upon health, controlling for other social markers such as education or occupation. In this line, Smith (2004) argues that in the US out of pocket payments may affect access to health and reduces family wealth in the long run. Furthermore, under economic stress, poor income and wealth may reveal some of the family strategies to cope with diseases over time such as borrowing or selling assets, access to health insurance, change of health habits or even migrate (Bengtsson et al, 2004).

Yet, a limitation to the wider use of wealth is its conversion into income under market forces. While some would argue that this might imply larger measurement error and bias respondent as in the case of income, studies using non-monetary wealth measures have proved to be better predictors of health than income or expenditure in developing countries (Stifel and Sahn, 2000; Rutstein and Johnson, 2004; Singh-Manoux et al, 2005; Pollack et al, 2007).

Case and Paxson (2002) argue that children in lower wealth families are more likely to develop a variety of serious chronic health problems. After all, asset limitation may hamper the preparation of basic cures, the capacity to complement truncated breastfeeding or food quality. Likewise, a high parity will increase the risk of infant death because of the competition for resources. Wealthy children will experience this competition less than non-wealthy children because more resources are available and their number of siblings tend to be less than in poor households. Moreover, unintentional injury may come from a violent environment, which causes high levels of stress in the pregnant mother (Urdinola, 2004; Camacho, 2007).

In sum, absolute rather than relative income correlates with infant mortality and may work through intra-household competition in the consumption of resources such as nutrition and medical services. Moreover, in circumstances of low income, wealth may contribute to the explanation of health inequalities by indicating the lack of strategies to cope with diseases.

Knowledge

Education affects infant health through maternal factors. Although father´s education is important, the literature delves more with mother´s education, given that they are likely to spend more time with the children, specially in traditional societies. This implies that a young uneducated mother ought to face a higher risk of infant mortality than an educated one; thus, as educational achievement rises with age, more educated mothers can reduce their children´s risk (Caldwell (1982;Corman and Grossman, 1984; Goldman, 2001).

In this line, given that many studies indicate that compositional changes in education and fertility decline are highly correlated and have influenced positively health outcomes, specially for infant and child mortality (Cutler and Lleras-Muney, 2007), educated mothers ought to have preferences for lower family size (contraceptive use) and may become more efficient in allocating time and resources among children than less educated mothers (Meara, 2001). Furthermore, more educated women are expected to make decisions about their reproductive and family health without reference to their elders or partners (Caldwell, 1982; Miller, 2005).

Certainly, preferences change as schooling introduces parents to a global culture of largely Western origin and loosens their ties to traditional cultures. Hence more educated mothers are expected to be more knowledgeable about nutrition and food quality and preparation of cures than less educated mothers (Hobcraft, 1993). Yet, more educated mothers are likely to marry later and favor truncated breastfeeding and shorter birth intervals, which raises infant mortality risk (Caldwell, 1982; Haines and Avery, 1983).

True, the value of time does matter for decision-making on health issues. After all, the drugs and cures to keep infants healthy are time intensive rather than expensive (Miller and Urdinola, 2009). Furthermore, recent studies for developed countries indicate that labor participation for women after delivery has not fallen (Cutler et al, 2010). In a case study for Colombia, the rise of female labor participation is also apparent (Medina, xxx; Lopez-Uribe et al, 2010).

Education is also closely related to health habits such as smoking, diet or drinking. For instance, women who smoke jeopardize their own health and their infants (Meara, 2001). Townsend and Davidson (1982) indicate that smoking is a class related habit, and lower educated people tend therefore to smoke more than high educated people. Hence, any subsidized health programs for the poorest must be accompanied with changes in health habits in order to become effective (Case and Paxson, 2002).

In this line, some argue that the timing of the first antenatal visit, the diet before and during pregnancy and so forth is another health habit, which creates inequalities in infant health. Certainly, more educated mothers are more perceptive of health risks and may decide to visit the doctor earlier than less educated mothers, in other words, they are more prone to exploit

the system, given that their understanding about health issues and communications skills are superior to mothers with lower education (Deaton, 2003; 2011).

In sum, maternal education is strongly correlated with infant survival and seems to increase the general efficiency in generating healthy infants. Moreover, education influences infant health through maternal factors (parity and age), nutrition (food quality) and the use of common knowledge on health issues.

Hypotheses

Based on these theoretical ideas, my hypotheses indicate that: (1)lower occupational class rises infant mortality through the environmental exposure to disease and personal illness care (preventive measures and medical services) and thus creates inequalities in infant mortality; (2) low income has a strong and negative impact upon infant mortality through consumption of resources (nutrition and medical services) (3)low educated mothers influence infant mortality through personal illness care. (4) the inequality in infant mortality has been increasing over time despite rises in education, subsidized health and living standards.

3. Data and Statistical Methods

This paper uses an unbalanced pooled sample data from six (6) waves of Demographic and Health Surveys (DHS-1986, 1990, 1995, 2000, 2005, 2010), based on the complete fertility history of women between 13 and 49 years. DH Surveys occur every five years and are nationally representative. The surveys collect general socio-economic household and demographic data by place of residence (rural and urban). Yet, the DHS infant mortality estimates are said to be biased downwards compared to official sources estimates from censuses and the vital registration data, which are known in turn to suffer of underreporting (Medina and Gutiérrez, 1999; Flórez, 2000).

The initial pooled sample includes 43.995 children and 1001 deaths. The final pooled sample includes 40.541 singleton births with 738 deaths, after deleting 741 children of multiple birth and 2.713 children with missing observations for one of the main controls, namely breastfeed duration. To avoid problems with censored data, infant mortality rates or the probability of dying before or at 12 months since birth are estimated using life tables. Furthermore, the analysis is based on a piece-wise hazard constant model, where the constant is allowed to vary within pre-defined time segments, allowing an adequate treatment of censored data. I defined the time pieces as a quarter per year for a period of five years. To avoid recall bias, only births occurring in the last five years are included in the analysis.

Table 1: DHS surveys used in the analysis

Table 1 indicates a clear trend of decline in infant mortality with a modest steep in survey year 1995, which may be related to sampling size in survey year 1990. Indeed, the relative

standard error declines with sample size, and suggests that the accuracy to detect changes in infant mortality has been raised in more recent surveys. A brief look at the confidence intervals and chi-square tests (not shown here) confirm the decline in the rate.

Figure 2: trend of infant mortality rates

Based on the previous section, the theoretical model of infant survival may contain the following variables:

$$\text{mortality} = f(\text{occupation}_i, \text{wealth}_i, \text{Edu}_i, \text{Controls})$$

Mortality is a binary variable indicating whether an infant died at and before the age of 1 year[3]; SES contains mainly social class (father´s occupation), wealth (permanent income/resources) and mother´s education; controls are the household members, survey time and the proxy determinants of the Mosley and Chen framework.

Father´s occupation. The DHS data adapts the national occupational scales to ISCO, which makes it comparable among developed and developing countries alike. The DHS data provides 11 categories of occupation: not working, professional, clerks, sales, agricultural self-employed, agricultural employee, domestic, services, skilled manual, unskilled and don´t know. Not working and don´t know were dropped given that there was no information to categorize them under the variable father´s occupation. Yet, we don´t know whether anyone is formally employed.

I merged these categories into five groups using the Goldthorpe scheme. The reason is that this scheme relates directly to distinguish occupational position by form of employment contracts and conditions (Evans, 1992; Torssander and Erikson, 2009). The categorization is as follows: 1) professionals (Goldthorpe I) + clerks (Goldthorpe II) 2) sales and services (Golthorpe IIIb) as the reference group 3) skilled manual workers (Goldthorpe VI) (4) unskilled manual workers + domestic service (Goldthorpe VII) (5) agrarian including self-employed farmers or employed agricultural workers (Goldthorpe IV+VII).

I aggregate category (5) given that self-employed farmers and agricultural workers share the same disease exposure and more than 80% of them live in rural areas (see table 2). This assumption is based on the estimate that 85% of the land owners in Colombia between 1984-2000 are small farmers, who own 14,9% of the total area of land (Kalmanovitz, 2009, p.229).

Table 2: Urban population by father´s occupation

Wealth index. A proxy for income/resources based on housing conditions, key durable assets and public infrastructure. It is estimated through the use of factor analysis[4], which assigns

[3] Note that age heaping was a criteria to choose this definition of infant mortality, including those children with exact 12 months of age

[4] Factor analysis is an statistical method to construct an index for a group of variables. This is essentially the sum of the asset variables, weighted by the elements of the first eigenvector

weights to the assets. The index includes electricity, radio, tv, fridge, motor_bike, car, source of water, type of toilet and type of floor. This composite measure of income/assets is a closer proxy for permanent income and classifies children by poorest, poor, middle and rich asset-based status (see table 3). For instance, access to water and sanitation is unequally distributed, and as such correlated with child mortality (Rutstein and Johnson, 2004; Sahn and Stifel, 2003).

Table 3: Asset quartiles

Table 3 indicates that around 57% of the children live in poverty, which confirms estimates of persistent poverty and income inequality in the country (PNUD, 2010; Kalmanovitz, 2010). Access to water and sanitation (in-house toilet), telephone and TV make the difference between the poorest and the poor; so do general housing conditions (water, sanitation and floor quality) to mark the difference between the poor and the middle class.

Mother´s education. Because of the shrinking size of the none education category, I merged the 6 initial categories into four: (1) no education plus some primary education (2) complete primary education (3) incomplete secondary education as the reference category (4) complete secondary education plus higher education.

Control variables.

(1) Proximate risks of Mosley and Chen framework: maternal factors (age, parity and birth order), demography (sex and marital status), location (urban/rural), nutrition (duration of breastfeeding[5]), preventive measures[6] (none, traditional and modern contraceptive method) and medical services (trained assistance at delivery). I check the data using life tables to check that the assumptions[7] of the Mosley and Chen framework were fulfilled (not shown here).
(2) Household members account for number of people living at home.
(3) Time by survey year is a dummy variable, which captures the risk of mortality in case the covariates have not. This dummy is more and less the same as to capture the difference between the date of birth and the time of the interview.

To study changes in the level of inequality in infant mortality over time, I estimate the slope index of inequality (SII) and its relative difference counterpart –the relative index of inequality (Pamuk, 1985; Wagstaff, 2000). Unlike other estimators of inequality such as the Lorenz curve or the range, the slope index of inequality captures the experience of the entire population and responds to the population distribution across socio-economic groups; the

[5] None or less than 3 months, between 4 and 6 months and more than 6 months

[6] I run models using tetanus toxoid and timing of antenatal care, and their impact of SES variables did not differ in a significant way apart from the fact that the sample data was reduced by around 26% and 19%.

slope index of inequality is the slope of the regression line indicating the absolute effect to move from the lowest to the highest social status in relationship to health outcomes.

In this line, the relative index of inequality (RII) is the product of dividing the slope by the mean infant mortality for the survey period. This implies that the index will be between 0 and 1, being 0 full equality and 1 full inequality. Hence the easiness in its interpretation is what makes the RII superior to the use of the concentration index, which has been the most frequent estimator for health inequalities in previous studies on Colombia[8]. Only births happening 1-5 years before the survey are considered to avoid censored data in infant mortality rates. Finally, to avoid heterokedasticity in the use of grouped data, a WLS regression is run using infant mortality by group and births as weights. Thus, standard diagnostic testing such as the R-square may be used.

Estimation Strategy.

Initially I estimate a basic model of infant mortality and each SES dimension by itself, controlling only for survey time. Then I compare a "no control" model using the three measures of SES simultaneously with a full model. Then I test the omitted variable bias excluding the proxy determinants one by one and comparing them against the full model. Finally, I break the pooled sample by place of residence (urban-rural) and by survey year to run interaction models accounting for the trend of inequality. Results are expressed as relative risks, considering family based frailty to correct for unobserved heterogeneity and to account for multiple death events for children within the same family. Finally, the analysis is complemented with the relative index of inequality for each survey using a WLS regression estimates.

4. Results

Table 4: Descriptive summary

The descriptive measures indicate that the distribution of occupational class by category remains basically the same for the bottom and top groups with a clear mobility from unskilled to skilled groups over time. In contrast, a third of the occupational distribution is composed of workers and self-employed in the agricultural sector, which reflects more and less the current level of urbanization: 73% (DANE, 2005). On the other hand, while the proportion of less than primary educated mothers changed dramatically from 50 to 20%, secondary and higher educated mothers rose from 8 to 38%. Family wealth captures the around 55-60% of population living in poverty. Household size and number of children share a downwards trend, reflecting probably the demographic transition of the Colombian population.

Table 5: Survival models of infant mortality

[8] For a thorough discussion on measures of health inequalities, see Wagstaff, Van Doorslaer and Kakwani (1997) in Journal for Econometrics, volume 77 issue 1; Koolman and Van Doorslaer (2004), On the interpretation of a concentration index of inequality, Health economics, 2004

I begin by estimating a basic model of infant mortality by SES measures, controlling only for survey time. The estimates from these basic models indicate that compared to children of high SES, all other children below the ladder had an increasing, higher and significant mortality risk. Using all three SES measures simultaneously, income and education present significant and large estimates, but class. Children of the poorest mothers have 47% higher risk of infant mortality than the reference category; children of the lowest educated mothers have a 26% higher risk. However, once we add all the controls, the educational gradient on infant mortality disappears while income remains statistically significant and large. Surprisingly, class reappears indicating that children of unskilled fathers have a statistically significant estimate of 40% higher risk of mortality than the reference category. In this line, omitting income from the model indicates that class still reveals the SES gradient, but education. Hence a potential explanation lies therefore in the control variables that mediate the relationship between SES and infant mortality, and how they have changed with time.

Certainly, to know more about the mechanisms through which income affect infant health, I test the omitted variable bias (OVB) by excluding the "proximate determinant" groups one by one from the full model. The idea is to capture those groups of control variables with the most power to diminish the correlation between SES and infant mortality. So if we omit a group of control variables, we expect the SES measures to pick up its effect. Otherwise, robustness of the SES measures is confirmed.

Table 6: Proximate risks and omitted variable bias (OVB)

In line with previous research income is the main SES determinant of infant mortality across models. In other words, poverty or lack of income has a direct impact on infant mortality. Strikingly, it becomes clear from this exercise that nutrition (breastfeeding duration) diminishes the correlation between SES measures and infant mortality. Similarly, maternal factors (parity) has a say in explaining the relationship between education and infant mortality. The educational gradient, which virtually disappeared in the full model, reappears in the absence of maternal factors; children from lowest educated mothers have a 37% higher risk than the secondary educated mothers. Finally, class remains stable across these OVB models, and therefore seems to work through other variables.

For location, I break the pooled sample into rural and urban, given that the estimated mortality rates are higher for the poor or rural residents across surveys. Both models confirm our previous finding that income rather than class and education is the main determinant of infant mortality. As expected, the relative risk of mortality is greater for those on the bottom of the ladder in both settings (urban 2.1; rural 2.3 compared to the reference category). In short, location seems to provide little information (Caldwell, 1982; Haines and Avery, 1983).

Finally, I break the sample by groups of survey year to test the hypothesis that the inequality in infant mortality is increasing over time. I came up with five groups, starting with 1986 and

1990, then 1990 and 1995 and so forth. Using interactions of SES measures with time, I compare changes of relative risks between periods for the bottom and the top groups.

Table 7: Interaction models

Table 7 indicates the interaction between each SES measure and time by groups of surveys. The estimates are not significant in any case, but a stable pattern appears to emerge in the bottom groups of the SES distribution if the 1986 survey (mortality estimate was not representative of the period-see table 1) is omitted from the analysis. The interaction term for low income groups appears to remain rather stable and high compared to its other two competing SES measures. In contrast, agrarian workers drive the results by moving from a relative risk of 1,7 in 1995/2000 to 0,75 in 2005/2010. A similar pattern is to be found for less educated mothers between 1990/1995 and 2005/2010.

Table 8: The relative index of inequality (RII) by SES

Using the relative index of inequality (RII), I found out that inequality in infant mortality by education declines from 39% in 1986 to 27% in 2010. The index indicates a statistically significant trend for education only and suggests that moving from one educated group to another reduces the infant mortality by 11.2 units in 1986 and 4.3 by 2010. The index for education is significant only in 2010 and has a value of 24%. For occupational class, it reveals a significant 13% in 2010, but the relative risks are still so high – above 40% for children with unskilled fathers - that any claim leading to think that the class gradient has narrowed cannot be considered seriously. Certainly, we have to look with caution to this index of inequality because it may be biased downwards because of under-reporting, and because the high relative risks in survival models, which were around 2 times for the low income groups compared to the reference group, reveal very high inequalities. Hence, the relative inequality is narrowing down, but the bottom groups still dominate the mean of infant mortality.

So far I can reject the first hypothesis that class creates inequalities in infant mortality through personal illness care, at least, and conclude that class has a small effect, which works through other variables not captured here. Second, low income has indeed a strong and negative impact upon infant mortality, and breastfeeding duration is an independent factor in the relationship between SES and infant mortality. Hence we have to understand how nutrition relates to both measures of SES and ascertain what alternative variables may test the power of nutrition in understanding the link between SES and infant mortality. Third, the impact of education on health is mediated by maternal factors, and therefore I reject the hypothesis that low educated mothers influence infant mortality through personal illness care. Finally, the trend of inequality in infant mortality appears to be declining, but the relative risks across groups remain strikingly high over time.

5. Discussion and conclusions

Low mortality and low inequality lies in our distant future. The evidence from Colombia confirms the strong correlation between SES and health, with income as the main driver of inequalities in infant mortality. In this study, wealth as a proxy for income predicts infant mortality well and makes clear that the bottom groups face a greater risk of mortality even though the universal health insurance prioritized children and women from its onset and has widened in the last decade to cover more than 90% of the population by 2010 from a low of 20% in 1990´s. In other words, if we were to manipulate income to improve health outcomes, the health care reform of the 1990´s appears not to have delivered. However, it is not income, but education the measure capturing the out-flattening of the SES gradient.

In this line, Montgomery et al (2000) argue that, even though non-monetary wealth is a weak proxy for income, a statistical test combining both SES measures suggests that education plays a determinant role in demographic behavior and health outcomes. Surprisingly, the educational gradient disappears in the full model and happens to reappear only in the absence of maternal factors (age, parity and birth order). Education below secondary education has fallen from around 92% to 60%, but it has not reached the point to promote widespread externalities in health. Out of the three components of maternal factors, parity seems to matter the most; this implies that the larger the parity the greater the risk of mortality, an empirical fact that tends to relate to household with lower SES (DHS final reports). Hence, if we are to manipulate education, a combination of additional years of education and fertility control are still central to any effort to reduce mortality.

In short, previous research indicates that income and education were expected to work through personal illness care, namely preventive measures and medical access (Hanmer et al, 2003). My findings suggest that poor women in Colombia may not have the means to buy adequate contraceptive devices and end up experiencing undesired pregnancies more often than less educated women experience the cost of learning by doing through unexpected pregnancies. This result supports the idea that contraceptive plans do relate to income rather than education. Furthermore, it puts into question whether the expansion of health insurance in the country has failed to provide the monetary means and the knowledge to use contraceptive plans and avoid infant and maternal mortality. In this line, Case et al (2002) argues that preventive measures, namely parental health habits such as medical access during pregnancy, contraceptive use, smoking, and so forth, and universal health insurance have to go hand in hand to equalize health outcomes.

Third, the class gradient was fully captured in the full model and remained rather stable across the OVB[9] models. I conclude that social class has an effect on infant mortality, but works through other variables. Third factor variables such as race or time preferences are not captured here. Class relates to social prestige and therefore to social and racial discrimination. This is more acute in developing countries, where informal labor markets still cover more than half of their economies, and social stratification is blended with discrimination in the

[9] OVB: ommited variable bias

formal and informal labor markets. Similarly, the lack to control one´s time conditioned on the relative price of health and be forced to face whether to invest time in their children or forego consumption. On the other hand, the DHS Colombian data presents very ambiguous data on occupational groups, which are confounded within the features of a dual economy like Colombia, where more than 50% of the population work in the informal labor market and poverty is widespread.

Class could be only an indirect target for public policy through leveling out the educational opportunities. Velez (2002) claims that the increase of education in years has been so slow, barely 4 years between 1960 and 1999 to an average of 7 years, mirrors the level of income inequality. Furthermore, the effect of education in rural areas may be mediated by the high levels of violence, lack of roads and poor quality of the service, what curtails the expansion of the externalities of education and therefore of health.

Fourth, nutrition (duration of breastfeeding) plays a role on its own in understanding the link between SES and infant mortality. The WHO recommends at least 6 months of exclusive breastfeeding. Although more than 94 % of Colombian women breastfeed their children, regardless of age, income, education or region of residence, the median duration of exclusive breastfeeding was less than a month in 1995 and around 1.8 months in 2010 (DHS report, 2010, p. 278). A similar pattern has been denounced for other Latin American countries and indicates that (Betrán et al, 2001). Thus, we have to understand how a broader definition of nutrition relates to SES and promote the idea that regional disparities in nutrition may have a say in understanding the social context affecting the relationship between breastfeeding and SES measures.

Fifth, the decline in infant mortality has been a story of success, but inequalities persist. Yet, the finding that the gradient has been declining over time, at least through education, excludes Colombia for the bulk of research indicating an increasing trend of inequality in the developing world (Wang, 2003; Minujin and Demonica, 2003; Jasper et al 2011). This implies that education and living standards are indeed associated with the relative decline in infant mortality by SES even though the household with low SES still dominate its mean. A caveat is though that estimates of infant mortality are said to be under-reported in the DHS and other sources of mortality data (Medina and Gutiérrez, 1999; Flórez, 2000; Minprotección Social, 2009). In sum, if we are to manipulate our SES measures to improve infant health through public policy, we must remember that subsidies are not enough to compensate the lack of income or the effects of poverty on health. A change in the relationship between education and health habits have to be put in motion in the set of instruments for public policy.

Appendix: figures and tables

Figure 1: An extended version of the Mosley and Chen framework

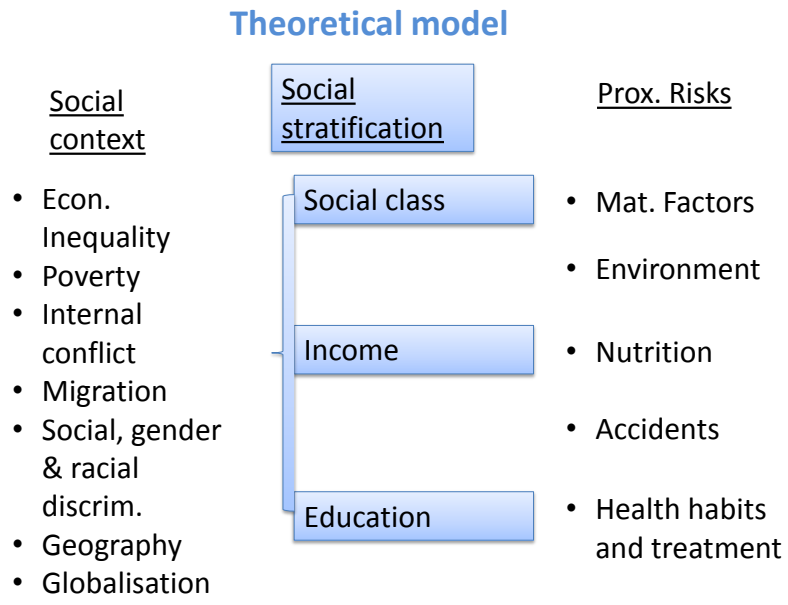
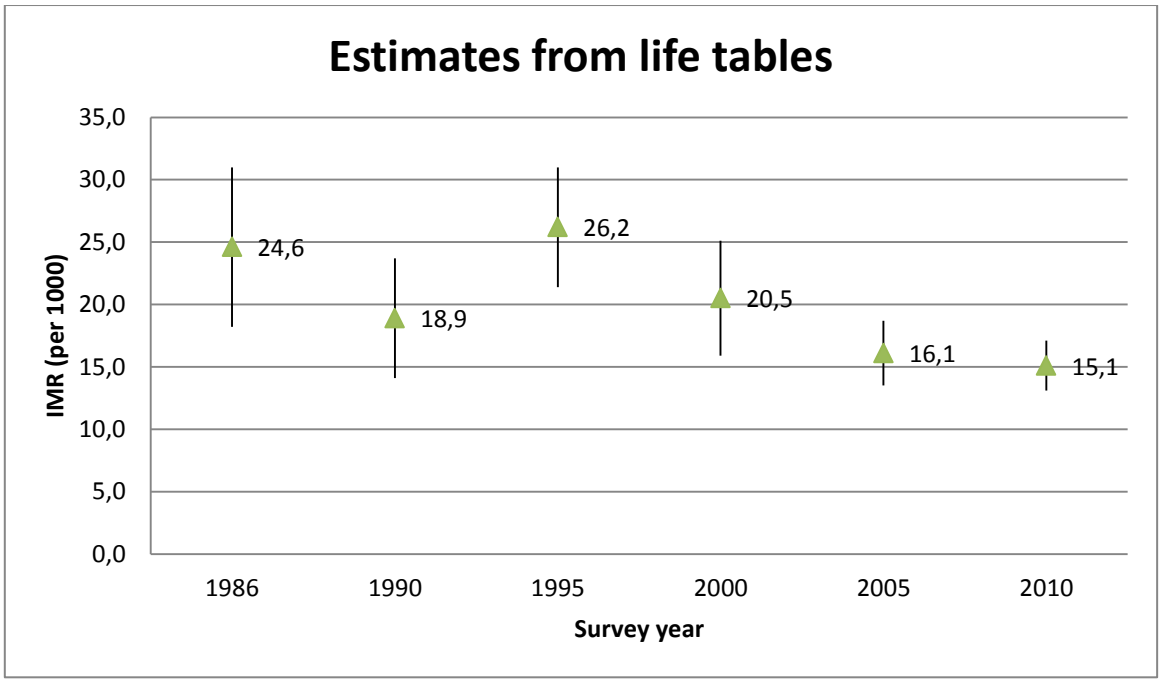


Figure 2: Trend of infant mortality (per 1000)



Source: Author, using life tables on DHS data

Table 1: Surveys used in the analysis, after deletion of censored data

DHS	IMR - life tables	std error per 1000	CI lower	CI higher	rel std error	number of births in analysis	DHS IMR
1986	24,60	3,2	18,20	31,00	13%	2 462	33
1990	18,90	2,4	14,10	23,70	13%	3 464	17
1995	26,20	2,4	21,40	31,00	9%	4 667	28
2000	20,50	2,3	15,90	25,10	11%	4 108	21
2005	16,10	1,3	13,50	18,70	8%	10 113	19
2010	15,10	1	13,10	17,10	7%	15 727	15
						40 541	

Source. DHS data, own calculations using ltable command from Stata; 3.454 observations were deleted from the original pooled sample, including 741 singleton births and 2713 missing observations relating to breastfeeding duration, in particular from the 2005 DHS survey.

Table 2: Percentage of urban population by father´s occupation

Occupation	1990	2010
Prof. And clerks	95%	95%
Sales and services	94%	94%
Skilled	94%	94%
Unskilled	89%	89%
Agrarian workers	35%	35%
totals	82%	82%

Source. DHS data, own calculations

Table 3: Asset quartiles in four wealth groups, DHS pooled sample

Asset	Poorest	Poor	Middle	Rich
has electricity	0,71	0,99	0,99	1,00
has radio	0,47	0,70	0,77	0,90
has fridge	0,16	0,37	0,88	0,99
has tv	0,43	0,84	0,99	1,00
has moto	0,06	0,14	0,05	0,42
has car	0,01	0,04	0,03	0,28
has telephone	0,28	0,75	0,99	1,00
water_piped	0,25	0,03	-	-
water_pumpwell	0,29	0,06	-	-
water_open	0,13	0,14	0,01	-
Intoilet	0,43	0,91	1,00	1,00
floor_dirt	0,39	0,06	0,00	-
floor_cement	0,31	0,48	0,40	0,21
floor_brick	0,07	0,18	0,14	0,58
share by quintile	0,31	0,26	0,26	0,16

Source. DHS data, own calculations using factor analysis.

Table 4: Descriptive summary

Means	1986	1990	1995	2000	2005	2010	Pooled
Infant mortality (per 1000)	24,6	18,9	26,2	20,5	16,1	15,1	18,1
Hhsize	6,6	5,9	5,9	5,7	5,5	5,5	5,7
Father´s occupational (in %)							
Prof & clerks	9,3	18,6	10,8	9,9	11,3	11,3	11,6
Sales and Services	18,9	23,1	20,9	23,03	39,9	35,9	31,8
Skilled	32,4	18,8	10,6	12,07	16,7	18,8	17,2
Unskilled	4,8	20,8	25,6	24,8	5,7	5,5	11,3
Agrarian work or self-employed	34,4	18,5	31,8	30,1	26,1	29,06	28,2
Family wealth (in %)							
Rich	0,8	11	22,5	32,5	23,4	16,9	19,2
Middle	31	46,7	26,1	23,9	19,7	23	23,3
Poor	18,2	22,2	24,2	21,4	30,5	30	28
Poorest	50	20	27,1	22,1	26,2	29,9	29,4
Mother´s education in (%)							
No prim	49,4	29,4	32,6	26,7	20,6	20,5	24,9
Primary	18,03	19,08	17,8	19,9	16,7	15,3	16,9
Less than sec	24,2	30,3	29,4	27,7	26,4	25,8	26,9
Secondary and higher	8,2	21,1	20	25,7	36,1	38,7	31,2
Maternal factors							
Age at child´s birth (in years)	19,9	20,71	20,44	20,5	19,9	19,8	20,4
Parity	3,5	2,8	3	2,7	2,6	2,7	2,79
Birth interval (in months)	21,6	21,7	22,2	2,6	23,6	30,7	26,5
Female born (%)	48,1	50,3	48,3	49	49,4	48,4	48,8
Marriage (%)	52,3	43,1	37,3	32	24,4	18,9	27,8
Nutrition							
Breastfeeding duration (in months)	23,3	24,3	24,4	31,6	27,1	31,7	28,4
Personal illness control							
No fplan (%)	39,1	36,8	31,6	27	25,5	25,8	28,3
Born with medical assistance (%)	71,4	82,5	82,6	85,1	89,4	88,7	86,3
Environment							
Place of residence (% rural)	37,9	18,2	36,4	33,2	28,6	36,9	32,9

Table 5: Survival models of infant mortality

Variables	1	2	3	3a	4
Prof and clerks	0,72**			0,9	0,99
Sales and services	1			1	1
Skilled	1,03			1,01	1,19
Unskilled	1,12			1,08	1,40*
Agrarian workers and self employed	1,29***			0,95	1,15
Rich		0,86		0,97	0,96
Middle class		1		1	1
Poor		1,33***		1,25**	1,50**
Poorest		1,73***		1,47***	2,32***
Higher and secondary			0,62***	0,68***	0,77
Some secondary edu			1	1	1
Primary edu			1,1	1,06	1,01
Less than primary edu			1,38***	1,26**	0,92
survey time	x	x	x	x	x
controls					x
failures	738	738	738	738	738
subjects	40541	40541	40541	40541	40541
clusters	32962	32962	32962	32962	32962
degrees of freedom	30	29	29	36	49
log likelihood	-5120,67	-5107,56	-5101,43	-5093,8	-3776,01
prob. likelihood ratio of theta	0,001	0,002	0,002	0,002	0

Piece-wise constant hazard models. Controls for household size and the proxy determinants (categorical variables for age, parity and firstborn, marital status, breastfeeding duration and contraceptive methods; dummy for child´s sex, place of residence, and trained assistance at delivery).

Table 6: Proximate risks and omitted variable bias

Variables	full	no maternal factors	no demography	no location	no nutrition	no prevention	no medical services
Prof &clerk	0,99	0,94	0,96	0,99	0,94	0,92	0,99
Services and sales	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Skilled	1,19	1,17	1,20	1,19	1,04	1,15	1,18
Unskilled	1,40*	1,38	1,38	1,40*	1,09	1,39	1,40*
Agrarian work and self. Employ.	1,15	1,17	1,16	1,13	0,98	1,12	1,18
Rich	0,96	0,89	0,93	0,96	1,06	0,93	0,97
Middle class	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Poor	1,50**	1,54**	1,51**	1,50**	1,13	1,55**	1,51**
Poorest	2,32***	2,62***	2,39***	2,30***	1,17	2,73***	2,45***
Sec. And higher	0,77	0,64**	0,76	0,78	0,74**	0,76	0,78
Some sec. edu	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Prim edu	1,01	1,16	1,02	1,01	1,00	1,01	1,02
Less than primary	0,92	1,37*	0,93	0,92	0,99	0,99	0,96
failures	738	738	738	738	738	738	738
subjects	40 541	40 541	40 541	40 541	40 541	40 541	40 541
clusters	32 962	32 962	32 962	32 962	32 962	32 962	32 962
degrees of freedom	49	46	46	48	47	47	48
log likelihood	- 3 776	- 3 820	- 3 784	- 3 776	- 4 976	- 3 821	- 3 778
prob log likelihood of theta	0	0	0	0	0	0	0

Piece-wise constant hazard models. Survey time plus controls for household size and the proxy determinants (categorical variables for age, parity and firstborn, marital status, breastfeeding duration and contraceptive methods; dummy for child´s sex, place of residence, and trained assistance at delivery).

Table 7: Interactions models

	1986/1990	1990/1995	1995/2000	2000/2005	2005/2010
	1	2	3	4	5
time*poor	20,9	1,33	0,66	0,73	2,1
time*poorest	5,97	1,55	1,04	0,77	1,36
time*primary	0,69	1,16	1,12	0,59	1,45
time*less than primary	0,67	1,19	0,4	1,98	0,74
time*unskilled	5,54	0,28*	1,7	0,31	3,48
time*agrarian workers	2,56	0,55	1,71	1,11	0,75

Piece-wise constant hazard models. Groups of observations are pooled together by adding two surveys subsequently for a total of five, starting with 1986/1990. Controls for household size and the proxy determinants (categorical variables for age, parity and firstborn, marital status, breastfeeding duration and contraceptive methods; dummy for child´s sex, place of residence, and trained assistance at delivery).

Table 8: The relative index of inequality (RII) by SES

Svyear	Occup	R^2	Wealth	R^2	Edu	R^2
1986	0,08	16%	na	na	0,39***	90%
1990	0,17	53%	0,24	80%	0,39**	84%
1995	0,07	13%	0,31	88%	0,31*	87%
2000	0,10	48%	0,18	86%	0,14	49%
2005	0,14*	68%	0,22	88%	0,27*	87%
2010	0,13***	84%	0,24**	93%	0,27**	95%

Table 8.1: The RII by education

survey	slope	IMR	RII
	(a)	(b)	(a/b)
1 986	11,90	30,20	0,39***
1 990	7,80	20,20	0,39**
1 995	9,40	30,00	0,31*
2 000	3,40	24,00	0,14
2 005	5,70	20,90	0,27*
2 010	4,30	16,10	0,27**

Data source: DHS data, own calculations using WLS. The pooled sample size contains 35,768 children to avoid censoring on the estimation of the infant mortality rates by groups, in other words, children not exposed to the full risk of mortality during their first year of life. * significant at the 10% level, ** at the 5% and at *** the 1% level

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