Socioeconomic Inequalities in Mortality in Colombia:

trends, health insurance coverage and economic cycles

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Socioeconomic Inequalities in Mortality in Colombia: trends, health insurance coverage and economic cycles

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Μαικελ χαι Αντώνιος,
“Δύο [ἀδελφοὶ] είσιν ειν ψυχὴ εν δύο σώματι”
Αριστοτελες

CONTENTS

SECTION I

INTRODUCTION

Chapter 1

Background

1.1. CONCEPTUAL FRAMEWORK

1.1.1. Health inequalities in Colombia

While much research has examined health inequalities in the developed world, less is known about health inequalities within low- and middle-income countries (LMIC) [1]. Documenting health inequalities in low- and middle-income countries is important for several reasons: First, from a public health perspective, a large fraction of the Global burden of disease takes place in low- and middle-income countries [2]. Second, low- and middle-income countries have experienced major changes in policy and the role of the state in improving population health, both through the expansion of public health services and the increase in coverage from health insurance programmes. Understanding the impact of these changes on inequalities in population health can offer important lessons on how policy reforms can contribute to reducing health inequalities worldwide. Documenting health inequalities in low- and middle-income countries can also offer important insights on the extent to which health inequalities are amenable to change.

Colombia is an interesting case study due to the many changes in health care, social and economic policy during the past two decades. Several studies have documented the existence of large inequalities in Colombia, with particular focus on inequalities in the onset of disease, risk factors, financing of the health care system and access to health care. Large inequalities in Colombia have been observed in the prevalence of infectious diseases [3-7], and nutrition-related conditions, particularly among children [8-12]. Large ethnic [13] and gender [14-17] inequalities in health and health care have also been documented. Inequalities have been documented in physical activity [18, 19]- and tobacco use [20]. A recent study estimated that 26% of lower-educated Colombians aged 25-50 years have at least one risk factor for cardiovascular disease, as opposed to only 5.9% in those with a university degree [21]. Socio-economic inequalities in the use of health care services have also been documented for access to expensive therapies [22, 23], infectious diseases [6], preventive services [24-26], dental care [27] and access to primary care [28-33].

Despite their valuable contribution, there are several limitations in these studies. First, most of them focus on a particular point in time. Few studies have analysed trends in health inequalities in Colombia, and no studies have linked changes in the distribution of health to recent social policy reforms and changes in the broader economic context. This is important because Colombia has experienced major changes in health and social policy, as well as large changes in economic well-being. In recent decades, Colombia has experienced high levels of economic growth albeit offset by rising levels of social inequality [34-37], but whether this pattern has resulted in increasing health inequalities over time has not yet been examined [38]. The gap in earnings among higher and lower educated workers has also grown during the past decades [39]. It is estimated that 59% of lower educated households live in poverty, as opposed to only 4.1% among their higher-educated counterparts [40]. 96% of households in the highest income quintile have access to water services as opposed to 75% in the lowest income quintile. Similarly, 90% of households in the highest income quintile have access to drainage services, in contrast to 54% in the lowest income quintile [41]. Latin America and the Caribbean remains the most unequal region in the world, despite important advances in recent decades [42]. A potential unexplored hypothesis is that despite improvements in overall conditions of living, those in the lower socioeconomic groups have been left behind in their health and mortality [38]. The distinctively high levels of social inequalities in Colombia may thus lead to higher levels of health inequalities when compared with more prosperous societies.

1.1.2. Epidemiological transition in Colombia

The epidemiologic transition theory poses that low- and middle-income countries are undergoing an epidemiologic transition characterized by falling rates of infectious diseases and increasing rates of non-communicable diseases. [43]. Evidence, however, suggests that many middle-income countries often combine a pattern of increasing levels of mortality from non-communicable diseases similar to that in high-income countries [44], with relatively high mortality from infectious diseases and injuries [45]. This results in a "double burden", which is often combined with relatively high levels of mortality inequalities [46]. The double burden model is based on the "protracted polarized model" [47] that has been used to describe the Latin American transition, and has two key elements: (i) coexistence of infectious diseases, injuries and non-communicable diseases and (ii) a concentration of morbidity and mortality among poor populations [46].

Data from the World Health Organization (WHO) (see appendix-figure 1 in chapter 2 page 53) suggest that Colombia faces relatively high mortality from communicable diseases and injuries, as well as high mortality from non-communicable diseases [48]. Rates of premature mortality from non-communicable diseases in Colombia are comparable in magnitude to those in high-income countries, while mortality from infectious diseases and injuries are up to four times higher [2]. Unlikely high-income countries, this transition has not occurred at the same pace for mortality from injuries [49], particularly homicide, which remains a leading cause of death among men [50].

A potential hypothesis is that the increasing burden of non-communicable disease mortality in Colombia [48] has disproportionately affected the lower socioeconomic groups, who have traditionally experienced larger mortality from communicable diseases and injuries [48]. Lower socioeconomic groups may be more vulnerable to communicable diseases, injuries, and non-communicable diseases than their higher socioeconomic counterparts [46]. In European countries, approximately two thirds of socioeconomic inequalities in mortality are attributable to cardiovascular disease and cancer, with less than 5% attributable to injuries and communicable diseases [51]. In the

USA, cardiovascular diseases accounts for the larger share of educational inequality in life-years lost (34.0%), while trauma contributes 10.7% and infections 21.1% [52].

This pattern may be markedly different in low- and middle-income countries, where non-communicable diseases have become a leading cause of death, but mortality from both communicable diseases and injuries remains relatively high [47, 53]. While lower socio-economic status is often associated with higher mortality from 'poverty-related diseases' such as preventable infections [49], it is less clear how socioeconomic status might relate to conditions associated with modern lifestyles such as cardiovascular disease, cancer, and other non-communicable diseases [49]. Earlier studies have documented the contribution of socioeconomic inequalities in mortality from different causes in Europe [51, 54, 55], the United States [52, 56] and other wealthy countries [57], while studies addressing this question in low- and middle-income countries are scarce [58]. Part of this gap in the literature reflects a lack of available data on mortality stratified by meaningful indicators of socio-economic status. Whether this contributes to increased inequalities in mortality for each cause of death remains unknown.

In conclusion, Colombia offers an interesting case study owing to several reasons. It combines a pattern of high mortality from non-communicable diseases with high mortality from communicable diseases and injuries [48]. It has experienced major social and economic changes over the last decades, combined with persisting inequalities in social and economic circumstances [59], which may have contributed to widening health inequalities. Further research is required to better understand the mechanisms that lead to health inequalities, and the potential policies that may be useful in tackling health inequalities in Colombia and other middle- and low-income countries.

1.1.3. Insurance coverage and health outcomes

Expanding health care Insurance Coverage (HIC) across all socio-economic groups has been proposed as a key strategy in low and middle-income countries to improve health [60-62]. Previous studies indeed support the idea of a positive impact of increasing insurance coverage on population health [63, 64], albeit it has not been shown to be as effective in reducing health inequalities [65]. Few studies have examined the impact of health insurance on mortality, particularly in middle-income countries, many of which have introduced mandatory insurance programmes over the last decades.

Several studies have examined the effects of insurance coverage on health in both developed [64, 66, 67] and developing countries [68-72]. There is some controversy on whether expanding health insurance coverage has contributed to improving health and reduce health inequalities in Colombia [73-78], the USA [64, 65, 79, 80] and elsewhere [70, 81-83]. Moreover, several studies in the US [84, 85] and middle-income countries as Taiwan [81] or Thailand [70] support the notion that despite its benefits, health insurance access is insufficient to reduce inequalities in health, and may play only a limited role compared to other factors that determine both access to high-quality care and mortality. In European countries, for example, inequalities in mortality persisted and tended to increase even if universal health care coverage was achieved [82, 83, 86]. Across most OECD countries, specialist care has been found to be pro-rich even after controlling for need differences, but these inequities are not systematically smaller in countries with universal coverage, such as Finland or Sweden [67].

Despite potential beneficial effects, several studies support the hypothesis that health insurance is only one among many determinants of inequalities in health and mortality [79, 80]. Other important risk factors for inequalities are unhealthy behaviours, psychosocial well-being, parental socioeconomic status, childhood living circumstances [87], sedentary life-styles, higher obesity [88] as well as distal determinants such as poverty and living and working conditions [63].

In conclusion, little is known about the impact of HIC on socioeconomic inequalities in mortality. Findings of this study will be relevant to a broader set of countries that have recently implemented similar reforms to their welfare system and, like Colombia, have experienced major economic transformations during the last decades.

1.1.4. Health care insurance reform and coverage in Colombia

Colombia offers a unique case study to examine the impact of health insurance coverage due to extensive structural reforms implemented in recent decades, including an aggressive policy of decentralization and expansion of coverage across the country [73, 89]. In 1993, a major health care reform introduced mandatory insurance coverage [73]. The reform assigned citizens to two major schemes based on income: (i) the contributory scheme, which covers workers and their families with an income above the cut-off and is financed through payroll and employer's contributions; and (ii) the subsidized scheme, mainly funded via taxes, which subsidies the poor as identified through a proxy means test [75]. Health care insurance coverage was 23.7% in 1993 just before the reform [31] and rose to 37.7% in 1994 [73] by going from individual coverage only to family coverage. After a period of sluggish growth over the forthcoming years (56.5% in 2000) [73], a decentralization reform in 2001 led to a noticeable increase of health care coverage by improving efficiency in the use of sources and by reducing its reliance on national budgets [89]. There was also an explicit commitment of successive Colombian governments to expand health care insurance coverage for the poor through the subsidized scheme [73]. As a result, insurance coverage increased from 61.3% to 93.4% between 2003 and 2009 [73], almost reaching universal coverage afterwards (96%) (Figure 1).

A common expectation is that increasing insurance coverage among the poor will reduce health inequalities [73, 75]. As shown in Figure 2, in the poorest income quartile, insurance coverage increased from 4.3% in 1993 to over 87% in 2011[75] owing to the large increase in affiliation to the subsidized scheme [90], which shows that the programme reached the poorer income groups more aggressively.

Previous evidence suggests that the expansion of health insurance coverage has increased access to services among the lower socioeconomic groups [74-76]. A recent paper also examined the impact of subsidized health insurance and found large effects on several health outcomes such as birth weight and other newborn health measures [91], while another study found increased use of preventative health services in the subsidized scheme, with mixed effects on curative care (increase use in the adult population, but not in children) [92]. The debate about the impact of increased coverage on actual access to high quality care remains [93, 94].

Although the Colombian reform may have improved access to care among the poor, whether it ultimately influenced socioeconomic inequalities in mortality has not yet been explored in detail. Few studies in Colombia have examined trends in socioeconomic inequalities in mortality after the health care reform. A recent government study reveals large SES inequalities in disability, infectious and childhood diseases, sexually transmitted diseases, perceived morbidity and health care access [95], despite of the favourable increase of HIC [90]. Previous studies found also that despite significant increases in HIC among lower SES groups in Colombia, this does not seem to have been translated into improved health care in these groups [93, 96, 97]. Several explanations may account for this, including costs associated with accessing care even in the context of universal coverage; less knowledge of available care among the lower educated; and less investment in care and prevention in these groups.

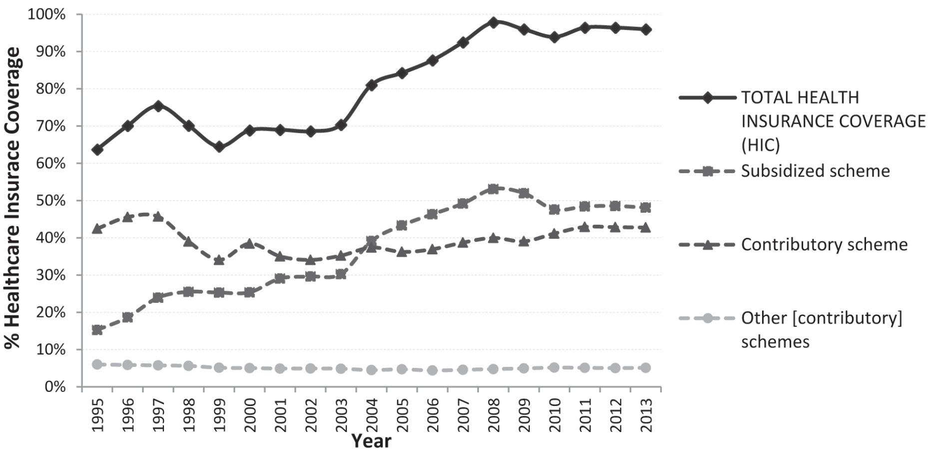

Figure 1. Healthcare Insurance Coverage (HIC) in the aftermath of the reform to the Colombian health system (1995-2013)
Source: Reports of the Ministry of Health and Social Protection

Exploring health inequalities in Colombia is of particular interest due to these major reforms to the health care system. Similar to the Colombian example, many middle income countries have recently introduced major health care system reforms in the past decades [98]. Studying how health inequalities have evolved in response to the Colombian reform can shed light on the impact of the health care system on population health and health inequalities. Although Colombia is close to reaching universal health care insurance coverage [75], whether these recent reforms have actually contributed to diminishing inequalities in health outcomes remains largely unknown.

1.1.5. Short-term economic fluctuations and mortality

An alternative perspective to examine the relationship between socioeconomic circumstances and health is to explore how macro-economic conditions influence health and mortality. The very first studies carried out in high-income countries initially found that mortality decreases when the economy improves [99-102]. However, these studies were strongly criticised by being sensitive to the observation period, and potentially biased as they were based on macro-level time-series analyses [103]. Since then, studies on the effect of economic fluctuations on mortality have used regional or state fixed methods to overcome methodological limitations of previous studies [104]. Contrary to earlier research, several recent studies using panel regressions show that mortality decreases during economic downturns and increases during economic upturns [104-114]. Cross correlation studies for long periods have reported similar findings [115-117]. These findings were also obtained using health indicators other than mortality [118, 119]. Most of these studies focused on the USA [104, 110, 113, 114, 117, 119], Europe [107-109, 111, 112, 115, 118], and other developed countries [105, 106, 116], while few studies have examined whether economic fluctuations influence mortality in middle-income countries [120-122].

Previous research in wealthy nations found that during short-term economic cycles there are three major potential effects on mortality: (i) An noticeable decrease during downturns in mortality from cardiovascular diseases [104, 106-108, 111-114, 116, 117] and traffic accidents [104, 106-108, 111, 112, 114, 116, 117, 123], which contribute substantially to total mortality, and a similar effect for mortality from other chronic conditions (respiratory disease [108, 114, 117], renal failure [114, 117], liver disease [104, 111, 116]), infant mortality [104, 106, 110, 114, 116], and mortality from infectious diseases [108, 114], particularly from pneumonia/flu [104, 111, 112, 116, 117]; (ii) An increase in suicide during economic downturns [104, 106, 108, 114, 116, 117, 123]; and (iii) no effect of business cycles on mortality from tuberculosis [116, 123] or other causes of death not mentioned above. Diabetes showed a weak decrease during upturns or even no association [106, 116, 123]. Some studies found increased mortality from cancer during upturns [108, 117], while other studies found a decrease [114, 116] or no association with the bussiness cycle [104, 107, 111, 112]. During upturns, homicide increased in the USA [104, 114], but was unrelated to the business cycle [108, 112] or declined in European studies [111, 123].

As mechanisms driving these increases in mortality during short-term upturns, it has been suggested that unhealthy behaviours and external 'risks' (environmental, labour) increase when the economy improves. Some of these potential pathways have been summarized by Tapia-Granados [108]. In this model, environmental and labour conditions become more hazardous during upturns. In the same way, increases in income lead to increases in alcohol and tobacco consumption, saturated fat diet, and traffic volume [108]. Using individual level data, previous studies have also found that individuals engage in more healthy behaviour during economic downturns: they engage in more physical activity, healthy diet and reduction in smoking and obesity [104, 124], as well as reduction in alcohol consumption [110, 114, 124]. Increases of traffic accidents during upturns were mirrored by reduction of car-use during recessions [104, 110, 114]. Alcohol consumption associated with car-use also reduces during economic downturns [125]. An increase in use of preventive medical care during economic downturns owing to reduction in cost of time was also previously reported [104, 114]. These changes in behaviours offer a potential explanation for variations in mortality patterns observed in recent studies.

On the other hand, the existing evidence suggests that the decreased mortality during economic recessions observed in high-income countries may not be as consistent in middle- and low-income countries [120, 121, 126-128]. There are at least two reasons why the reduction in mortality associated with economic downturns in high-income countries may not be replicated in less wealthy nations. The impact of downturns on living conditions in high-income countries may be partly offset by social protection programmes such as unemployment benefits or health care insurance as well as by support from family members [123, 129-131]. In contrast, most low- and middle-income countries lack comparable

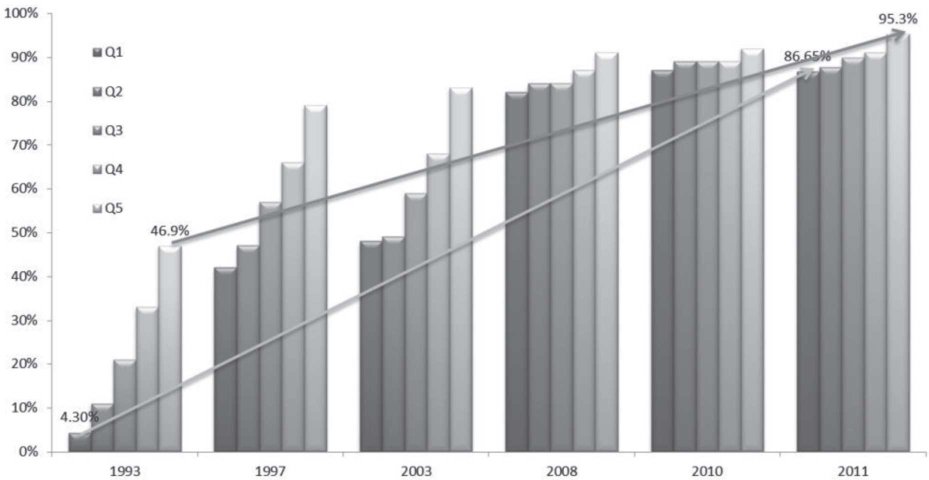

Figure 2. Healthcare Insurance Coverage in Colombia by income quintiles
Source: Ministry of Health and Social Protection, based in Quality Health Surveys (QHS)

safety nets to mitigate the social and economic impact of economic downturns [131]. A potential hypothesis is that populations in low- and middle-income countries are more vulnerable, so that any decreased mortality during economic downturns is outweighed by strong negative effects of worsening in living conditions relevant to health [126, 127]. This difference in living standards is also reflected in the different composition of causes of death across high-, middle- and low-income countries [132], which may lead to different associations with economic cycles [131]. In wealthy nations, non-communicable diseases contribute the largest share of all deaths, while in many low- and middle-income countries, injuries and communicable diseases also contribute considerably to mortality [132]. Because the impact of economic fluctuations on mortality may differ for different causes of death [125], the larger contribution of external and communicable disease mortality may yield different associations for total mortality in low- and middle-income countries than in wealthy nations.

Evidence from several countries suggests that the association between economic fluctuations and mortality may vary within each country also according to the level of regional development. For example, evidence from Mexico suggests that the association between business cycles and mortality in the period 1993-2004 differed by level of economic development. While mortality was procyclical in the ten most developed states, it was countercyclical in the least ten developed states [121]. This was primarily driven by strong procyclical non-communicable disease mortality in the most developed states, compared to countercyclical mortality for communicable diseases such as tuberculosis and HIV/AIDS in the least developed states [121]. In general, the mechanisms which may explain the shifts in the association between short-term economic fluctuations and mortality are not yet well understood [126, 127, 131].

Results from previous studies in developed countries indicate that more developed social safety nets may mitigate the negative effects of economic downturns on mortality [107, 111, 133]. Colombia was characterized in past decades by its relatively weak social safety nets, and in particular an underdeveloped health system as well as a lack of social programmes to protect the unemployed or most vulnerable populations during economic downturns [134]. In contrast, from the mid-nineties Colombia witnessed the introduction of major social protection programmes and an increase of social expenditures in many regions, most notably through the introduction of subsidized health insurance for a large majority of the population [75, 135]. In parallel, public social expenditure as a percentage of GDP increased from 6.0% in 1990 to 13.6% in 2010 [136]. Average of per capita income has tripled from 1980 to 2010 [137]. Furthermore, since 2000 several social protection programmes targeted to the poor have been introduced, including social benefits to alleviate the effects of poverty through conditional cash transfers, social housing and food programmes, and special transfers to poor families [135]. As a result we expect the substantial improvements in access to health care, social welfare programmes and overall living conditions may have outweighed potential negative health effects of economic expansions.

1.2. THIS THESIS

The present thesis aims to make several important contributions to the understanding of health inequalities in Colombia and how their evolution relates to the expansions of health insurance coverage and changing macro-economic conditions over the last two decades. From the review of studies above, it is clear that most studies are based on self-reported data from surveys and do not examined inequalities in mortality. Previous studies on health insurance coverage have focused on the impact of health care reform on utilization and access to health care services, while few studies have examined the impact on population health [68, 74, 76, 138], and none have examined mortality and survival. The main contribution of this thesis is thus to use an innovative approach based on mortality registry data linked to census information to understand how inequalities in mortality have evolved over a critical period of policy reform in Colombia.

Examining mortality as an outcome and focusing on inequalities is important for several reasons. First, even if evidence might suggest that increased access to health insurance increases access to health care services, from a public health perspective, the main interest is whether insurance ultimately improves population health and reduces mortality. This question can only be answered by analysing long-term trends in mortality over the period covering the major reforms. A focus on inequality is essential because health insurance reforms are often particularly targeted to expanding access to the most vulnerable and socioeconomically disadvantaged groups. In the case of Colombia, this took place through the expansion of subsidized health insurance, which is targeted to the poorest segments of society and currently represent almost half of the insured through the system. By definition, therefore, subsidized health insurance should contribute to reducing inequalities in mortality if it ensures access to high-quality care that has an impact of the health and mortality of the poor.

A second important contribution of this thesis is to document socioeconomic inequalities in mortality from multiple causes in Colombia. Understanding inequalities in different causes of death can shed light on the potential determinants of these inequalities. For example, the large inequalities in lung cancer mortality in Northern European countries and the United States have been traced back to large inequalities in smoking behaviour, suggesting that a focus on smoking prevention may be key to reducing inequalities in health. Similarly, inequalities in infant mortality, a cause of death that is to a large extent preventable, may point to specific failures in the health care system in providing high-quality pre- and post-natal care. Similarly, inequalities in homicide mortality may point at the need to target interventions to violence prevention in low-income settings as a strategy to reduce inequalities in mortality, particularly among young men. Thus, we expect that a detailed analysis of causes of death will contribute to a better understanding of the causes and pathways of health inequalities in middle-income countries.

An important organizing principle and end goal of this thesis is to provide a road map of potential policies to reduce health inequalities in Colombia. Findings from this thesis will be also of potential interest to other middle-income countries that have recently implemented reforms to achieve universal access. Although the social and economic context of Colombia is particular, lessons from the Colombian reform can shed light on the patterns and trends of inequalities in premature mortality and the potential impact of increased health care insurance coverage on health inequalities in a broad set of countries currently expanding insurance coverage.

1.2.1. Research questions

The distinctive nature of this thesis is in the combination of a focus on assessing trends in socioeconomic inequalities in total and cause-specific mortality; exploring the relationship between health insurance coverage and inequalities in mortality; and examining the impact of changing macro-economic conditions on trends in mortality over the past two decades in Colombia. For this purpose, this thesis addresses the following specific research questions:

1. Have socioeconomic inequalities in all-cause and cause-specific mortality by socioeconomic status changed in the period from 1987 to 2012?
2. Has the expansion of health insurance coverage contributed to decreasing trends in socioeconomic differences in mortality over the past two decades?
3. What was the impact of macro-economic fluctuations (business cycles as measured by regional GDP) on mortality trends in Colombia in the period from 1980 to 2010?

1.2.2. Structure of thesis

In addition to this introduction and methods (chapter 1), this thesis is divided into four additional sections. The first section comprises two chapters [2-3] aimed to examining trends in socioeconomic inequalities in mortality in total and cause-specific mortality by educational level between 1998 and 2007 in Colombia (research question 1). In chapter 2, we assessed inequalities by educational level in mortality from non-communicable diseases, infectious diseases, injuries and other causes of death. This study particularly underscores the significance of homicide as a major contributor to inequalities in total mortality in Colombia. Chapter 3 focuses specifically on examining trends in socioeconomic inequalities in cancer mortality, documenting inequalities in mortality from several major cancer sites comprised in three broad groups: Infection-related cancers (stomach and cervical cancer), cancer associated with behavioural risk factors (breast, prostate, lung and colorectal cancer), and other cancers not classified in the above categories (Chapter 3).

The third section comprises three chapters [5-7] and examines the relationship between health care insurance coverage and socioeconomic inequalities in mortality in Colombia (research question 2). In chapter 4, we assess the potential impact of increased HIC on health inequalities in Colombia by examining trends in mortality by educational level in the period 1998-2007, explicitly distinguishing two periods with different levels of health care insurance coverage. If socioeconomic differences in mortality were responsive to increased HIC, we would expect a more favourable trend in socioeconomic differences in mortality during the second as compared to the first period. In the next chapter we evaluate whether trends in inequalities in premature cancer mortality by educational level are associated with different levels of access to healthcare insurance during the period 1998-2012, a period in which virtual universal healthcare coverage was achieved (chapter 5). Finally, in chapter 6 we use vital registration data to examine the relationship between health insurance status and newborn mortality in Colombia. This chapter also explores the role of access to caesarean section as a potential mechanism linking health insurance access and neonatal mortality. Newborn mortality is a sensitive measure of access to high-quality care and is arguably more responsive to insurance coverage than many causes of adult mortality.

The fourth section of this thesis (chapter 7) adopts a 'macro-economic' perspective and concentrates on assessing the impact of changes in Gross Domestic Product, a measure of the state of the economy, on mortality in Colombia. Using panel fixed effects and exploiting regional variations in the business cycle, this chapter contributes to an expanding literature that links fluctuations in the economy to temporary changes in mortality (research question 3). Distinguishing two separate periods (1980-1995 and 2000-2010), this chapter assesses whether associations between economic fluctuations and mortality changed after the large expansion of healthcare insurance coverage in Colombia since 2000.

This thesis concludes in chapter 8 (Section V) with a general discussion of the findings, the new insights provided by our studies and the implications for public health policy and future research.

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Section II

Trends in socioeconomic inequalities in mortality in Colombia

Chapter 2

Socioeconomic inequalities in premature mortality in Colombia, 1998–2007:

the double burden of non-communicable diseases and injuries

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Socioeconomic inequalities in premature mortality in Colombia,
1998–2007: the double burden of non-communicable diseases and injuries
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ABSTRACT

Objectives

Non-communicable diseases have become the leading cause of death in middle-income countries, but mortality from injuries and infections remains high. We examined the contribution of specific causes to disparities in adult premature mortality (ages 25–64) by educational level from 1998 to 2007 in Colombia.

Methods

Data from mortality registries were linked to population censuses to obtain mortality rates by educational attainment. We used Poisson regression to model trends in mortality by educational attainment and estimated the contribution of specific causes to the Slope Index of Inequality.

Results

Men and women with only primary education had higher premature mortality than men and women with post-secondary education (RRmen = 2.60, 95% confidence interval [CI]: 2.56, 2.64; RRwomen = 2.36, CI: 2.31, 2.42). Mortality declined in all educational groups, but declines were significantly larger for higher-educated men and women. Homicide explained 55.1% of male inequalities while non-communicable diseases explained 62.5% of female inequalities and 27.1% of male inequalities. Infections explained a small proportion of inequalities in mortality.

Conclusion

Injuries and non-communicable diseases contribute considerably to disparities in premature mortality in Colombia. Multi-sector policies to reduce both interpersonal violence and non-communicable disease risk factors are required to curb mortality disparities.

Keywords

- Mortality determinants;
- Health transition;
- Colombia;
- Health status disparities;
- Educational status;
- Socioeconomic factors;
- Burden of illness;
- Age-specific death rate

Highlights

- Both injuries and non-communicable diseases contribute to mortality inequalities.
- Homicide contributed more than half of inequalities in male premature mortality.
- Policies on violence and chronic disease risk factors are key to curb disparities.

INTRODUCTION

In most high-income countries, approximately two thirds of socioeconomic inequalities in mortality are attributable to cardiovascular disease and cancer, with less than 5% attributable to injuries and communicable diseases (Huisman et al., 2005). This pattern may be markedly different in low- and middle-income countries, where non-communicable diseases have become a leading cause of death, but mortality from both communicable diseases and injuries remains relatively high (Frenk et al., 1991). While lower socioeconomic status is often associated with higher mortality from 'poverty-related diseases' such as preventable infections (Singh and Singh, 2008), it is less clear how socioeconomic status might relate to conditions associated with modern lifestyles such as cardiovascular disease (Singh and Singh, 2008). The contribution of different causes to socioeconomic inequalities in mortality has been documented in wealthy nations (Fawcett et al., 2005, Huisman et al., 2005, Kunst et al., 1998b and Wong et al., 2002), while few studies have focused on low- and middle-income countries (Belon et al., 2012).

Colombia faces relatively high mortality from communicable diseases and injuries, as well as high mortality from non-communicable diseases (Mayorga, 2004). Rates of premature mortality from non-communicable diseases are comparable to those in high-income countries, while mortality rates from infections and injuries are four times higher (Appendix Figure 1) (World Health Organization, 2012). This pattern has resulted in a double burden, with injuries and communicable diseases accounting for approximately half of all deaths, and non-communicable diseases for another half (Mayorga, 2004 and World Health Organization, 2012). A potential hypothesis is that the increasing burden of non-communicable disease mortality (Mayorga, 2004) has disproportionately affected the lower socioeconomic groups, which also have higher mortality from infectious diseases and injuries (Mayorga, 2004).

Classified as a middle-high income country (World Bank, 2011), Colombia has experienced improvements in socioeconomic and healthcare indicators over the last decades. Between 1998 and 2007, constant GDP per capita grew on average by 1.9% per year. The percentage of population living in poverty (less than US$2 per day) declined from 14.1% in 1998 to 7.5% in 2007 (World Bank, 2011), and healthcare insurance coverage increased from 59.8% to 92.5% (Arroyave et al., 2013). Educational attainment has also risen (Appendix Figure 2), with noticeable increases in the proportion of population with secondary and tertiary education (IIASA/VID, 2010). Despite these improvements, inequalities in Colombia remain high by international standards; in 1999–2003, the Gini coefficient of income inequality was 55.9% (World Bank, 2011).

In this study, we examine trends in socioeconomic inequalities in mortality and estimate the contribution of specific causes of death to these differentials between 1998 and 2007 in Colombia. We hypothesized that mortality from non-communicable diseases, infections and injuries contributes each to socioeconomic differences in mortality. However, we expected an increasing concentration of non-communicable diseases in the lower socioeconomic groups, leading to widening socioeconomic inequalities in total mortality.

Table 1. Premature mortality rates per 100,000 person-years by educational level, ages 25–64, 1998–2007, Colombia.

	Deaths		Percentage of deaths		Standardized mortality rates per 100,000 person-years [a]	
	Men	**Women**	**Men**	**Women**	**Men**	**Women**
Deaths by cause						
Cardiovascular diseases (CVD)	70,757	51,976	18.1%	25.8%	44.0	30.5
Malignant neoplasm	49,809	65,601	12.7%	32.5%	37.1	47.9
Diabetes mellitus (DM)	9,769	10,616	2.5%	5.3%	5.6	5.0
Chronic lower respiratory diseases (CLRD)	7,298	5,729	1.9%	2.8%	3.0	2.4
Total Non-Communicable diseases	**137,633**	**133,922**	**35.2%**	**66.4%**	**89.7**	**85.8**
Traffic Accident	29,104	6,373	7.4%	3.2%	33.1	6.8
Suicide	9,399	1,929	2.4%	1.0%	10.5	1.9
Homicide	121,983	9,966	31.2%	4.9%	124.3	10.0
Other injuries	25,056	4,057	6.4%	2.0%	28.7	4.3
Total Injuries	**185,542**	**22,325**	**47.4%**	**11.1%**	**196.6**	**23.0**
Tuberculosis (TB) and sequelae	4,200	1,861	1.1%	0.9%	4.0	1.9
HIV disease (AIDS)	14,369	3,218	3.7%	1.6%	15.4	3.1
Pneumonia	5,057	3,494	1.3%	1.7%	4.9	3.0
Other infectious diseases	4,894	3,520	1.3%	1.7%	5.1	3.3
Total Infectious Diseases	**28,520**	**12,093**	**7.3%**	**6.0%**	**29.5**	**11.2**
Other Non-Communicable Diseases	24,225	17,281	6.2%	8.6%	21.5	14.7
Rest of diseases	9,602	13,309	2.5%	6.6%	9.8	14.1
Ill Defined Causes	5,841	2,877	1.5%	1.4%	6.4	2.8
Total Other Diseases	**39,668**	**33,467**	**10.1%**	**16.6%**	**37.7**	**31.6**
Deaths by educational attainment [b]						
Primary	244,971	139,358	62.6%	69.1%	439.9	192.2
Secondary	121,136	52,386	31.0%	26.0%	312.2	126.6
Tertiary	25,258	10,064	6.5%	5.0%	166.0	81.8
Total deaths	**391,363**	**201,807**	**100%**	**100%**	**353.5**	**151.7**
Population	**Person-years**		**Percentage of person-years**			
	Men	**Women**	**Men**	**Women**		
Primary	40,773,078	42,981,451	46.7%	45.9%		
Secondary	33,768,114	37,506,347	38.6%	40.1%		
Tertiary	12,849,341	13,079,674	14.7%	14.0%		
Total:	**87,390,533**	**93,567,472**	**100%**	**100%**		

[a] Percentage of deaths out of total mortality separately for men and women.

[b] Percentage distribution of educational attainment out of total population separately for men and women.

METHODS

Data

Data were obtained from official registries of the National Administrative Department of Statistics, which collects and harmonizes data on deaths based on international guidelines. For all deceased individuals (633,906 deaths), data were collected on sex, age of death and educational level. Causes of death were coded according to the International Classification of Diseases (ICD-10) and aggregated into 10 major causes of death grouped into four broad categories: non-communicable diseases, injuries, infections and other causes. Table-Appendix 1 shows specific ICD-10 codes for each cause of death.

Data on population counts were obtained based on the following procedure: First, we estimated the distribution of education by 5-year age group, sex and year, based on data from censuses and national surveys harmonized by the International Institute of Applied System Analysis (IIASA) and the Vienna Institute of Demography (VID) as part of the IIASA/VID database (IIASA/VID, 2010). We then combined this information with data on national population counts from the National Statistics Office to obtain the number of population by educational attainment. IIASA/VID data were only available per quinquennium; therefore, we performed demographic projections to obtain population counts for in-between years using the demographic software PASEX (U.S. Census Bureau, 2011).

Data on educational level was missing for approximately a third of the deceased cases. We used multiple imputation methods implemented in SAS through the IMPUTE procedure to impute educational level for these cases. This was done to avoid bias due to the potentially higher rates of missing education for lower educated individuals, and to minimize the potential for numerator/denominator bias (Kunst et al., 1998a). This procedure fits a sequence of regression models and draws values from the corresponding predictive distributions. The sequential regression procedure was applied based on a model that included sex, region, age and marital status as covariates. Imputation was not possible in 6.8% of the cases. Full details on the procedure are available elsewhere (Raghunathan et al., 2001).

We distinguished three groups based on their highest educational level attained: (a) completed primary school, (b) completed secondary school, and (c) completed tertiary education. We excluded individuals below age 25, because many would not have completed their education before this age. In addition, we focused on adult premature mortality (mortality below age 65), an indicator of population health believed to be strongly influenced by social, economic and environmental factors (World Health Organization, 2008), and a common indicator of health system performance (Smith et al., 2009). While some premature deaths are unavoidable, a substantial part of premature mortality is avoidable through public health programs and policies that address the social determinants of health (World Health Organization, 2008).

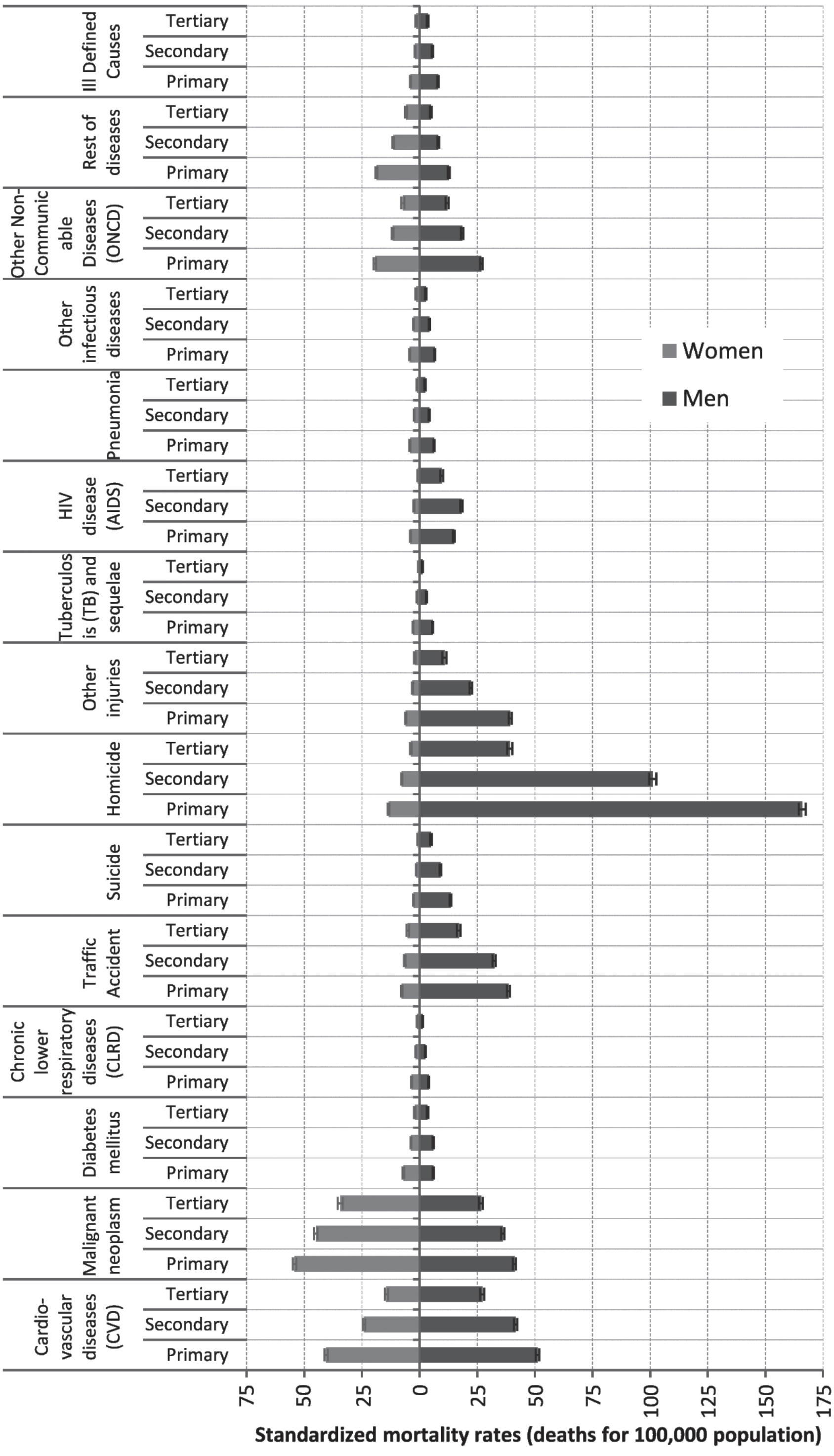

Figure 1. Age-standardized premature mortality rates per 100,000 populations by educational level, ages 25–64, 1998–2007, Colombia.

Methods of analysis

We first calculated age-standardized mortality rates by educational level, sex and year. Rates were standardized using the direct method based on the WHO standard population of 1997, which better reflects the age structure of the world population than the Segi standard population (Ahmad et al., 2001). Subsequently, we implemented separate Poisson regression models with deaths as the dependent variable and the natural log of person-years as offset variable, incorporating age and educational level as the independent variables.

To assess mortality trends by educational level, we estimated the annual percent change in mortality (APC) based on a Poisson model that incorporated an interaction between educational level and year. The APC measures the average rate of change in the mortality rate per year (Clegg et al., 2009). At a second stage, we estimated rate ratios (RR) of mortality by educational level. To assess changes in inequalities 'controlling' for changes in the educational distribution, we estimated the Slope Index of Inequality (SII) and the Relative Index of Inequality (RII). To construct these measures, educational groups are first ordered from lowest to highest. The population in each educational level covers a range in the cumulative distribution of the population. Mortality is then regressed on the mid-point of the cumulative distribution of education for each group (Mackenbach and Kunst, 1997). The RII can be interpreted as the ratio of mortality between a hypothetical person whose relative rank in the distribution of education is zero and a person whose relative rank in the cumulative distribution of education is 100% (Mackenbach and Kunst, 1997). The SII corresponds to the equivalent absolute rate difference between these two points. Further details on the RII and SII are available elsewhere (Mackenbach and Kunst, 1997).

Regression analyses were conducted in each of the five multiple databases generated by the multiple imputation process. Since results were nearly identical for all imputations, we used the PROC MIANALYZE procedure in SAS to combine estimates from all databases and adjust standard errors, accounting for the uncertainty in the imputation (SAS Institute, 2008). This procedure reads the parameter estimates and associated covariance matrix for each imputed dataset, and then derives valid multivariate inferences for these parameters. This allows for valid statistical inference that appropriately reflects uncertainty due to missing values (SAS Institute, 2008). All analyses were conducted in SAS® version 9.2.

RESULTS

Table 1 shows mortality rates at ages 25–64 years between 1998 and 2007 in Colombia. 633,905 deaths occurred from 1998 to 2007, with male deaths accounting for two thirds

Table 2. Rate ratios (RR) of age-standardized premature mortality rates by educational level, ages 25–64, 1998–2007, Colombia.

	Men		Women		Men		Women		Men		Women		Men		Women	
	Cardiovascular diseases (CVD)				**Traffic accident**				**Tuberculosis (TB) and sequelae**				**Other non-communicable diseases (ONCD)**			
Primary	1.88	(1.82, 1.95)	2.81	(2.68, 2.95)	2.28	(2.17, 2.40)	1.52	(1.32, 1.74)	4.70	(3.87, 5.70)	6.60	(4.85, 8.99)	2.24	(2.11, 2.38)	2.67	(2.42, 2.94)
Secondary	1.54	(1.48, 1.59)	1.67	(1.59, 1.77)	1.91	(1.82, 2.01)	1.26	(1.12, 1.41)	2.49	(1.96, 3.16)	2.80	(1.99, 3.92)	1.54	(1.45, 1.64)	1.61	(1.44, 1.79)
Tertiary (ref)	1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00	
	Malignant neoplasm				**Suicide**				**HIV disease (AIDS)**				**Rest of diseases**			
Primary	1.54	(1.49, 1.60)	1.58	(1.52, 1.63)	2.73	(2.51, 2.98)	3.45	(2.84, 4.19)	1.55	(1.44, 1.67)	5.50	(4.51, 6.72)	2.61	(2.38, 2.86)	3.18	(2.93, 3.47)
Secondary	1.35	(1.30, 1.41)	1.31	(1.26, 1.35)	1.84	(1.69, 2.00)	1.89	(1.53, 2.34)	1.90	(1.77, 2.03)	3.36	(2.78, 4.07)	1.67	(1.52, 1.83)	1.94	(1.78, 2.12)
Tertiary (Ref)	1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00	
	Diabetes mellitus				**Homicide**				**Pneumonia**				**Ill defined causes**			
Primary	1.72	(1.57, 1.90)	3.33	(2.90, 3.83)	4.22	(4.10, 4.34)	3.57	(3.27, 3.90)	2.76	(2.39, 3.18)	3.62	(2.98, 4.39)	2.27	(2.00, 2.58)	2.93	(2.22, 3.87)
Secondary	1.71	(1.55, 1.89)	1.78	(1.54, 2.05)	2.57	(2.49, 2.65)	2.04	(1.87, 2.23)	1.80	(1.58, 2.06)	2.06	(1.67, 2.54)	1.59	(1.42, 1.78)	1.47	(1.07, 2.01)
Tertiary (ref)	1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00	
	Chronic lower respiratory diseases (CLRD)				**Other injuries**				**Other infectious diseases**				**Other diseases**			
Primary	2.98	(2.57, 3.47)	3.48	(2.94, 4.11)	3.66	(3.35, 4.01)	2.93	(2.50, 3.43)	2.48	(2.14, 2.87)	2.96	(2.50, 3.50)	2.33	(2.23, 2.43)	2.91	(2.74, 3.08)
Secondary	1.89	(1.60, 2.22)	1.63	(1.36, 1.95)	2.07	(1.87, 2.28)	1.48	(1.24, 1.76)	1.60	(1.38, 1.86)	1.80	(1.50, 2.14)	1.58	(1.51, 1.65)	1.74	(1.63, 1.84)
Tertiary (ref)	1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00	
	Non-communicable diseases				**Injuries**				**Infectious diseases**				**All deaths**			
Primary	1.77	(1.73, 1.81)	2.06	(2.01, 2.12)	3.64	(3.54, 3.73)	2.64	(2.45, 2.85)	2.14	(2.02, 2.26)	4.22	(3.83, 4.65)	2.60	(2.56, 2.64)	2.36	(2.31, 2.42)
Secondary	1.48	(1.45, 1.52)	1.43	(1.39, 1.47)	2.32	(2.25, 2.38)	1.63	(1.53, 1.75)	1.89	(1.79, 1.99)	2.40	(2.17, 2.65)	1.87	(1.83, 1.90)	1.56	(1.52, 1.60)
Tertiary (ref)	1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00	

of overall deaths (66.0%), mainly owing to exceptionally high rates of homicide mortality. Non-communicable diseases accounted for half of all female mortality (50.4%) while 46.3% of mortality among men was due to injuries. Infections accounted for around 7% of deaths.

Figure 1 shows premature mortality rates by educational level. Men and women with lower levels of education had higher premature mortality from any cause of death than their higher-educated counterparts. Rate ratios summarizing differences in mortality across educational groups are presented in Table 2. Less-educated men and women had higher rates of mortality for all causes than their higher-educated counterparts (RRmen = 2.60, 95% confidence interval [CI]: 2.56–2.64; RRwomen = 2.36, 95% CI: 2.31–2.42). Inequalities were largest for injuries among men (RR = 3.64, 95% CI: 3.54–3.3), while among women, they were largest for infections (RR = 4.22, 95% CI: 3.83–4.65), particularly for tuberculosis and HIV/AIDS.

Appendix Figure 3 shows that premature mortality declined among both men and women over the study period. However, mortality rates for those with primary and secondary education remained relatively constant or grew for deaths from infectious disease and other causes, while rates for higher educated men steadily declined for all causes. While mortality from injuries declined steadily among men with middle and higher education, it increased during the first few years for lower-educated men, and only started to decline in 2002. Figure 2 summarizes trends in mortality differences by education on the basis of the RII. For both men and women, inequalities in total and cause-specific mortality widened over the first half of the period (1998–2003), but remained stable over the second half (2004–2007).

APC estimates in Figure 3 show that the initial increase in inequalities by educational level is due to more favorable trends among the higher-educated groups. Among men, mortality declined by 4.5% (95% CI: – 5.0%, – 4.0%) per year in men with tertiary education, as compared to 2.3% (95% CI: – 2.6%, – 2.1%) in men with secondary education and 1.5% (95% CI: – 1.7%, – 1.4%) in men with primary education or less. Similar results were observed among women, although differences in the APC were not significant. The largest difference in trends was for injuries among men and women. Similar trends were observed for non-communicable disease mortality among men, while declines were similar for women from all educational groups. Although confidence intervals were wide, results suggest that those with primary education experienced an increase in infectious disease mortality, while those with tertiary education experienced no change.

Figure 4 shows the contribution of each cause of death to absolute differences in premature mortality by education measured with the SII. Absolute differences in mortality were nearly twice larger for men (SII = 402.4 deaths for a 100,000 population) than for women (SII = 228.9). This difference was almost entirely due to the large contribution of injuries, particularly homicide, to inequalities in mortality among men, which overall

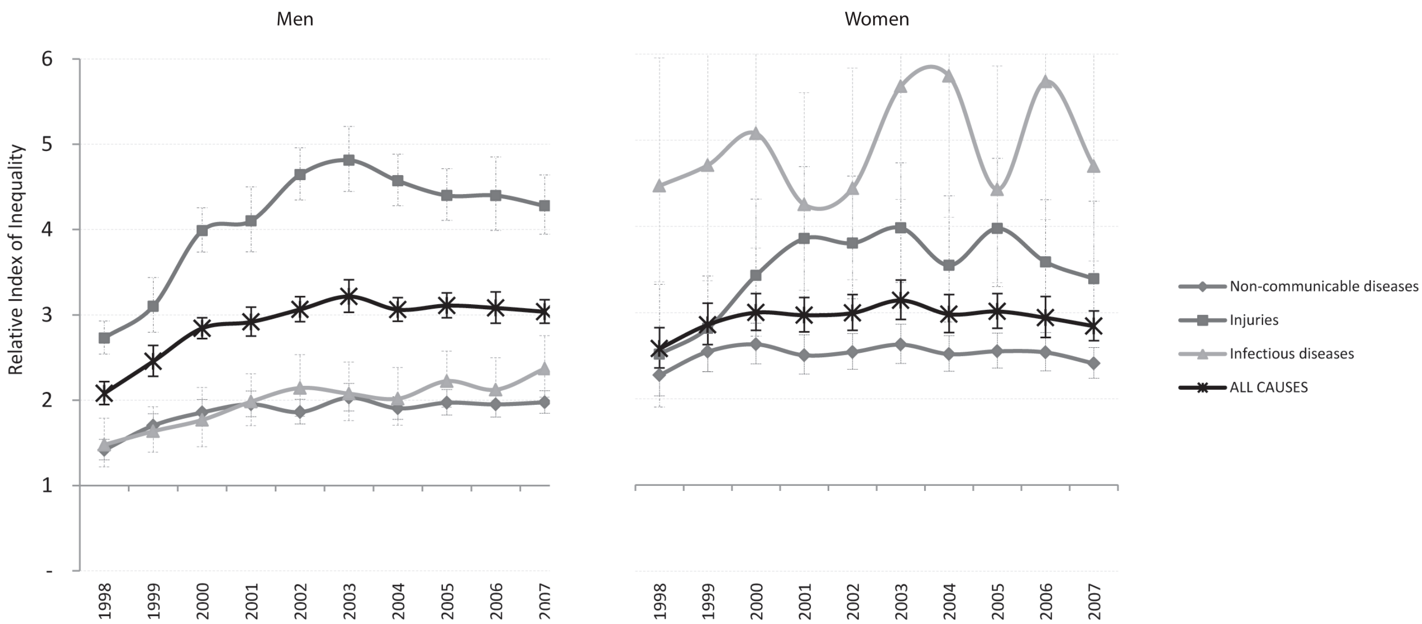

Figure 2. Trends of the Relative Index of Inequality (RII) of age-standardized premature mortality rates by educational level, ages 25–64, 1998–2007, Colombia.

explained 55.1% of male inequalities. Non-communicable disease mortality was the second largest contributor among men, accounting for 27.1% of inequalities in total mortality. Among women, non-communicable diseases were by far the largest contributor to inequalities, explaining 62.5% of inequalities in total mortality. Infections explained only 5.9% of differences in mortality by education among men and 8.0% among women.

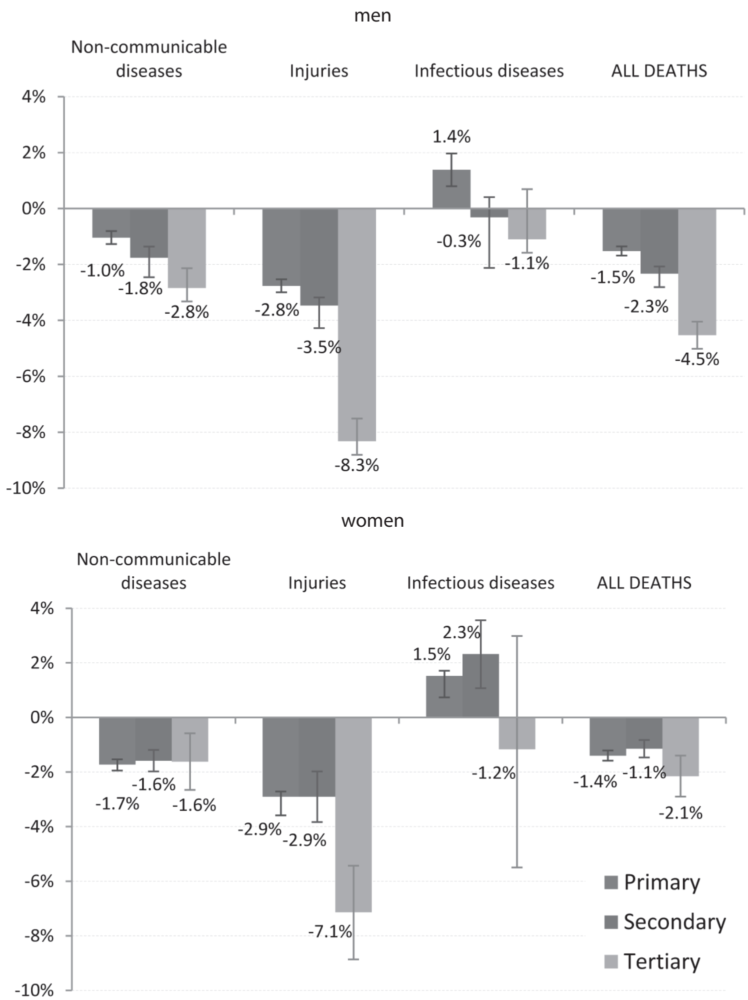

Figure 3. Annual percentage change (APC) of age-standardized premature mortality rates by educational level, ages 25–64, 1998–2007, Colombia.

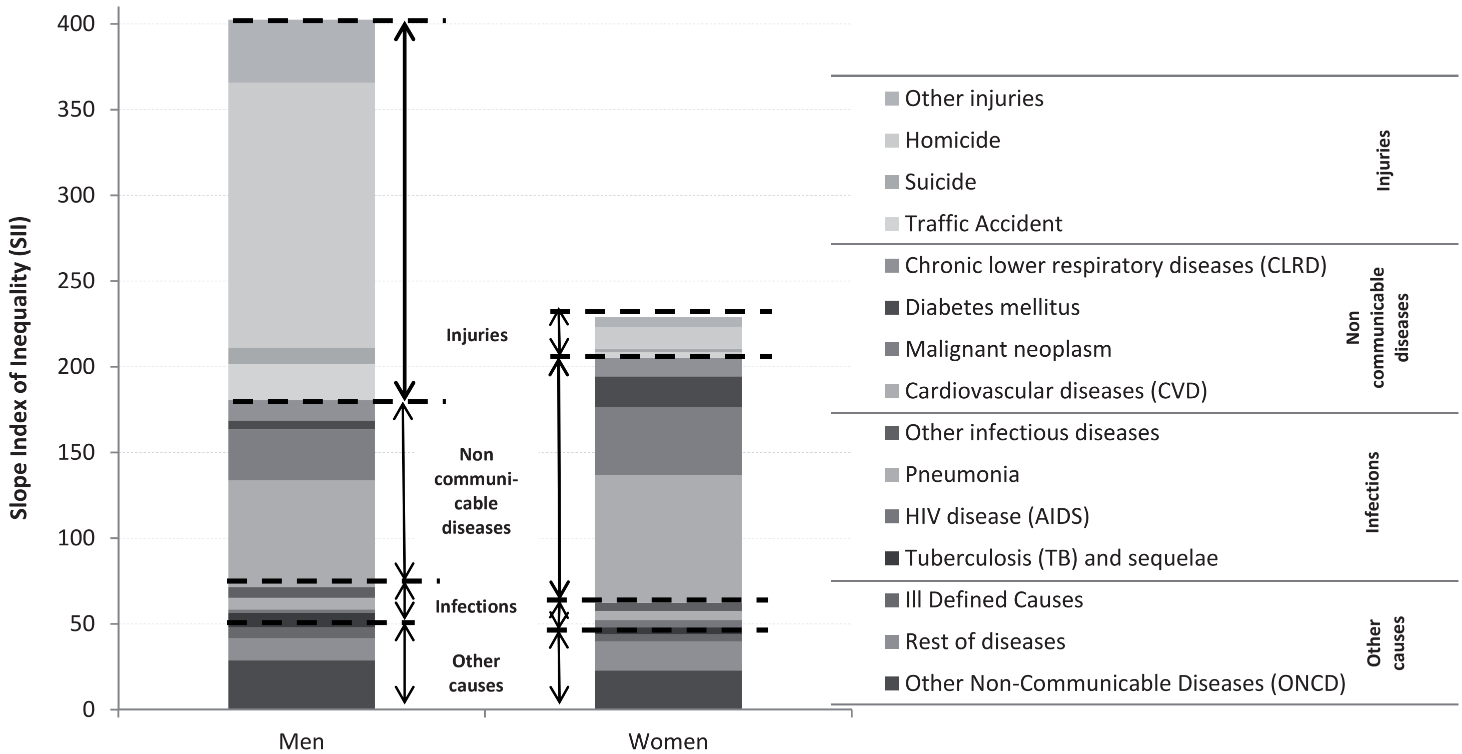

Figure 4. Slope Index of Inequality (SII) of age-standardized premature mortality rates per 100,000 person-years by educational level, ages 25–64, 1998–2007, Colombia.

DISCUSSION

Inequalities in premature mortality by education in Colombia widened over the first half of the study period and remained constant over the second half. Mortality from injuries, particularly homicide, explains more than half of inequalities among men, while non-communicable diseases are the most important contributors to female inequalities and the second contributor among men. Infections explain a relatively small proportion of inequalities in premature mortality. Our results highlight the need for a shift in focus towards policies addressing the increasing contribution of non-communicable disease and injuries to socioeconomic inequalities in premature mortality.

Explanation of results

Our study suggests that lower-educated men and women have benefited significantly less from declining premature mortality than their higher-educated counterparts. Several explanations could account for this pattern, including inequalities by educational level in social, economic and working conditions; access to health care; and risk factor prevalence. Our decomposition by cause of death sheds some light on the role of some of these mechanisms.

The most striking finding from our study is the large contribution of homicide to socioeconomic inequalities in premature mortality among men. Homicide rates in Colombia have declined (Acero-Álvarez, 2011 and Bonilla Mejía, 2010) but remain among the highest worldwide (World Health Organization, 2012). We found that homicide is primarily concentrated among lower-educated men, and it is disproportionately high for young men (Acero-Álvarez, 2011). Lower-educated men face high levels of poverty, unemployment, social disruption and risky behaviors (e.g., alcohol, drug use, smoking), and are more likely to live in deprived areas (Acero-Álvarez, 2011). Colombia has one of the highest levels of income inequality in Latin America (UNDP, 2010), which may contribute to high youth homicide rates (Briceño-León et al., 2008). Our findings underscore the significance of homicide as a major contributor to male mortality inequalities.

Our study also suggests that traffic accidents have large socioeconomic gradients and contribute importantly to socioeconomic differences in mortality in Colombia. Lower education has been linked to higher reliance on unsafe forms of transportation (Males, 2009). Vehicle safety infrastructure is less well-developed in socially deprived areas, where individuals may be less likely to comply with safety regulations on seat belt use, driving while drinking, and speed limit enforcement (Males, 2009 and Rodríguez et al., 2003).

Mirroring findings for high-income countries (Fawcett et al., 2005, Huisman et al., 2005,Kunst et al., 1998b and Wong et al., 2002), we found that non-communicable diseases are a leading contributor to inequalities in mortality by educational level in

Colombia. Socioeconomic inequalities in non-communicable diseases have been associated with the unequal distribution of behavioral risk factors, particularly smoking, alcohol consumption, an unhealthy diet and a sedentary lifestyle (Adler and Newman, 2002). Existing evidence suggests that, as in high income countries, lower education is associated with a worse risk factor profile in Colombia. Data from 2007 suggests that the prevalence of smoking was 41% among Colombians with primary education or less, as opposed to 26% among those with a college education (Storr et al., 2008). Similarly, 26% of lower-educated Colombians aged 25-50 years have at least a risk factor for cardiovascular disease, as opposed to only 5.9% in those with a university degree (Patiño-Villada et al., 2011). Trends in infections, on the other hand, might reflect socioeconomic differences in both preventive and curative care, which may remain despite large increases in health insurance coverage (Arroyave et al., 2013 and Gaviria et al., 2006). Noticeably, there are large inequalities in the availability of running water, sewage systems and adequate housing in Colombia (UNDP, 2010), which may be more important in generating inequalities in communicable diseases.

Limitations of the study

Despite several strengths, some limitations should be considered. Data on mortality were obtained from mortality registries, while data on population counts came from censuses. This may have led to the so-called numerator/denominator bias, which generally results in an overestimation of inequalities (Kunst et al., 1998a). For some years, data on population size were obtained from demographic projections, as censuses were conducted in 1985, 1993 and 2005 (DANE, 2012). We focused on premature mortality, given the public health relevance of this measure and strong association with social determinants and health system performance (Smith et al., 2009 and World Health Organization, 2008). Further research is required to examine mortality patterns for older ages.

As in other middle-income countries (Murray and Lopez, 1997) underregistration of deaths remains a problem in Colombia, particularly in the poorest regions (Rodríguez-García, 2007). For example, the estimated proportion of registered deaths in the Choco region, one of the poorest in the country, was only 25%, compared to 90% or higher in most other regions (Rodríguez-García, 2007). Our estimates of inequalities are likely an underestimation, because those with lower education are more likely to live in areas with higher underregistration. We may also have underestimated the increase in inequalities, because underregistration has decreased over the study period (Florez and Méndez, 1995 and Rodríguez-García, 2007). Our results, therefore, are indicative of potentially larger inequalities in mortality by education.

It is likely that part of the differences in mortality by education observed in our study reflects regional differences in mortality. Unfortunately, no data are available on mortality by educational level separately by region. To partly address this question, however, maps in Appendix Figure 4 show age-standardized mortality rates and average years of schooling for each region in 2002 (similar regional patterns are observed for other years). Based on these aggregate data, we find only a weak correlation between regional average years of schooling and mortality ($r = 0.07$, $p = 0.73$). Nevertheless, more detailed data is required to fully examine to what extent regional variations explain differences in mortality by education.

Information on education was missing for 34.2% of death records. This may have led to an underestimation of inequalities, as missing values are likely to be more common for the least educated (Rodríguez-García, 2007). We imputed missing values on education based on a rich set of variables available for most deceased individuals, partly minimizing potential bias.

Conclusion

Mortality from both injuries and non-communicable diseases contributes considerably to disparities in premature mortality in Colombia. The striking contribution of homicide to socioeconomic differences in mortality among men highlights the need for public policies that address the profound social and economic factors that underlie interpersonal violence in Colombia. At the same time, the increasing contribution of non-communicable diseases calls for urgent prevention policies for curbing the increasing prevalence of non-communicable disease risk factors in the lower socioeconomic groups.

FOOTNOTES

Authors' contributions:

I. Arroyave was the leading author and developed the article idea, constructed and analysed the data set, and wrote drafts of article. A. Burdorf contributed to interpretation of results and commented on all drafts. D. Cardona contributed to the quantitative analysis and commented on all drafts of the article. M. Avendano analysed data, wrote sections of the article, and contributed to the coordination of all steps of the analysis and article preparation.

Ethics committee approval:

This article is based on secondary analysis of data on deaths and population counts in aggregate form made publically available by the National Statistics Office in Colombia. Ethical approval for this study was not required.

Conflict of interest statements:

We are pleased to report no conflict of interest by any of the authors of this paper. There is no financial support for this work that could have influenced its outcome.

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The sponsors of the authors had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

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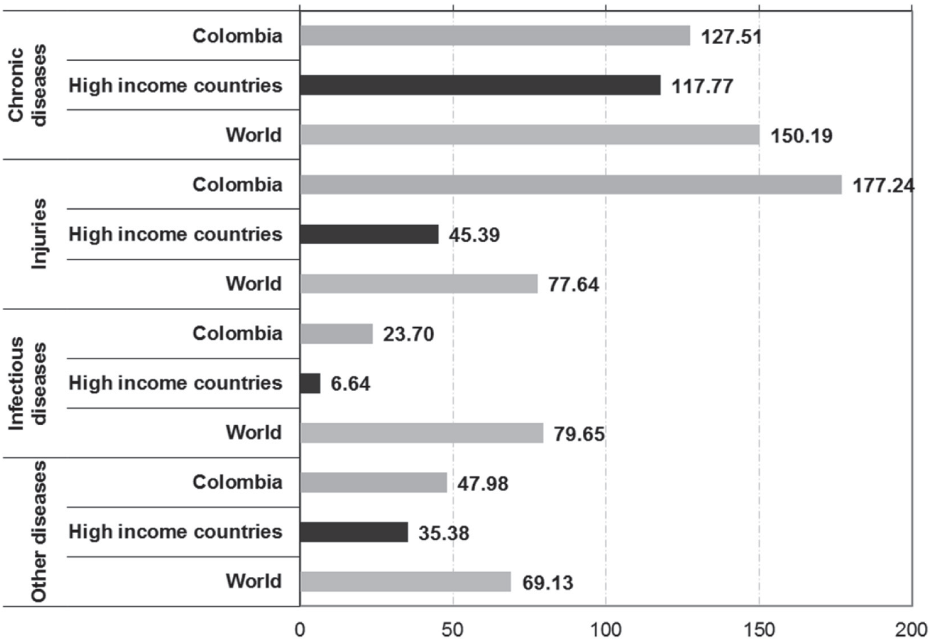
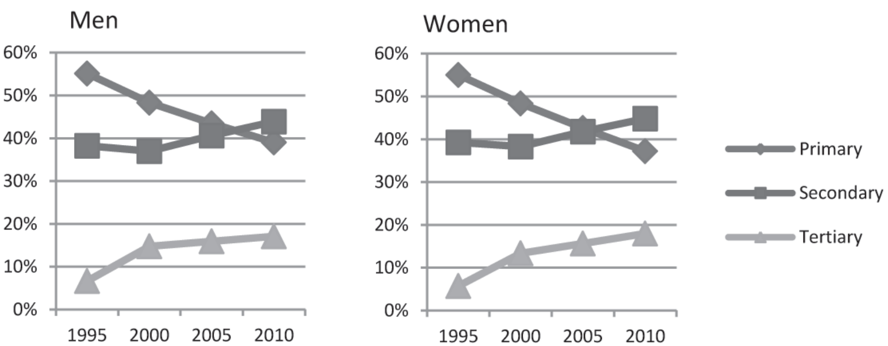
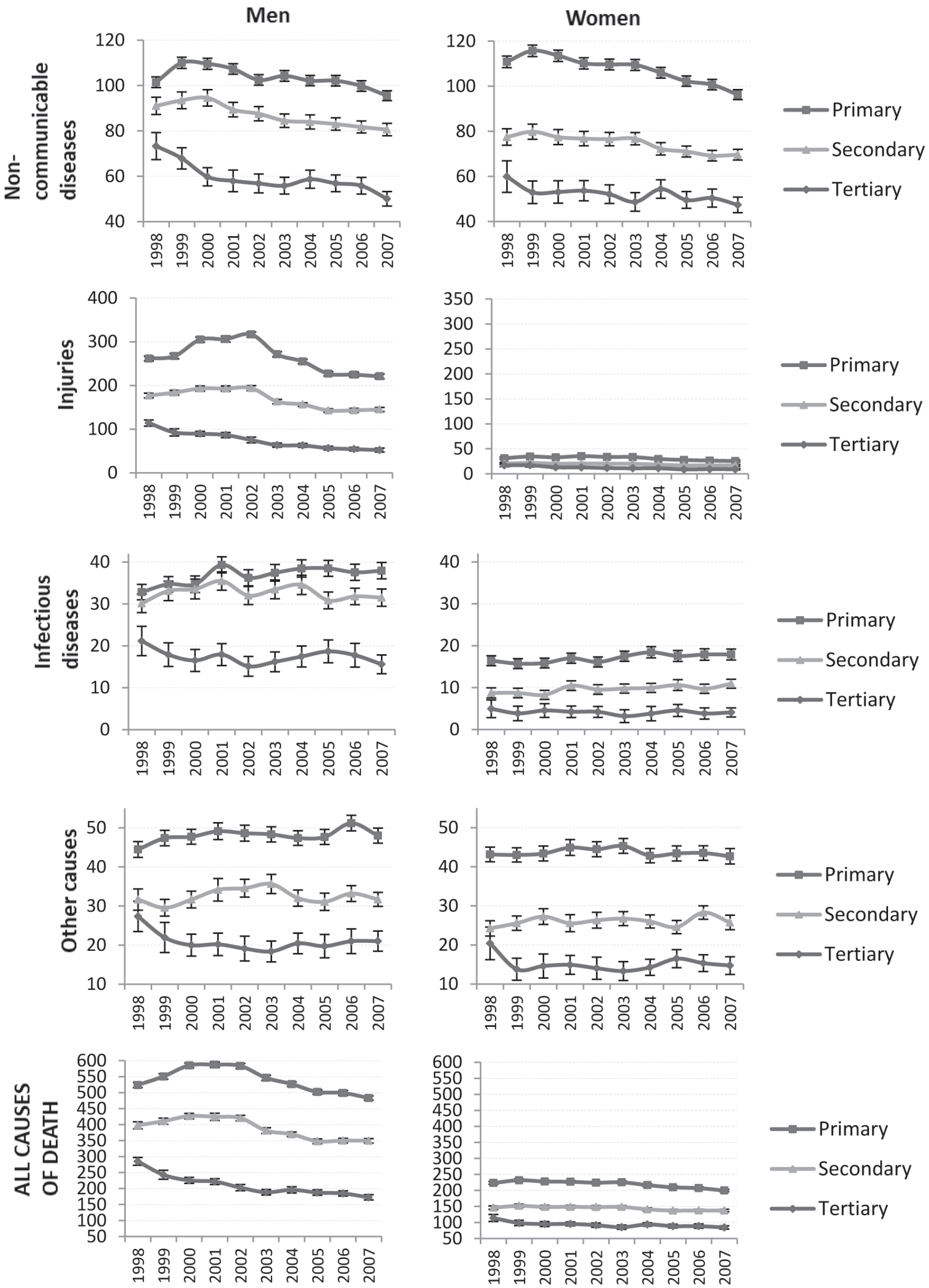
APPENDIX A. SUPPLEMENTARY DATA



Appendix Figure 1. Comparative of premature mortality rates per 100,000 population (15-59 years) in 2008 according to Global Burden of Diseases Study (GBD)



Appendix Figure 2. Distribution of highest level of educational attainment by year and sex in Colombia (1995, 2000, 2005, 2010)
Source: Based on data from census and national surveys harmonized by the International Institute of Applied System Analysis (IIASA) and the Vienna Institute of Demography (VID) as part of the IIASA/VID database [139]



Appendix Figure 3. Trends of age-standardized premature mortality rates per 100,000 person-years by educational level, ages 25-64, 1998-2007, Colombia

Appendix Table 1. Classification of Causes of death, International Classification of Diseases (ICD-10)

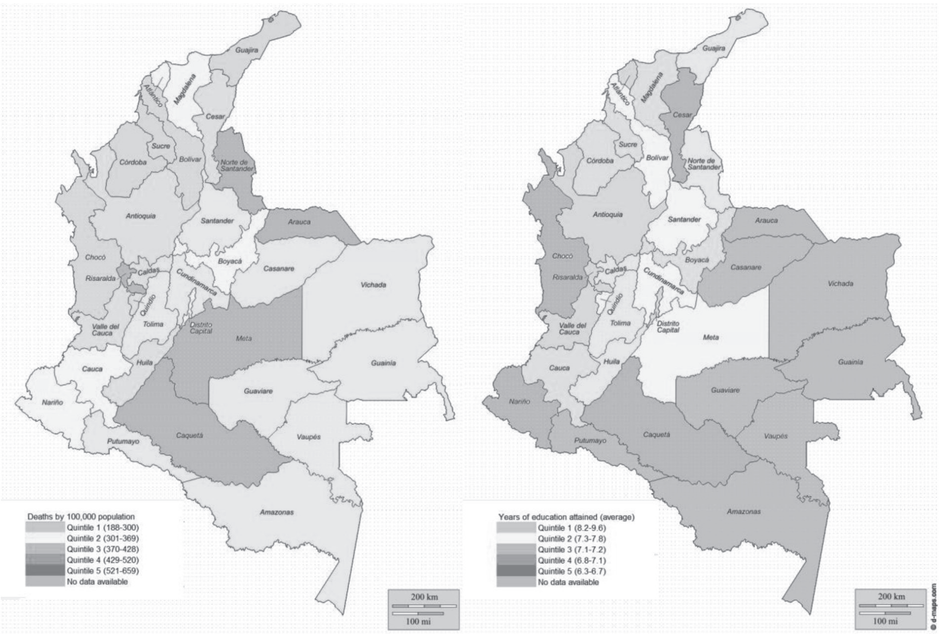
Group	Cause of death		International Classification of Diseases (ICD-10) codes
Non-communicable diseases	Cardiovascular diseases		I00-I99
	Malignant neoplasm		C00-D48
	Diabetes mellitus		E10-E14
	Chronic lower respiratory diseases (CLRD)		J40-J47
Injuries	Traffic accident		V01-V89, Y85.0
	Homicide		X85-Y09, Y87.1
	Suicide		X60-X84, Y87.0
	Other Injuries	Other accidents and unspecified transport and sequels	V90-V99, Y85.9
		Fallings	W00-W19
		Shot gun accidents	W32-W34
		Accidental drowning and submersion	W65-W74
		Other accidental which obstructing breathing	W75-W84
		Exposure to electric current, radiation and temperature and extreme air pressure	W85-W99
		Exposure to smoke, fire and flames	X00-X09
		Accidental poisoning by and exposure to noxious substances	X40-X49
		Events of undetermined intent and sequels	Y10-Y34, Y87.2
		Legal intervention and operations of war	Y35-Y36, Y89.0-Y89.1
		Accidents in surgical and medical care consequences	Y40-Y84, Y88
		Other accidents and sequelae	W20-W31, W35-W64, X10-X39, X50-X59, Y86, Y89.9
Infectious diseases	Tuberculosis and sequelae		A15-A19, B90
	HIV disease (AIDS)		B20-B24
	Acute respiratory infectious disease (ARID)		J00-J22
	Other Infectious diseases	Intestinal infectious diseases	A00-A09
		Vector-borne diseases and rabies	A20, A44, A68, A75-A79, A82-A84, A85.2, A90-A91, A95, B50-B57
		Vaccine-preventable diseases	A33-A37, A80, B05, B06, B16, B17.0, B18.0, B26, B91, P35.0
		Meningitis	A32.1, A39, A87, B00.3, B01.0, B02.1, B37.5, B38.4, G00-G03
		Septicaemia	A40-A41
		Infections with a predominantly sexual mode of transmission	A50-A64

Appendix Table 1. (continued)

Group	Cause of death		International Classification of Diseases (ICD-10) codes
		Pneumonia	J12-J16, J18
		Other infectious and parasitic diseases	A21-A31, A32.0, A32.7-A32.9, A38, A42-A43, A46-A49, A65-A67, A69-A74, A81, A85.0-A85.1, A85.8, A86, A88-A89, A92-A94, A96-A99, B00.0-B00.2, B00.4-B00.9, B01.1-B01.9, B02.0, B02.2-B02.9, B04, B07-B15, B17.1-B17.8, B18.1-B19.9, B25, B27-B36, B37.0-B37.4, B37.6-B37.9, B38.0-B38.3, B38.7-B38.9, B39-B49, B58-B89, B92-B99
Other causes of death	Other Non-Communicable Diseases	Mental and behavioural disorders	F00–F99
		Diseases of the nervous system	G00–G99
		Diseases of the digestive system	K00–K93
		Diseases of the genitourinary system	N00–N99
		Congenital malformations, deformations and chromosomal abnormalities	Q00–Q99
	Rest of diseases	Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	D50–D89
		Endocrine, nutritional and metabolic diseases except diabetes	E00–E09, E15–E90
		Diseases of the eye and adnexa	H00–H59
		Diseases of the ear and mastoid process	H60–H95
		Diseases of the respiratory system except CLRD, pneumonia and acute respiratory infectious disease	J23–J39, J48–J99
		Diseases of the skin and subcutaneous tissue	L00–L99
		Diseases of the musculoskeletal system and connective tissue	M00–M99
		Pregnancy, childbirth and the puerperium	O00–O99
		Certain conditions originating in the perinatal period except infections specific to the perinatal period	P00–P19, P29–P96
	Ill-defined causes		R00–R99.

Appendix Figure 4. Mortality and average years of schooling by region, Colombia, 2002

Panel A. Standardized mortality rate per 100,000 person-years, ages 25-64 years	**Panel B. Average Years of schooling**



Source: Standardize mortality rate data were calculated from the databases of the Office for National Statistics [140]; years of schooling data come from the Ministry of National Education in Colombia (Estadísticas Sectoriales Ministerio de Educacion Nacional , 2013)
The original maps are from d-maps.com: http://d-maps.com/carte.php?num_car=70453&lang=en

Chapter 3

Trends in inequalities in premature cancer mortality by educational level in Colombia, 1998–2007

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Trends in inequalities in premature cancer mortality by educational level in Colombia, 1998–2007
J Epidemiol Community Health. 2015 May;69(5):408-15

ABSTRACT

Background

There is a paucity of studies on socioeconomic inequalities in cancer mortality in developing countries. We examined trends in inequalities in cancer mortality by educational attainment in Colombia during a period of epidemiological transition and rapid expansion of health insurance coverage.

Methods

Population mortality data (1998–2007) were linked to census data to obtain age-standardised cancer mortality rates by educational attainment at ages 25–64 years for stomach, cervical, prostate, lung, colorectal, breast and other cancers. We used Poisson regression to model mortality by educational attainment and estimated the contribution of specific cancers to the slope index of inequality in cancer mortality.

Results

We observed large educational inequalities in cancer mortality, particularly for cancer of the cervix (rate ratio (RR) primary vs tertiary groups=5.75, contributing 51% of cancer inequalities), stomach (RR=2.56 for males, contributing 49% of total cancer inequalities and RR=1.98 for females, contributing 14% to total cancer inequalities) and lung (RR=1.64 for males contributing 17% of total cancer inequalities and 1.32 for females contributing 5% to total cancer inequalities). Total cancer mortality rates declined faster among those with higher education, with the exception of mortality from cervical cancer, which declined more rapidly in the lower educational groups.

Conclusions

There are large socioeconomic inequalities in preventable cancer mortality in Colombia, which underscore the need for intensifying prevention efforts. Reduction of cervical cancer can be achieved through reducing human papilloma virus infection, early detection and improved access to treatment of preneoplastic lesions. Reinforcing antitobacco measures may be particularly important to curb inequalities in cancer mortality.

INTRODUCTION

Cancer is among the top three causes of death in Colombia.[1] The distribution of cancer types reflects the dual situation in many middle-income countries, with a relatively high burden of infection-related cancers (primarily cervical and stomach cancer) combined with a growing burden of cancers associated with lifestyle and other risk factors of non-infectious character (primarily prostate, lung, colorectal and breast cancer). Recent analysis shows that cancer mortality is stabilising or decreasing,[1] but no studies have examined how cancer mortality trends differ by socioeconomic status (SES).

Colombia is a middle-income country with large social and economic inequalities. Despite extensive healthcare reforms leading to almost universal health insurance coverage, large differences in all-cause mortality by SES, including cancer, remain.[2] We hypothesise that the association between SES and cancer differs by cancer type, with the poor suffering disproportionately from mortality from infection-related cancers due to their higher risk of infection. In contrast, the higher SES-groups may experience higher mortality from cancers associated with non-communicable risk factors, reflecting their earlier adoption of unhealthy behaviours and longer life expectancy.

In this study, we use a unique administrative data set to examine trends in cancer mortality by educational level from 1998 to 2007 in Colombia. This is a period of important changes, including major healthcare reform that resulted in a rapid increase in health insurance coverage from 59.8% in 1998 to 92.5% in 2007.[2] Earlier studies documented large socioeconomic differences in access to screening and treatment in specific subpopulations,[3–6] but how these disparities influence inequalities in cancer mortality has not been assessed. We evaluate differences in cancer mortality by educational level and assess time trends in mortality from the most important cancer sites distinguishing infection-related cancers and frequently occurring cancer types associated with other risk factors.

MATERIALS AND METHODS

Data

National mortality data for the years 1998–2007 were obtained from the National Administrative Department of Statistics (DANE), with causes of death coded according to the 10th revision of the International Classification of Diseases (ICD-10). Information on sex, date of death and educational level are routinely registered on death certificates. Our data comprise 117 597 deaths from invasive malignant neoplasms (ICD-10, C00–C97). Data were analysed for all cancers combined, but also separately for the following groups: infection-related cancers (represented by stomach cancer (C16) and cervical cancer (C53)); cancers related to other risk factors (represented by prostate (C61), lung (C33–C34), colorectal (C18–C21) and breast cancer (C50)); and the group of 'other cancers'. Deaths due to unspecified uterus cancer (C55) were reassigned to deaths due to cancers of the cervix uteri (C53) or corpus uteri (C54) according to their reported proportions.[7] In a similar way, cases without information on age, those with a death certificate issued by a non-medical doctor and causes based on symptoms were redistributed, based on relative frequencies.

Data on age and sex were available for >99% of all cancer deaths, while data on educational level were missing for 16.7% of cancer deaths (varying from 13% for breast to 18.9% for lung cancer). Multiple imputation methods implemented with the SAS procedure IMPUTE were used to impute educational level for these cases,[8] to reduce bias due to the potentially higher rates of missing education for lower educated individuals and to minimise the potential for numerator/denominator bias.[9] This procedure fits a sequence of regression models and draws values from the corresponding predictive distributions. The sequential regression procedure was applied based on a model that included sex, region, rural/urban residential area, age and marital status as covariates. Details of this procedure are described elsewhere.[8] The imputation procedure was successful in 98% of cases resulting in a total of 115 410 cancer deaths left for analysis (table 1).

Description of the study population, 1998–2007

We excluded individuals aged <25, because many would not have completed their education before this age. We focused on adult premature mortality (mortality below age 65), an indicator of population health strongly influenced by social, economic and environmental factors,[10] and a common indicator of health system performance.[11] In addition, information on educational level from death registries has been shown to be unreliable at ages ≥65 years.[9]

Education was reclassified into three categories based on the highest educational level and grade attained by the deceased: (A) primary: no education, complete or incomplete primary education; (B) secondary: some secondary schooling, complete secondary but incomplete tertiary and (C) complete tertiary education (including college and university).

To obtain midyear population counts we first extracted data on the proportion of individuals in each educational level from the IIASA/VID database,[12] which contains information on the distribution of education for every 5-year age group, sex and year combinations for the period 1970–2000 obtained from census, national surveys and demographic projections.[12] We performed demographic projections to obtain population counts for years in-between every lustrum using the software PASEX.[13] We then multiplied the proportion of individuals in each educational category by population counts from national census and statistical projections obtained from DANE[14] to estimate the annual population size of each educational group.

Table 1. Description of the study population, 1998–2007

	Absolute number of deaths		Percentage of cancer deaths		Age-standardised mortality rates*	
	Men	Women	Men	Women	Men	Women
Cancer type						
All cancers	49 809	65 601	100	100	76.24	93.68
Stomach	10 075	5966	20.2	9.1	15.61	8.34
Cervix	–	10 455	–	15.9	–	16.55
Prostate	2268	–	4.6	–	3.87	–
Lung	6786	4345	13.6	6.6	10.95	6.35
Colorectal	3260	3825	6.5	5.8	4.91	5.33
Breast	–	11 005	–	16.8	–	14.89
Other	27 420	30 005	55.1	45.7	40.90	42.36
Educational attainment						
Primary	32 111	42 755	64.5	65.2	83.01	104.76
Secondary	13 533	18 535	27.2	28.3	72.83	85.13
Tertiary	4164	4311	8.4	6.6	57.23	72.80
All cases after imputation	49 809	65 601	100	100		
All cases before imputation	50 881	66 716	NA	NA		
Cases not imputed (missing after imputation)	1072	1115	2.1	1.7		

	Absolute numbers		Percentage of population	
Population size	Men	Women	Men	Women
Primary	40 773 078	42 981 451	46.7	45.9
Secondary	33 768 114	37 506 347	38.6	40.1
Tertiary	12 849 341	13 079 674	14.7	14.0
Total population	87 390 533	93 567 472	100	100

*Standardised mortality rates age-standardised to the Segi world population, for ages 25–64.
NA, not applicable.

Statistical analysis

We calculated annual age-standardised mortality rates (ASR, expressed per 100 000 person-years) by educational level and sex using the Doll World Standard Population.[15] Annual trends in ASR by sex and educational level were quantified by calculating the estimated annual percentage change (EAPC) in mortality. To test whether an apparent change in mortality trends was statistically significant, we used joinpoint regression, which fits a series of joined straight lines to age-adjusted rates and uses a Monte Carlo Permutation method to identify the best-fitting point (called joinpoint), where the rate of increase or decrease changes significantly.[16] EAPC and joinpoints (year in which a significant change in the mortality trend occurred) were determined based on the log-transformed ASRs and their SEs. We specified a maximum of two joinpoints with at least four observation points to either extreme of the data.[16]

We implemented separate Poisson regression models with number of deaths as dependent variable and the natural log of person-years as offset variable, incorporating age and educational level as independent variables. We first calculated rate ratios (RRs) to compare mortality between educational groups. However, changes in RR are difficult to interpret because of rising levels of education over the study period, for example, the proportion of people with no or only primary education decreased from 55% to 38% (see online supplementary figure S1). To 'control' for these changes in the composition of educational groups, we estimated the slope and relative index of inequality (SII and RII, respectively) by regressing mortality on the midpoint of the cumulative distribution of education.[17,18] The RII can be interpreted as the ratio of the mortality rate between a hypothetical person whose relative rank in the distribution of education is 0% and a person whose relative rank in the cumulative distribution of education is 100%.[19] A value of RII higher than 1 indicates educational inequalities favouring the higher educated.[19,20] To evaluate whether the RII significantly changed over time, an interaction term with calendar year was added to the regression models.

We calculated the contribution of each cancer site to the absolute differences in cancer mortality measured by the SII. The SII measures the absolute difference in rates between the population at the top and the bottom of the educational distribution.

Regression analyses were conducted in each of the five multiple databases generated by the multiple imputation process, using standard techniques of the PROC MIANALYZE procedure in SAS to combine estimates from all databases and adjust SEs to account for uncertainty in the imputation.[21] This procedure reads the parameter estimates and associated covariance matrix for each imputed data set, and then derives valid multivariate inferences for these parameters. This allows for valid statistical inference that appropriately reflects uncertainty due to missing values.[21] All analyses were conducted in SAS V.9.2.

RESULTS

The most common causes of cancer deaths were cancers of the cervix (ASR 16.55) and breast (ASR 14.89) among women, and stomach (ASR 15.61) and lung cancer (ASR 10.95) among men (table 1).

All-cancer mortality decreased significantly among both sexes in all educational groups, with a gradient towards stronger declines among the higher educated (figure 1). Mortality for 'other cancers' decreased in all groups over the entire time period, with a joinpoint observed only among males with tertiary education in 2001, after which initial strong declines stabilised (table 2). Stomach cancer mortality rates tended to decrease, but these trends failed to reach statistical significance with the exception of males with primary education or less (EAPC −1.13%). Particularly strong and statistically significant declines of 2–3% annually were observed for cervical cancer mortality, with strongest declines (EAPC −3.53%) among the lowest educated women. Strong declines of about

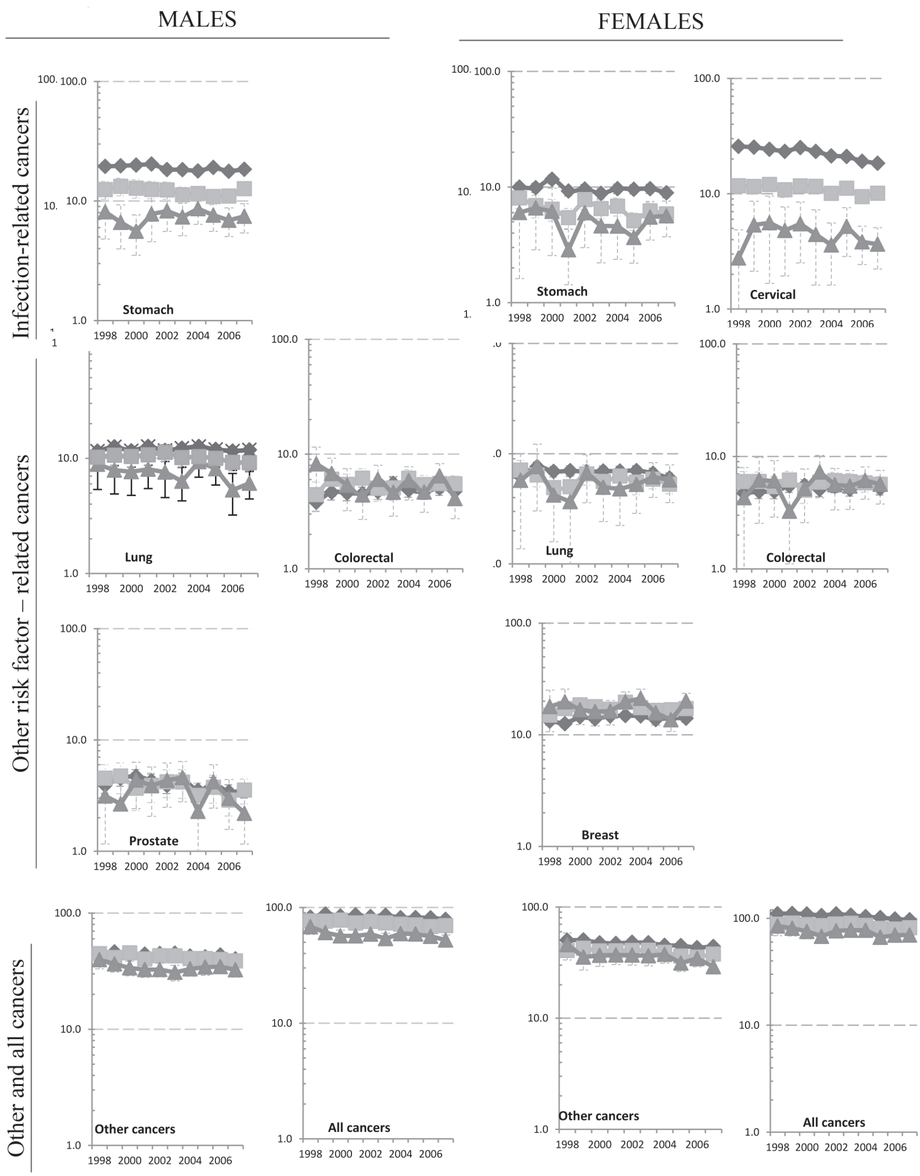

Figure 1. Time trends in age-standardised cancer mortality by type of cancer and educational level, 1998-2007, ages 25-64

Dark lines, diamonds= primary education, light lines, squares=secondary education, dark grey lines, triangles= tertiary education

3% annually were also observed for prostate, lung and colorectal cancer among the highest educated men, but these trends failed to reach statistical significance. Mortality of lung, colorectal and female breast cancers did not change significantly between 1998 and 2007 in either educational group or sex, with the exception of males with secondary education, among whom lung cancer mortality sharply declined (EAPC −3.70%) after 2002.

RRs of cancer mortality by educational attainment for the entire period were generally negatively associated with educational attainment (table 2), with higher rates in those with only primary education as compared to those with tertiary education (RRmen=1.54, 95% CI=1.48 to 1.59; RRwomen=1.62, 95% CI 1.57 to 1.68), and a clear gradient towards decreased overall cancer mortality with increasing educational level.

The most pronounced educational gradients were observed for cervical (RR=5.75) and stomach cancer (RRmen 2.56, RRwomen 1.98); prostate, lung and other cancers also showed substantial educational gradients. There was no significant educational gradient for colorectal and breast cancer mortality. Breast cancer mortality was highest in women with secondary education (RR=1.13, 95% CI 1.06 to 1.21), and lowest in women with primary education (RR=0.93, 95% CI 0.87 to 0.99).

Inequalities in cancer mortality by educational attainment were statistically significant for all cancers except for colorectal, prostate and breast cancers. Until 2002, the mortality due to colorectal, prostate and breast cancer was highest in the highest educated groups (RII significantly smaller than 1; figure 2). RII changed little over time, except for increases in RII for male total cancer mortality and male colorectal cancer, which were driven by increased inequalities from 1998 to 2003 only. None of the other cancer types showed any significant change over time (see online supplementary table S1).

Absolute differences in ASR by educational level expressed by the SII were larger for women than for men. This was almost entirely attributable to the large share of inequalities attributable to cervical cancer mortality, which accounted for 51% of inequalities in total female cancer mortality, while 14% of female inequalities were due to stomach cancer (figure 3). Among men, the main contributors to inequalities in cancer mortality by education were stomach cancer (49%) and lung cancer (17%). Breast (−9%) and colorectal cancers (−3% for males and −1% for females) contributed inversely to differences in mortality rates, with highest rates among the highest educated.

DISCUSSION

We found large inequalities in cancer mortality by educational level, although associations differed by cancer type. Among women, we observed large inequalities in cervical and stomach cancer, while there were no clear inequalities in colorectal and breast

Table 2. Joinpoints with corresponding EAPC and RR for cancer mortality by educational level, 1998–2007

Group	Cancer type	Educational level	Men JP	Men EAPC1(95% CI)	Men EAPC2 (95% CI)	Men RR	Men 95% CI	Women JP	Women EAPC1(95% CI)	Women EAPC2 (95% CI)	Women RR	Women 95% CI
TOTAL CANCER		Primary	No	−0.77 (−1.39 to −0.16)		1.54	(1.48 to 1.59)	No	−1.49 (−1.98 to −1.01)		1.62	(1.57 to 1.68)
		Secondary	No	−1.35 (−1.81 to −0.89)		1.34	(1.29 to 1.39)	No	−1.26 (−2.07 to −0.45)		1.35	(1.30 to 1.40)
		Tertiary	No	−1.43 (−2.79 to −0.05)		1		No	−1.59 (−3.16 to −0.01)		1	
Infection-related cancers	Stomach	Primary	No	−1.13 (−2.05 to −0.19)		2.56	(2.29 to 2.86)	No	−1.28 (−3.07 to 0.54)		1.98	(1.75 to 2.24)
		Secondary	No	−1.17 (−2.74 to 0.43)		1.65	(1.47 to 1.85)	No	−2.68 (−5.75 to 0.50)		1.38	(1.21 to 1.59)
		Tertiary	No	0.63 (−2.63 to 4.01)		1		No	−0.33 (−7.07 to 6.90)		1	
	Cervix	Primary	NA					No	−3.53 (−4.65 to −2.40)		5.75	(5.05 to 6.54)
		Secondary	NA					No	−2.08 (−3.54 to −0.59)		2.82	(2.47 to 3.22)
		Tertiary	NA					No	−2.33 (−7.43 to 3.06)		1	
Cancers related to other risk factors	Prostate	Primary	No	−2.45 (−4.57 to −0.28)		1.04	(0.92 to 1.19)	NA				
		Secondary	No	−3.74 (−6.38 to −1.03)		1.01	(0.87 to 1.16)	NA				
		Tertiary	No	−3.37 (−10.51 to 4.33)		1		NA				
	Lung	Primary	No	−0.15 (−1.16 to 0.88)		1.64	(1.47 to 1.82)	No	−0.84 (−2.51 to 0.86)		1.32	(1.16 to 1.50)
		Secondary	2002	1.69 (−1.59 to 5.09)	−3.70 (−5.55 to −1.81)	1.38	(1.22 to 1.55)	No	−1.42 (−4.16 to 1.41)		1.12	(0.98 to 1.28)
		Tertiary	No	−3.01 (−7.09 to 1.25)		1		No	0.49 (−4.47 to 5.72)		1	
	Colorectal	Primary	No	1.67 (−0.44 to 3.82)		0.91	(0.82 to 1.01)	No	1.38 (−0.07 to 2.85)		1.01	(0.90 to 1.13)
		Secondary	No	0.31 (−2.12 to 2.81)		1.05	(0.93 to 1.19)	No	−0.11 (−1.64 to 1.45)		1.13	(0.99 to 1.28)
		Tertiary	No	−3.36 (−8.08 to 1.61)		1		No	1.31 (−3.59 to 6.45)		1	
	Breast	Primary	NA					No	0.71 (−0.61 to 2.05)		0.93	(0.87 to 0.99)
		Secondary	NA					No	−0.20 (−1.96 to 1.58)		1.13	(1.06 to 1.21)
		Tertiary	NA					No	0.03 (−4.18 to 4.43)		1	
Other cancers		Primary	No	−0.88 (−1.67 to −0.08)		1.39	(1.33 to 1.45)	No	−1.64 (−2.16 to −1.12)		1.50	(1.43 to 1.57)
		Secondary	No	−1.34 (−2.21 to −0.47)		1.30	(1.24 to 1.37)	No	−1.60 (−2.54 to −0.65)		1.27	(1.21 to 1.34)
		Tertiary	2001	−6.48 (−13.14 to 0.69)	0.87 (−1.30 to 3.09)	1		No	−3.10 (−5.02 to −1.13)		1	

EAPC, estimated annual percentage change; EAPC1, EAPC during period from 1998 until joinpoint (in case of a joinpoint) or during the whole period; EAPC2, EAPC during the period from joinpoint until 2007; JP, joinpoint—was there a joinpoint and if so, in which year; NA, not applicable; RR, rate ratio, apply to period 1998–2007.

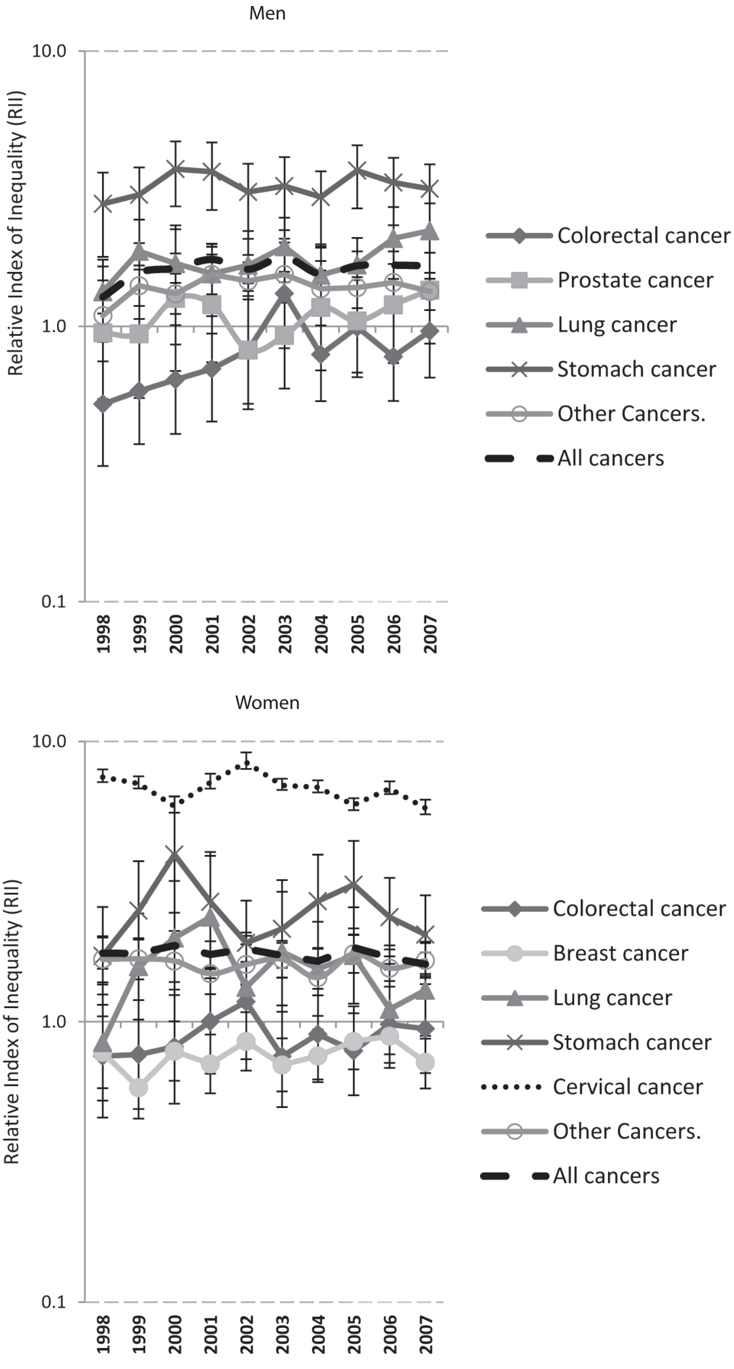

Figure 2. Time trends in relative index of inequality of cancer mortality by sex and cancer type.

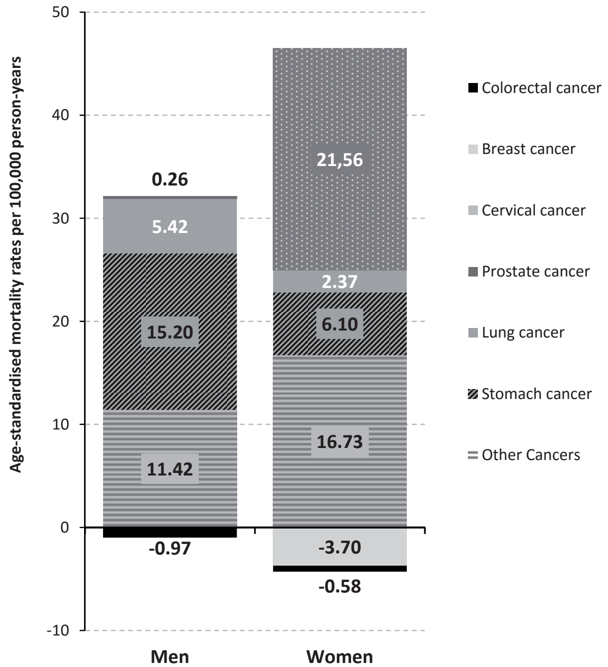

Figure 3. Slope Index of Inequality (SII) in cancer mortality 1998-2007 by sex.

cancers (associated with non-communicable risk factors). Among men, there were inequalities in all but colorectal and prostate cancers, with stomach and lung cancers having the largest inequalities.

Interpretation of results

Several explanations of cancer disparities should be considered, including disparities in preventable risk factors, insurance coverage and healthcare utilisation. We found striking differences in mortality from cervical cancer among women in Colombia. Risk of cervical cancer is related to the mechanisms of transmission of the human papilloma virus (HPV) and reproductive factors such as parity; in addition, limited access to regular healthcare to detect and treat preneoplastic lesions is an important determinant.[22] HPV vaccination has been advised in many countries to prevent cervical cancer,[23] but participation and access to good quality early detection activities remain limited in the lower socioeconomic groups.[24]

Although coverage by cytology is relatively high in Colombia, coverage is substantially lower among women with only primary education (74.9% of women aged 25–69 had a cytology in the past 3 years) compared to women with university education (85.4%); differences are also large between low-income (64.5%) vs high-income (85.8%) women.[24] This suggests that there are persistent barriers to access to medical services in the lower educated groups, which are precisely the groups at highest risks of developing cervical cancer.[24]

However, cervical cancer rates declined faster among lower educated women, which may reflect improved access and adherence to cytology and subsequent treatment for the poorest segments of the population, potentially as a result of the rapidly increasing health insurance coverage since 2002/2003.[2] In 2005/2006, 27% of women with an abnormal pap smear had no access to any of the diagnostic or therapeutic services.[25] Although colposcopies and biopsies have been by law part of the obligatory health plan since 2004, the gynaecological consultations previous to the colposcopy were not reimbursed until 2011.[26] These developments, combined with the introduction of HPV vaccination, may result in narrowing inequalities in cervical cancer mortality in the near future.

Stomach cancer is an aggressive tumour with short survival, so that mortality disparities are most likely related to disparities in risk factor exposure rather than to differences in care. Despite the presence of other risk factors, such as methods of food preservation, cigarette smoking and overweight, infections, mainly Helicobacter pylori, are believed to be a particularly important risk factor for stomach cancer in Colombia.[27] A large proportion of gastric cancer is located in the antrum,[28] of which 89% is believed to be related to H pylori, and risk factors such as smoking and high-salt intake show interactions with H pylori.[27,29] Early diagnosis may significantly improve prognosis of stomach cancer, but cost-effective early detection programmes for a middle-income country setting are unavailable.[27]

Cancer types associated with non-communicable risk factors were generally stable over time, with the exception of prostate cancer, which showed declines among the primary-educated and secondary-educated groups. Despite potential over diagnosis of prostate and breast cancers with currently available screening methods (prostate-specific antigen (PSA) testing and mammography, respectively), improved access to healthcare will reduce mortality trends of these two cancers, particularly among the lower educated. Access to mammographic screening varies by educational level (17% among women with no education to 59% among university-trained women), but is generally low.[5] Although we have no data on incidence, we expect breast cancer incidence to be highest among the higher educated women because of their higher prevalence of reproductive risk factors for breast cancer such as low parity, high age at first childbirth and short breastfeeding periods.[30]

The most important risk factors for prostate cancer are old age and access to PSA testing. We did not observe differences in prostate cancer mortality by educational level, which may be due to the low incidence of prostate cancer in our relatively young sample (25–64 years). Most prostate cancer cases are diagnosed after age 65, at which age disparities by education may emerge due to inequities in the use of PSA tests.

Colorectal cancer screening has been shown to be effective in reducing mortality; yet, no major interventions have been implemented in Colombia and increasing mortality rates and mortality: incidence ratios are a cause of concern.[1,31] Overweight and obesity are implicated in the aetiology of colorectal cancer (as well as in postmenopausal breast and potentially prostate cancers),[32,33] and have increased in Latin America. Although Colombians with primary education have higher body mass index than their higher educated counterparts, inequalities in overweight and obesity by educational level have been stable since at least the early 1990's,[34] a pattern consistent with the stable trends we observed for cancers associated with these risk factors.

Educational inequalities in ASRs for lung cancer likely reflect differences in smoking prevalence in Colombia. Overall smoking prevalence decreased from 21.4% to 12.8% between 1993 and 2007. In 2007, 14.3% of those with primary education smoked versus 11% and 9.7% of those with university or postgraduate education, respectively.[35] Lung cancer mortality rates during 1998–2007, however, reflect smoking patterns in the 1970s, for which data are not available.

Limitations of the study

Some limitations of our study should be considered: mortality data were obtained from official mortality statistics, while data on the population distribution by education were obtained from censuses and demographic projections. This may have led to the so-called numerator/denominator bias, which may have led to overestimation of disparities.[9] Additionally, for some years, data on population size were obtained from demographic projections combined with distributions of education from surveys. To assess the impact of this potential bias, we experimented with different education distributions from multiple data sources.[12,36,37] Although distributions and absolute rates sometimes differed, the overall level and trends observed in our study were robust to different assumptions regarding the distribution of education. As shown in online supplementary figure S2, the distribution of education in our data set mirrors data from other sources very well.

A common concern is coverage of death registration, which is relatively lower in regions with lower income and educational levels.[38–40] This may have led to an underestimation of disparities by education. However, the WHO estimates that, in the period 2000–2010, death registration coverage in Colombia was around 93–98%,[41] suggesting that any bias due to under-registration might be small.

Information on education was missing for 16.7% of cancer deaths, potentially leading to an underestimation of disparities, as missing values are usually more common in the least educated.[39,40] We imputed values for educational level for individuals with missing educational information based on the information on age, sex, marital status, region and urban/rural place of residence, thereby limiting the potential impact of this source of bias. Future studies should examine how results from our 'unlinked' study compare with more precise linkages based on individual identifiers.

Conclusion and policy implications

We found large educational inequalities in total cancer mortality in Colombia. Several explanations should be considered, including disparities in avoidable risk factors, early detection and treatment. Inequalities are not declining, despite improvements in health insurance coverage. On the contrary, with the exception of infection-related cancers, for which mortality declined faster in the lower educated groups, inequalities in mortality from several cancer sites grew during our study period. We document persistent and large inequalities in cervical cancer, which highlight the need for extending prevention efforts to reduce infection by HPV with a focus on the lower socioeconomic groups. Prevention of HPV infection by sex education and vaccination programmes may prove necessary to reduce inequalities in cervical cancer mortality, accompanied by efforts to improve access to cytology and follow-up care following abnormal pap smears. Large inequalities in stomach cancer highlight the need for identifying effective early detection strategies and public health strategies to eradicate H pylori. Smoking contributes importantly to inequalities in cancer mortality particularly among men, highlighting the need to reinforce efforts to reduce tobacco consumption, particularly among lower educated men.

What is already known on this subject?

Earlier studies have documented large and persistent inequalities in mortality from cancer by educational level in high-income countries. However, there is a paucity of studies documenting socioeconomic inequalities in cancer mortality in low-income and middle-income countries. Part of this gap in the literature reflects a lack of available data on mortality stratified by meaningful indicators of socioeconomic status.

What this study adds?

In this work, we use unique registry-linked data to examine inequalities in mortality by educational level in Colombia. Our results reveal large inequalities by educational level in infection-related cancer mortality, particularly cervical and stomach cancer, which represent a major share of socioeconomic inequalities in total cancer mortality. Results raise questions on the role of behavioural changes and health insurance coverage in inequalities in avoidable cancer mortality, and the potential role of increased access to early detection and treatment in curbing cancer inequalities.

FOOTNOTES

Acknowledgments

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Contributors

EdV, IA and MA developed the idea and design of the study, and analysed the data. CP, RM and CW acquired the data and obtained permission. EdV and IA drafted the work. MA, RM, CP, CW and AB critically revised the work. All authors contributed to the interpretation of data and gave the final approval of the version to be published.

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Competing interests

None.

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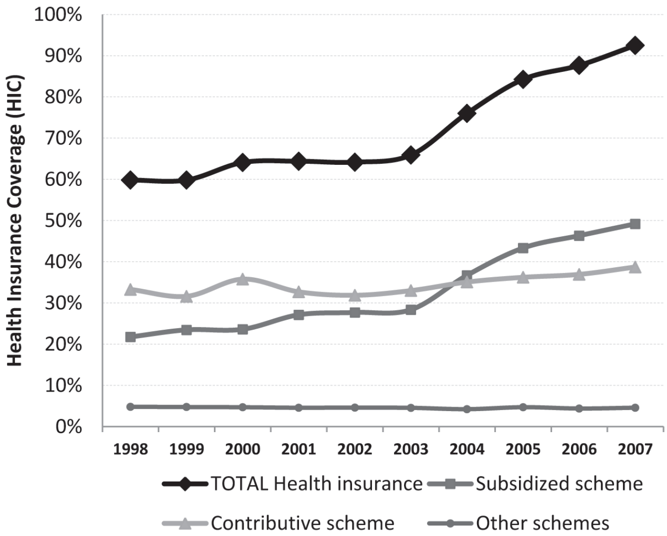
SUPPLEMENTARY DATA



Supplementary figure 1. Proportion of Colombian population covered by health insurance according to different schemes

Supplementary table 1. Estimates for the RR for the interaction term of RII*Year with corresponding confidence intervals

	MEN		WOMEN	
Relative Index of Inequality * Year	**RR**	**95% CI**	**RR**	**95% CI**
All cancers	1.01*	(1.00; 1.03)	0.99	(0.98; 1.00)
Stomach cancer	1.01	(0.97; 1.04)	1.00	(0.96; 1.04)
Cervical cancer			0.98	(0.95; 1.02)
Prostate cancer	1.02	(0.97; 1.08)		
Lung cancer	1.03	(1.00; 1.07)	0.99	(0.95; 1.04)
Colorectal cancer	1.06*	(1.01; 1.11)	1.02	(0.97; 1.07)
Breast cancer			1.02	(0.99, 1.04)
Other Cancers	1.01	(0.99; 1.03)	1.00	(0.98; 1.02)

* indicates statistically significant interaction of RII with year at p<0.05
95% CI: 95% Confidence interval

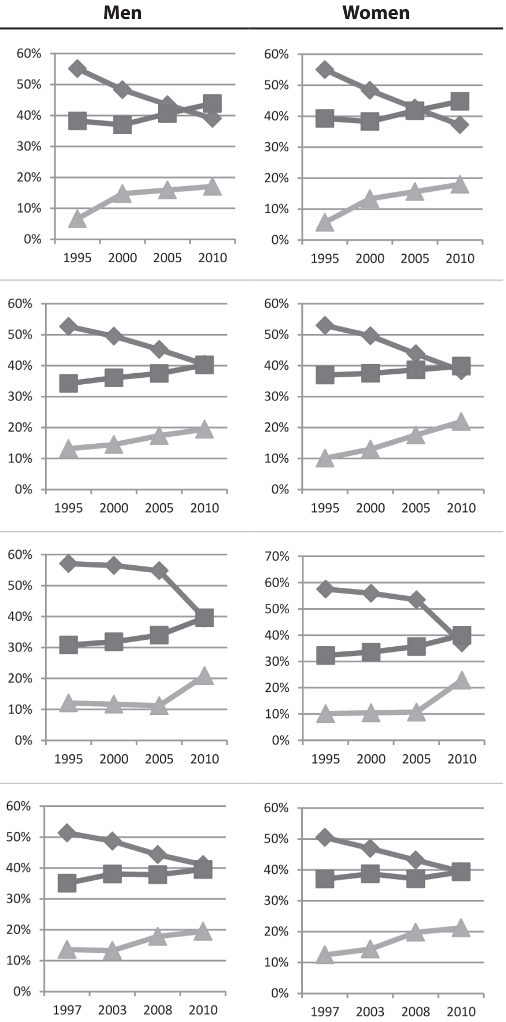
Supplementary figure 2. Comparisons of time trends in educational level in Colombia based on different sources

IIASA/VID		1995	2000	2005	2010
Men	Primary	55%	48%	43%	39%
	Secondary	38%	37%	41%	44%
	Tertiary	7%	15%	16%	17%
Women	Primary	55%	48%	43%	37%
	Secondary	39%	38%	42%	45%
	Tertiary	6%	13%	16%	18%

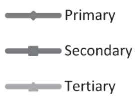
DHS - Colombia		1995	2000	2005	2010
Men	Primary	53%	49%	45%	40%
	Secondary	34%	36%	37%	40%
	Tertiary	13%	14%	17%	19%
Women	Primary	53%	50%	44%	38%
	Secondary	37%	37%	39%	40%
	Tertiary	10%	13%	18%	22%

Barro-Lee		1995	2000	2005	2010
Men	Primary	57%	56%	55%	39%
	Secondary	31%	32%	34%	40%
	Tertiary	12%	12%	11%	21%
Women	Primary	58%	56%	54%	37%
	Secondary	32%	34%	36%	40%
	Tertiary	10%	10%	11%	23%

QLS		1997	2003	2008	2010
Men	Primary	51%	49%	44%	41%
	Secondary	35%	38%	38%	39%
	Tertiary	14%	13%	18%	19%
Women	Primary	50%	47%	43%	39%
	Secondary	37%	39%	37%	39%
	Tertiary	12%	14%	20%	21%



Sources: IIASA/VID: International Institute for Applied Systems Analysis (IIASA), Austria , the Vienna Institute of Demography, Austria: World Population Program; http://datatopics.worldbank.org/education/wProjQuery/IISASModel.aspx
DHS: Demograpic Health Survey - Encuesta Nacional de Demografía y Salud. Profamilia: http://www.profamilia.org.co/encuestas/Profamilia/Profamilia/
Barro-Lee: Barro RJ, Lee JW. A new data set of educational attainment in the world, 1950-2010. J Developm Econ 2013: 104: pp 184-198
QLS: Quality of Life Survey (Encuesta de Calidad de Vida (ECV)): http://www.dane.gov.co/index.php/estadisticas-sociales/calidad-de-vida-ecv



Section III

The relationship between health care insurance coverage (HIC) and socioeconomic inequalities in mortality in Colombia

Chapter 4

The impact of increasing health insurance coverage on inequalities in mortality:

health care reform in Colombia, 1998–2007

Arroyave I, Cardona D, Burdorf A, Avendano M.

The impact of increasing health insurance coverage on disparities in mortality:
health care reform in Colombia, 1998-2007.
Am J Public Health. 2013 Mar;103(3):e100-6.

ABSTRACT

Objectives.
We examined the impact of expanding health insurance coverage on socioeconomic disparities in total and cardiovascular disease mortality from 1998 to 2007 in Colombia.

Methods.
We used Poisson regression to analyze data from mortality registries (633 905 deaths) linked to population census data. We used the relative index of inequality to compare disparities in mortality by education between periods of moderate increase (1998–2002) and accelerated increase (2003–2007) in health insurance coverage.

Results.
Disparities in mortality by education widened over time. Among men, the relative index of inequality increased from 2.59 (95% confidence interval [CI] = 2.52, 2.67) in 1998–2002 to 3.07 (95% CI = 2.99, 3.15) in 2003–2007, and among women, from 2.86 (95% CI = 2.77, 2.95) to 3.12 (95% CI = 3.03, 3.21), respectively. Disparities increased yearly by 11% in men and 4% in women in 1998–2002, whereas they increased by 1% in men per year and remained stable among women in 2003–2007.

Conclusions.
Mortality disparities widened significantly less during the period of increased health insurance coverage than the period of no coverage change. Although expanding coverage did not eliminate disparities, it may contribute to curbing future widening of disparities.

INTRODUCTION

Recent health care reform in the United States has sparked debate on the potential impact of expanding health insurance coverage on access to care and disparities in health care.[1] People with lower socioeconomic status are at increased risk of many conditions and are therefore more likely to benefit from an expansion in health insurance coverage.[1] Previous observational studies in the United States have suggested that a lack of health insurance was associated with an increased risk of subsequent mortality in all socioeconomic groups.[2] However, little is known about the impact of health insurance coverage on socioeconomic disparities in mortality following a major expansion in insurance coverage. In 1993, the Colombian government implemented a major health care reform that introduced mandatory health insurance.[3] As a result, coverage increased from 47% in 1994[4] to 98% in 2010.[5] Although the social and economic context of Colombia differs substantially from that in the United States, lessons from the Colombian reform can shed light on the potential impact of increased health insurance coverage on health disparities in the United States and middle-income countries currently expanding insurance coverage.

A desirable outcome of coverage expansion is that it will have a larger impact on the health of the poor and will contribute to a reduction in health disparities.[3,6] The reform in Colombia established a scheme of subsidies targeted to the poor, assigning citizens to 2 schemes on the basis of income: (1) the contributory scheme, which covers workers and their families with an income above the cut-off and is financed through payroll and employer's contributions, and (2) the subsidized scheme, which covers the poor as identified through a proxy means test.[6]

In the poorest income quartile, health insurance coverage increased from 6% in 1993 to more than 70% in 2007,[6] an increase attributable to the subsidized scheme.[5] Increased coverage among the poor is expected to improve health outcomes by ensuring timely care and bringing them into closer contact with the health care system.[7] However, the reform also increased the complexity of the system potentially leading to delays in some types of care[8] and reducing spending in prevention and public health.[9] Previous dynamic simulations for the United States have suggested that expanding health insurance coverage is cost-effective, but failing to also expand the primary care capacity for the disadvantaged could lead to increasing health disparities.[10] There have been no empirical studies examining these issues in the context of a major health care reform.

Most previous studies have focused on the impact of health care reform on utilization and access to health care services, with only some studies examining the impact on population health.[7,11–13] A recent review of available evidence concluded that expanding health insurance coverage generally improves access to care and population health particularly for lower income groups, but health gains may be dependent on the institutional framework and governance arrangements.[14] On the other hand, the World Health Organization Commission on Social Determinants of Health concluded that, although inequity in health care is critical, the largest burden of illness arises in large part because of the conditions in which people are born, grow, live, work, and age.[15]

We examined whether expanding health insurance coverage is associated with trends in socioeconomic disparities in mortality in the aftermath of the health care reform in Colombia. Findings from this study are of potential interest to the United States and middle-income countries that have recently implemented reforms to achieve universal access. We hypothesized that expanding health insurance coverage will contribute to curbing unfavorable trends in mortality disparities. To assess the impact of this expansion, we examined trends in mortality disparities by educational level separately for 2 divergent periods. In 2002, a process of decentralization led to a sharp increase in resource allocation to the subsided scheme in regional areas.[16] As a result, whereas in the period 1998–2002 there was a moderate increase in total health insurance coverage (coverage went from 59.8% in 1998 to 64.1% in 2002), thereafter total coverage increased rapidly from 65.9% (2003) to 92.5% (2007; Figure 1). This corresponds to a statistically significant increase of 5.1% per year ($p < .001$) in the period 2003–2007. As illustrated in Figure 1, this increase was driven by a particularly steep increase in affiliates to the subsidized scheme in 2003–2007 (15.1% per year; $P < .001$), as opposed to a much smaller increase in the period 1998–2002 (6.4% per year; $P < .001$), suggesting that it may have particularly reached the lower socioeconomic groups. The discrepancy

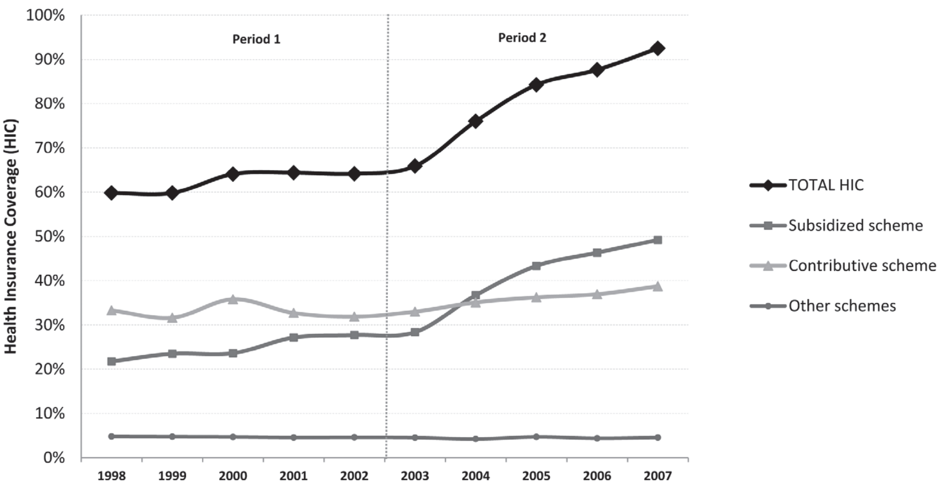


Figure 1. Percentage of population with health insurance coverage: Colombia, 1998–2007.
Note. Other schemes include primarily members of the military and teacher and oil workers syndicate members.
Source. Annual reports of the Ministry of Health and Social Protection.5,17–19

in health insurance coverage trends between these 2 periods thus provides a natural experiment to examine the impact of health insurance coverage on socioeconomic disparities in mortality.

Our specific aim was to evaluate to what extent increased health insurance coverage has contributed to diminishing socioeconomic inequalities in mortality in Colombia. If socioeconomic differences in mortality were responsive to increased health insurance coverage, we would expect a more favorable trend in socioeconomic differences in mortality during the second than the first period. If increased insurance coverage had no impact on socioeconomic disparities in mortality, we would expect similar trends in socioeconomic disparities in mortality between the two periods.

METHODS

Data on deaths came from the national statistics agency, which collects and harmonizes data on all deaths from all regions based on international guidelines. Causes of death were coded according to the International Classification of Diseases (ICD-10).[20] We focused on total mortality and mortality from cardiovascular diseases (CVDs), which is the major cause of death in Colombia and partly reflects changes in lifestyle associated with the epidemiological transition.[21] We defined CVD as codes I00 to I99 (Chapter IX, ICD-10).

For all deceased individuals (633 905 deaths), data were recorded on gender, age of death, and educational level. Data on age and gender were available for more than 99% of all deaths, and data on educational level was missing for approximately a third of deceased cases. We used multiple imputation methods as developed by Raghunathan et al.[22] and implemented in SAS version 9.2 through the IMPUTE procedure (SAS Institute, Cary, NC) to impute educational level for these individuals. This was done to avoid bias because of the potentially higher rates of missing education for lower-educated individuals, and to minimize the potential for numerator–denominator bias.[23,24] In short, this procedure fits a sequence of regression models and draws values from the corresponding predictive distributions. We applied the sequential regression procedure based on a model that included gender, region, age, and marital status as covariates. Full details on the procedure are available elsewhere.[22]

We restricted the sample to ages 25 to 64 years because our interest was on avoidable mortality at adult age. In addition, data on educational level from death registries has been shown to be unreliable at ages 65 years and older, potentially leading to biased estimates of differences in mortality by education.[23]

We obtained data on midyear population counts with the following procedure: First, we extracted data on the proportion of individuals in each educational level from the International Institute of Applied System Analysis and the Vienna Institute of Demography of the Austrian Academy of Sciences (IIASA/VID) database.[25] This database contains information on the distribution of education for every 5-year age group, gender, and year combinations every 5 years for the period 1970 through 2010, obtained from census, national surveys, and demographic projections for 120 countries. Second, we obtained data on yearly population counts for the entire population in Colombia from census and statistical projections from the national statistical office. Third, we estimated the yearly population in each educational group by multiplying the proportion of individuals in each educational category obtained from the IIASA/VID database by population counts from national census and statistical projections. The IIASA/VID database contained distributions of education every 5 years only. Therefore, we performed demographic projections to obtain population counts for years between every lustrum by using the demographic Software Population Analysis Spreadsheets (PAS).[26]

We then combined data on population counts with data on deaths to obtain a complete database of mortality by educational level. We reclassified national educational levels into 3 categories based on highest educational attainment. These levels corresponded approximately to the following US education system categories (in reference to the highest level attained): (1) primary (elementary or primary school), (2) secondary (high-school diploma), and (3) tertiary education (postsecondary education after high school including college and university).

We first calculated age-standardized mortality rates by educational level, gender, and year by using the World Health population of 1997[27] as reference. Subsequently, we implemented separate Poisson regression models with number of deaths as dependent variable and the natural log of person-years as offset variable, incorporating age and educational level as independent variables. We used Poisson regression because data were aggregated as counts of deaths per population, and because death counts followed a Poisson probability distribution.

First, to assess mortality trends by educational level, we estimated the annual percent change (APC) in mortality based on a Poisson model that incorporated an interaction between educational level and year. The APC is the average rate of change in the mortality rate per year in a given time frame (how quickly mortality has increased or decreased each year over a period of years).[28] It is presented as a percentage, such as a 1% per year increase. A negative APC describes a decreasing mortality trend, whereas a positive APC describes an increasing mortality trend.

At a second stage, we estimated two complementary measures of disparities separately for the periods 1998–2002 and 2003–2007. We started by estimating the rate ratio (RR) of mortality by educational level, which compared the mortality of all educational groups to the mortality in the tertiary education group. Changes in the RR over time result from changes in both risks and the distribution of educational level.[29] Therefore, to assess changes in disparities with control for changes in the educational distribution, we estimated the relative index of inequality (RII), a widely used measure to examine trends in health disparities.[30] The RII is a regression-based measure that takes into account the size of each educational group by regressing mortality on the midpoint of the cumulative distribution of education.[29] The RII can be interpreted as the ratio of the mortality rate of those at the bottom of the distribution of education compared with the rate of those at the top of the distribution of education.[29] An increase in the RII indicates an increase in disparities in mortality across educational level. Further details on the RII are available elsewhere.[29]

To estimate whether changes in disparities by educational level differed between the period of moderate increase (1998–2002) and the period of rapid increase in health insurance coverage (2003–2007), we incorporated interaction terms between educational level and year within each period. A significant positive interaction indicated a significant increase in disparities in mortality by education. To assess whether yearly changes in disparities between the 2 periods were statistically significant, we implemented a single model that incorporated a 3-way interaction among period, year, and educational level. A significant interaction was interpreted as indication of an effect of health insurance coverage on disparities in mortality by educational level.

We carried out all regression analyses in each of the 5 multiple databases generated by the multiple imputation process. Because results were nearly identical for all imputations, we used standard techniques as implemented in the PROC MIANALYZE procedure in SAS to combine estimates from all databases and adjust standard errors to account for uncertainty in the imputation.[31] This procedure reads the parameter estimates and associated covariance matrix for each imputed data set, and then derives valid multivariate inferences for these parameters. This allows for valid statistical inference that appropriately reflects uncertainty attributable to missing values.[31]

RESULTS

Table 1 summarizes data on deaths and midyear population (person-years). There was a total of 633 933 deaths over the period 1998–2007. Imputation of education was not possible in 6.4% of deceased cases, leaving a total of 593 173 deaths for analysis. Total mortality rates were 537.8 deaths per 100 000 population among men and 281.6 among women, and CVD rates were 115.5 and 78.0, respectively. From 1998 to 2007, men and women with only primary education or less schooling had higher mortality rates than their higher-educated counterparts (Figure 2). In all educational groups, mortality from both total and CVD declined over the study period. However, Figure 3 shows that men and women with tertiary education experienced a faster decline in mortality than their less-educated counterparts. The average APC in mortality according to educational level

Table 1. Descriptive Statistics Before and After Expanded Health Care Insurance: Colombia, 1998–2007

	Period 1: 1998–2002				Period 2: 2003–2007			
	Person-Years	**%**	**CVD deaths**	**All Deaths**	**Person-Years**	**%**	**CVD deaths**	**All Deaths**
Age groups, years								
25–29	15 681 229	18.3	1286	41 610	16 790 652	17.7	1254	35 447
30–34	15 295 439	17.9	1889	37 838	15 170 633	16	1676	31 311
35–39	14 113 107	16.5	3046	36 466	14 845 056	15.7	2736	31 442
40–44	11 924 028	14	5194	35 185	13 808 189	14.6	4712	32 899
45–49	9 636 969	11.3	7671	35 342	11 662 310	12.3	7876	36 109
50–54	7 672 753	9	10 436	37 543	9 383 845	9.9	11 112	41 478
55–59	6 053 379	7.1	13 451	41 850	7 399 564	7.8	14 522	46 499
60–64	5 090 243	6	20 063	56 203	5 732 546	6	19 445	56 684
Gender								
Men	41 329 276	48.4	5868	218 802	45 764 081	48.3	37 156	206 225
Women	44 137 871	51.6	27 168	103 149	49 028 714	51.7	26 177	105 578
Missing	…		…	86	…		…	66
Educational attainment [a]								
Primary	42 062 366	49.2	44 541	197 754	41 221 063	43.5	42 584	184 632
Secondary	32 349 705	37.9	13 393	84 445	38 739 709	40.9	15 350	91 178
Tertiary	11 055 076	12.9	3014	16 493	14 832 022	15.6	3718	18 671
Missing	…		2088	23 345	…		1681	17 388
Total	**85 467 147**		**63 036**	**322 037**	**94 792 795**		**63 333**	**311 869**

Note CVD = cardiovascular disease.

[a] Educational attainment values registered after final imputation: primary = elementary or primary school; secondary = high-school diploma; tertiary = postsecondary education after high school including college and university.

was −4.89% (95% CI = −5.35, −4.36) in men and −2.18 (95% CI = −2.96, −1.39) in women with tertiary education, compared with −1.31% (95% CI = −1.48, −1.15) in men and −1.27% (95% CI = −1.45, −1.08) in women with only primary education. We observed similar disparities for CVD mortality.

Table 2 summarizes the RR (model 1) and RII (model 2) separately for the periods 1998–2002 and 2003–2007. Both measures suggest that disparities by education in total and CVD mortality widened over the study period in both men and women. For total mortality, the RII increased from 2.59 (95% CI = 2.52, 2.67) in 1998–2002 to 3.07 (95% CI = 2.99, 3.15) in 2003–2007 in men, and from 2.86 (95% CI = 2.77, 2.95) in 1998–2002 to 3.12 (95% CI = 3.03, 3.21) in 2003–2007 in women. There was a particularly steep increase in disparities in CVD mortality in women, which increased from 3.33 (95% CI = 3.10, 3.59) in 1998–2002 to 4.20 (95% CI = 3.94, 4.47) in 2003–2007.

As shown in Table 2, disparities in mortality widened significantly less in the period of accelerated increase in health insurance coverage (2003–2007) than in the period of moderate increase in coverage (1998–2002). The RII for total mortality increased by 11% (RR = 1.11; 95% CI = 1.09, 1.13) in men and 4% in women (RR = 1.04; 95% CI = 1.02, 1.06) per year in the period 1998–2002, whereas it increased by only 1% (RR = 1.01; 95% CI = 1.00, 1.03) in men and remained stable among women (RR = 1.00; 95% CI = 0.98, 1.02) in the period 2003–2007. Similarly, the RII for CVD mortality increased by 9% in men and 7% in women in 1998–2002, whereas there was no significant change in disparities in

Table 2. Relative Disparities in Mortality by Educational Level as Measured by the Rate Ratio and the Relative Index of Inequality for Men and Women Aged 25–64 Years: Colombia, 1998–2002 and 2003–2007

	Men		**Women**	
	1998–2002, RR (95% CI)	**2003–2007, RR (95% CI)**	**1998–2002, RR (95% CI)**	**2003–2007, RR (95% CI)**
All-cause mortality				
Model 1 [a]				
Tertiary education (Ref)	1.00	1.00	1.00	1.00
Secondary education	1.80 (1.76, 1.84)	1.96 (1.91, 2.00)	1.63 (1.56, 1.70)	1.69 (1.64, 1.74)
Primary education	2.41 (2.36, 2.47)	2.76 (2.68, 2.83)	2.43 (2.34, 2.52)	2.56 (2.49, 2.63)
Year	0.92 (0.91, 0.94)	0.97 (0.96, 0.99)	0.95 (0.93, 0.98)	0.99 (0.97, 1.01)
Secondary × year	1.09 (1.07, 1.11)	1.00 (0.98, 1.02)	1.04 (1.02, 1.07)	0.99 (0.97, 1.01)
Primary × year	1.11 (1.09, 1.13)	1.00 (0.99, 1.02)	1.04 (1.02, 1.07)	0.99 (0.97, 1.01)
Model 2				
Relative index of inequality	2.59 (2.52, 2.67)	3.07 (2.99, 3.15)	2.86 (2.77, 2.95)	3.12 (3.03, 3.21)
Year	0.95 (0.94, 0.96)	0.96 (0.95, 0.97)	0.96 (0.95, 0.98)	0.97 (0.96, 0.99)
Relative index of inequality × year	1.11 (1.09, 1.13)	1.01 (1.00, 1.03)	1.04 (1.02, 1.06)	1.00 (0.98, 1.02)
Cardiovascular disease mortality				
Model 1 [a]				
Tertiary education (Ref)	1.00	1.00	1.00	1.00
Secondary education	1.47 (1.40, 1.54)	1.55 (1.47, 1.62)	1.73 (1.56, 1.90)	1.85 (1.69, 2.03)
Primary education	1.70 (1.63, 1.78)	1.97 (1.88, 2.05)	2.76 (2.50, 3.05)	3.20 (2.96, 3.46)
Year	0.91 (0.88, 0.96)	0.96 (0.92, 1.00)	0.91 (0.86, 0.97)	0.96 (0.91, 1.01)
Secondary × year	1.06 (1.01, 1.11)	1.03 (0.99, 1.08)	1.06 (0.99, 1.12)	1.02 (0.97, 1.08)
Primary × year	1.08 (1.03, 1.13)	1.03 (0.99, 1.08)	1.07 (1.01, 1.14)	1.02 (0.96, 1.07)
Model 2				
Relative index of inequality	1.75 (1.66, 1.84)	2.18 (2.07, 2.29)	3.33 (3.10, 3.59)	4.20 (3.94, 4.47)
Year	0.92 (0.90, 0.95)	0.97 (0.95, 1.00)	0.92 (0.89, 0.95)	0.96 (0.93, 0.99)
Relative index of inequality × year	1.09 (1.04, 1.14)	1.02 (0.98, 1.06)	1.07 (1.02, 1.12)	1.01 (0.96, 1.05)

Note. CI = confidence interval; RR = rate ratio. Table presents estimates that combine results from 5 databases generated by multiple imputation, appropriately reflecting uncertainty attributable to missing values. Model 1 shows RRs from a model that includes as independent variables educational level, age in 5-year age categories, a linear year trend, and an interaction between educational level and the linear year trend. Model 2 estimates the relative index of inequality based on a regression of mortality on the midpoint of the cumulative distribution of education, age in 5-year age categories, a linear year trend, and an interaction between the midpoint of the cumulative distribution of education and the linear year trend. It can be interpreted as the ratio of the mortality rate of those at the bottom of the distribution of education compared with the rate of those at the top of the distribution of education. An increase in the relative index of inequality indicates an increase in disparities in mortality by educational level.[29]

[a] Primary = elementary or primary school; secondary = high-school diploma; tertiary = postsecondary education after high school including college and university.

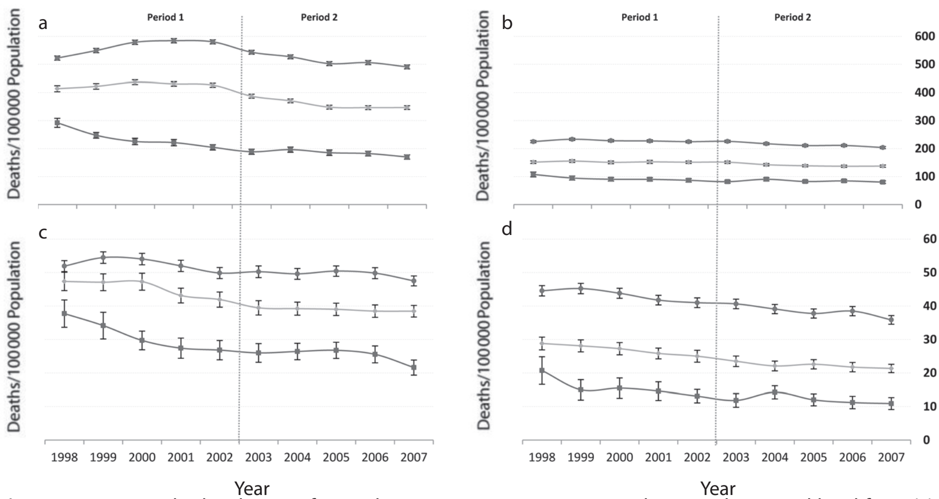


Figure 2. Age-standardized rates of mortality at ages 25–64 years according to educational level from (a) all-causes among men, (b) all-causes among women, (c) CVD among men, and (d) CVD among women: Colombia, 1998–2007.

the period 2003–2007. The interaction between the RII and year was always significant for the period 1998–2002, whereas in the second period, it was only significant for total mortality in men.

DISCUSSION

Our analyses suggest that there are large disparities in mortality by educational level in Colombia, which widened significantly during the post–health care reform period owing to larger decreases in mortality among higher-educated persons. However, socioeconomic disparities in mortality widened significantly less during a period of rapid expansion in insurance coverage, compared with a period of moderate increase in coverage. Findings suggest that expanding insurance coverage may not eliminate disparities in the short term, but over the long run, it may partly contribute to curbing widening disparities in mortality.

Interpretation of results

There is controversy on the impact of insurance coverage on health outcomes and health disparities in Colombia,[3,6–9,13] the United States,[1,2,10,32] and elsewhere.[33–36] Although some studies have suggested that the subsidized scheme led to improvements in maternal and children's health,[6] little is known about impact on adult outcomes and mortality. The slowdown in the rate of increase in disparities in adult mortality observed in our study during the period of rapid increase in coverage may have been the result of in-

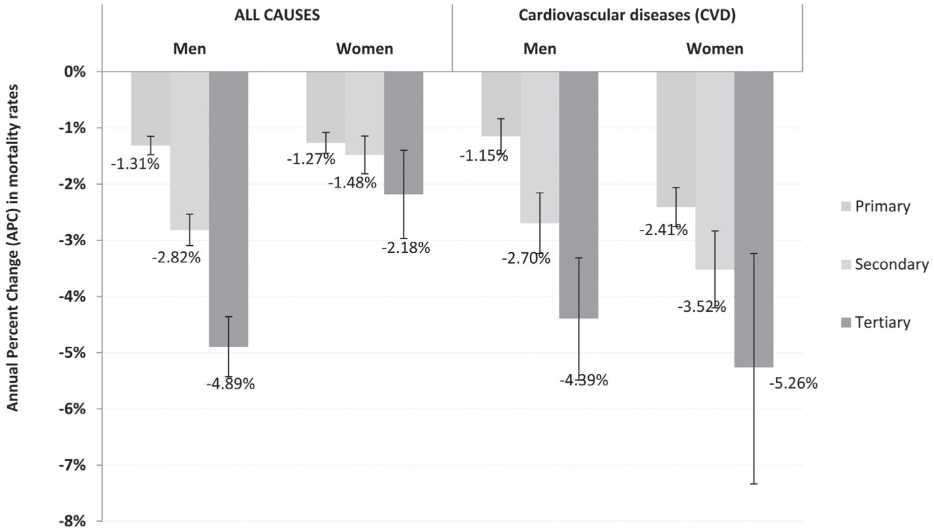


Figure 3. Annual percentage change in mortality rates at ages 30–64 years according to educational level: Colombia, 1998–2007.

Note. Primary = elementary or primary school; secondary = high-school diploma; tertiary = postsecondary education after high school including college and university. Annual percent change comes from separate Poisson regression models for men and women that control for age, year, and education.

creased access to care.[7] Those insured in the subsidized scheme were approximately 40% more likely to have used outpatient visits in the past year than were the uninsured, half as likely to have experienced barriers to access when needing care,[6] and less likely to have experienced catastrophic spending.[6] In addition, studies from other countries have suggested that increased coverage may contribute toward reducing disparities in health care utilization. A study in Taiwan, which in 1995 implemented a similar insurance-based reform, found that increased coverage significantly increased physician visits in all income groups,[33] but middle and lower household income groups benefited more than their higher-income counterparts.[33]

Despite almost universal coverage, low-income groups still face more barriers in access to care than their higher-income counterparts.[13] Following a large health care reform that increased coverage in Thailand, large disparities in health care utilization remained.[34] Several studies have shown that even European countries with universal health care coverage have large disparities in mortality that have persisted and increased during the past decades.[35–37] A possible explanation of our results is the persistence of disparities in behavioral determinants of mortality uninfluenced by access to care. In 2003, the prevalence of smoking among lower-educated Colombians was 41%, compared with 26% in those with college education.[38] Similarly, a recent study estimated that 26% of lower-educated Colombians aged 25 to 50 years have at least a risk factor for CVD, as opposed to only 5.9% in those with a university degree.[39]

Despite potential beneficial effects, several studies support the hypothesis that health insurance is only 1 among many determinants of disparities in health and mortality.[2,32] Disparities in behavioral risk factors, psychosocial well-being, parental socioeconomic status, and childhood living circumstance may all contribute to disparities in mortality.[40] In addition, health care reform may not have been sufficient to curb autonomous trends in chronic disease risk factors resulting from secular lifestyle changes toward more sedentary lifestyles and higher obesity.[21] Socioeconomic disparities in distal determinants of mortality such as poverty, living conditions, and working conditions may also have contributed to disparities. The gap in earnings among higher- and lower-educated workers has grown during the past decades.[41] It is estimated that 59% of lower-educated households live in poverty, as opposed to only 4.1% among their higher-educated counterparts.[42] Among households in the highest income quintile, 96% have access to water services as opposed to 75% in the lowest income quintile. Similarly, 90% of households in the highest income quintile have access to drainage services, in contrast to 54% in the lowest income quintile.[43] The persistence of disparities in these social and behavioral determinants of mortality may explain why disparities persist even after universal access to care has been achieved.

Limitations of the study

Despite several strengths, some limitations should be considered in our study. Data on mortality came from mortality registries, whereas data on the population distribution by education came from census and demographic projections. This may have led to the so-called numerator–denominator bias, which generally results in an overestimation of disparities.[23,24] Another limitation is that, for some years, data on population size came from demographic projections combined with distributions of education from surveys. To assess the impact of this potential bias, we experimented with different education distributions from multiple data sources.[25,44,45] Overall, although distributions and absolute rates sometimes differed, the overall trends observed in our study were robust to different assumptions on the distribution of education.

Education was missing for 38.4% of death records in the first period and 29.9% of records in the second period. This may have led to underestimation of disparities, as missing values are likely to be more common in less-educated and higher-mortality areas. However, we imputed values for individuals with missing education based on a rich set of variables available for most deceased individuals that strongly predicted education, minimizing the potential impact of this source of bias. Overall, because of relatively small changes in the proportion of missing over time, these trends may generally lead to underestimation of disparities, but they are unlikely to account for differences in trends in disparities over the 2 periods assessed.

Our study was based on a comparison of trends in socioeconomic disparities in mortality between 2 periods. We assumed a common trend in factors other than coverage between the first and second periods. In preliminary analyses, we found that our results were robust to adjustment for several national-level variables such as gross domestic product growth and employment rates, which showed similar trends in both periods. However, we cannot discard the possibility that other time-varying covariates contributed to trends in mortality. Most importantly, increased coverage may have occurred parallel to other changes in the health care system.[4,6] Our results may therefore reflect not only the impact of increased coverage but also the impact of other aspects of the health care reform.

Conclusions

Socioeconomic disparities in mortality widened throughout the period 1998–2007, but they increased significantly less during a period of increased insurance coverage than during a period of moderate increase in coverage. The reform may take several decades to have a meaningful impact on the mortality of disadvantaged populations. Therefore, future studies should closely monitor changes in disparities in mortality in the coming years. Our findings underscore the importance of understanding the impact of determinants other than health care in explaining disparities in mortality, including lifestyle, as well as the living and working conditions of the poor. Given trends in these determinants, increasing insurance coverage may not be sufficient to eliminate disparities, but our findings suggest that it may contribute to curb increasing trends in disparities in mortality.

FOOTNOTES

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Contributors

I. Arroyave was the leading author and developed the article idea, constructed and analyzed the data set, and wrote drafts of article. D. Cardona contributed to the quantitative analysis and commented on all drafts of the article. A. Burdorf contributed to interpretation of results and commented on all drafts. M. Avendano analyzed data, wrote sections of the article, and contributed to the coordination of all steps of the analysis and article preparation.

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Human Participant Protection

This article is based on secondary analysis of data on deaths and population counts in aggregate form made publically available by the National Statistics Office in Colombia. Ethical approval for this study was not required.

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Chapter 5

Time trends in educational inequalities in cancer mortality in Colombia, 1998-2012

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Time trends in educational inequalities in cancer mortality in Colombia, 1998-2012

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** Shared first authorship (both authors contributed equally)*

STRUCTURED ABSTRACT

Objectives:
To evaluate trends in premature cancer mortality in Colombia by educational level in three periods; 1998-2002 with low healthcare insurance coverage, 2003-2007 with rapidly increasing coverage, and finally 2008-2012 with almost universal coverage (2008-2012).

Setting:
Colombian population-based, national secondary mortality data..

Participants:
We included all (n=188,091 cancer deaths occurring in age groups 20-64 years between 1998 and 2012, exclusing only cases with low levels of quality of registration (n=2,902, 1.5%).

Primary and secondary outcome measures:
In this descriptive study we linked mortality data of ages 20-64 years to census data to obtain age-standardized cancer mortality rates by educational level. Using Poisson regression we modelled premature mortality by educational level estimating rate ratios (RR), relative index of inequality (RII) and the Slope Index of Inequality (SII).

Results:
Relative measures showed increased risks of dying among the lower educated compared to the highest educated, this tendency was stronger in women (RRprimary 1.49; RRsecondary 1.22, both p<0.0001) than in men (RRprimary 1.35; RRsecondary 1.11, both p<0.0001). In absolute terms (SII) cancer caused a difference per 100,000 deaths between the highest and lowest educated of 20.5 in males and 28.5 in females. RII was significantly higher among women and the younger age categories. RII decreased between the first and second period, afterwards (2008-2012) increased significantly back to their previous levels. Among women, no significant increases or declines in cancer mortality over time were observed in recent periods in the lowest educated group, whereas strong recent declines were observed in those with secondary education or higher.

Conclusions:
Educational inequalities in cancer mortality in Colombia are increasing, in absolute and relative terms concentrated in young age categories. This trend was not curbed by increases in healthcare insurance coverage. Policy makers should focus on improve equal access to prevention, early detection, diagnostic and treatment facilities.

Strengths and limitations
- Population-based mortality databases with information on educational level provide a unique data source to evaluate educational differences
- Definition of the variable for educational level does not guarantee having terminated the indicated level, there may be variance within the educational groups
- Time period included covers a period of important changes in Colombian society, expected to be reflected in cancer mortality rates
- Multiple imputation improved statistical power and precision of analyses
- The underlying causes of these trends are unknown

INTRODUCTION

Colombia is a country with very large socioeconomic inequalities, causing, among others, large differences in health-related topics such as life expectancy and incidence, prognosis and mortality of disease [1-3]. In 1993, a major health care reform in Colombia introduced mandatory health insurance coverage (HIC) [4]. Citizens are assigned to two major schemes based on income: (i) the contributory scheme, which covers workers and their families with an income above the cut-off and is financed through payroll and employer's contributions; and (ii) the subsidized scheme, mainly funded via taxes, which subsidizes the poor as identified through a proxy means test [5]. HIC was 23.7% in 1993 just before the reform [6] and rose to 37.7% in 1994, just afterwards [4]. Initially, the coverage slowly improved [4] and a subsequent reform led in 2002 to a noticeable increase of healthcare coverage (reaching around 96% by 2008) by improving efficiency in the use of resources and by reducing its reliance on national budgets [7] (Figure 1). In the poorest income quartile, HIC increased from 6% to over 70% between 1993 and 2009 [5], attributable to the subsidized scheme [8], which shows that the program reached the poorer income groups more aggressively. This increased HIC is expected to contribute to a reduction in health inequalities [4 5], mainly by improving the situation for the poor: ensuring timely care and bringing patients in closer contact with the health care system [9 10]. It has been argued, however, that the reform increased the complexity of the system which could potentially lead to delays in certain types of care [11] and reduced spending in prevention and public health [12].

In Colombia, three different periods in the implementation of universal HIC can be discerned (Figure 1): During the period 1998-2002, HIC was relatively low and stable (around 70% during all the period); the second period (2003-2007) covered the years of rapid increase in coverage among the poor (6.9% average annual growth in HIC, 12.2% in subsidized scheme); while during the third period (2008-2012) universal coverage remained stable according to official figures at on average 96.1%. The discrepancy in HIC trends between these three periods offers a natural experiment to examine the impact of HIC on socioeconomic disparities in mortality.

Few studies have examined the impact of different health insurance status on inequalities in mortality and even less is known about inequalities in mortality in middle-income countries, many of whom introduced major health care system reforms during the last decades. As in Colombia the increase of HIC towards universal coverage was deliberately addressed to the poorest population [4 5], and educational level is a good proxy variable for Socioeconomic Status (SAS) [13], we hypothesize that increased HIC contributed to reducing inequalities in cancer mortality. Cancer mortality is a particularly interesting indicator of the effect of insurance coverage due to the expected increased access to prevention measures, early detection, timely treatment therapies, and high-cost interventions [14-16].

Indeed, previous analyses of time trends of differences in cancer mortality by attained educational level in Colombia (1998-2007) were promising, particularly for gastric and cervical cancer where faster declines in mortality occurred in the lowest educated groups and therefore socioeconomic differences were expected to decrease in the near future [3]. In this paper we evaluate if the seemingly positive trend in cancer mortality by educational level continued, by using a slightly different definition of educational level which allowed us to extend the previous analyses (up to 2007) by 5 extra years, covering 1998-2012.

METHODS

Data

Education level criteria

Educational level was defined as the highest level in which the individual has been enrolled during his life (i.e. the person accessed but not necessarily graduated this level), and was categorized in three groups based on the highest educational level accessed by the deceased: (a) Primary school or less, (b) Secondary school, and (c) Tertiary (post-secondary education). In previous papers educational level has been used, based on the highest educational level attained (i.e. completed) by the deceased [1 3] but this category is restricted to the period 1998-2007. In our calculations we found both approaches to be similar in terms of the results yielded.

Deaths

National mortality data for cancer deaths (International Classification of Diseases (ICD-10) codes C00-C96, see Appendix-Table 1) for the period 1998-2012 were obtained from the National Administrative Department of Statistics (DANE), which routinely registers information on sex, date and cause of death as well as educational level from death certificates. Although the exact wording for the variable "accessed education" changed in the DANE database since 2008, the new categories were consistent with those of the databases of previous years and could be used. Trends of counts were found to be continuous and regular.

We focused on adult premature mortality (mortality below age 65) because it is known that information on educational level from mortality statistics is unreliable at ages 65 and beyond [17]. Additionally, premature mortality is an indicator of population health

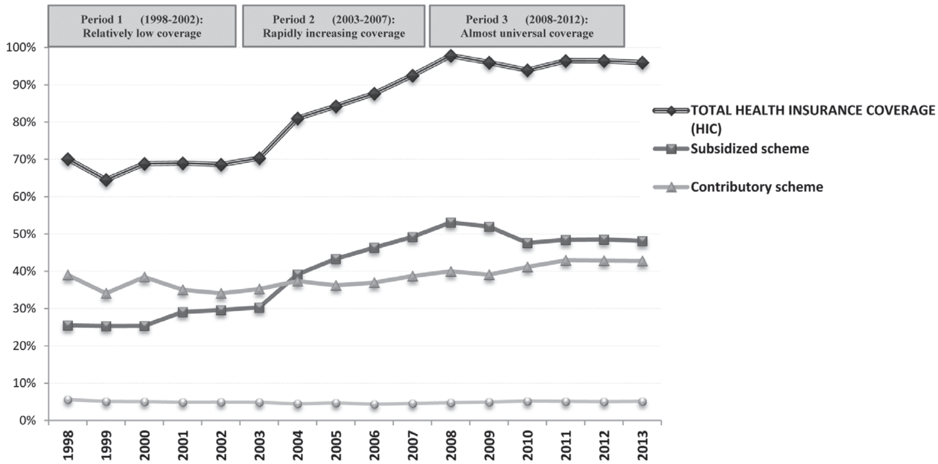

Figure 1. Trends in national healthcare insurance coverage (HIC), Colombia, 1998-2012
Other schemes include primarily members of the military and teacher and oil workers syndicate members.
Based on Annual reports of the Ministry of Health and Social Protection
Source: Annual reports of the Ministry of Health and Social Protection to the Congress of the Republic of Colombia

believed to be strongly influenced by social, economic and environmental factors [18], and is a common indicator of health system performance [19].

Data on age and sex were available for more than 99% of all deaths, while data on educational level was missing for approximately 16.5% of 190,993 cancer deaths. We used multiple imputation methods [20] implemented in SAS through the IMPUTE procedure to impute educational level for these cases in order to avoid bias due to the potentially higher rates of missing education for lower educated individuals, and to minimize the potential for numerator/denominator bias [17]. In short, this procedure fits a sequence of regression models and draws values from the corresponding predictive distributions. The sequential regression procedure was applied based on a model that included sex, region, urban/rural residence and marital status as covariates. Details of this method are explained elsewhere [20]. The imputation procedure was successful in 90.8% of cases with missing information, resulting in a total of 188,091 (98.5%) cancer deaths for our analyses.

Population

Data on mid-year population counts by age, sex and educational level were obtained from the Colombian Demography Health Surveys (DHS) [21], which contain periodical information on the distribution of education by age, sex and calendar year (1995, 2000, 2005 and 2010). Age 20 was chosen as the lower age limit of this study as almost 100% of individuals accessed their highest educational level by this age.

The resulting proportions of individuals in each educational level were multiplied with the total population numbers per year, age and sex which were obtained from census combined with statistical projections from DANE [22]. These two information sources were combined to estimate the annual population size in each educational group (Appendix-Figure 1). We performed demographic projections to obtain population counts for years in-between every lustrum using the demographic Software PASEX [23]. Additional details on the procedure are available elsewhere [23].

Analysis

All analyses were conducted in each of the five multiple databases generated by the multiple imputation process. Since results were nearly identical for all imputations, we used standard techniques as implemented in the PROC MIANALYZE procedure in SAS to combine estimates from all databases and adjust standard errors to account for uncertainty in the imputation [24]. This procedure reads the parameter estimates and associated covariance matrix for each imputed data set, and then derives valid multivariate inferences for these parameters. This allows for valid statistical inference that appropriately reflects uncertainty due to missing values [24].

All analyses were conducted in SAS® version 9.2.

Age Standardised Mortality Rates (ASMR)

Data on population counts were combined with data on deaths to obtain a complete database of death counts by educational level, sex and five-year age group. We first calculated age-standardized mortality rates by educational level, sex and year using the World Health population of 1997 [25] as standard population, resulting in Age Standardised Mortality Rates (ASMR) expressed per 100,000 person-years (Figure 2). We also calculated ASMR by sex and year (Figure 2) and by educational level and sex (Table 1).

Annual trends in ASMR by sex and educational level were quantified by calculating the estimated Annual Percentage Change (EAPC) which measures the average rate of change in the mortality rate per year (negative EAPC: decreasing trend, positive EAPC : increasing trend). To test whether an apparent change in mortality trends was statistically significant, we used joinpoint regression, which fits a series of joined straight lines to age-adjusted rates and uses a Monte Carlo Permutation method to identify the best-fitting point (called joinpoint, year in which a significant change in the mortality trend occurred), where the rate of increase or decrease changes significantly [26]. EAPC and joinpoints were determined based on the log-transformed ASMRs and their standard errors. We specified a maximum of 2 joinpoints with at least 4 observation points to either extreme of the data using joinpoint modelling based on the Joinpoint program [27] (Figure 2).

Regression models

We implemented separate Poisson regression models separately by sex with number of deaths as dependent variable and the natural log of person-years as offset variable, incorporating age and educational level as independent variables. We first estimated Rate Ratios (RR) of mortality by educational level, which compared the mortality of all educational groups to the mortality in the tertiary education group. Changes in the rate ratio over time result from changes in both risks and the distribution of educational level [28]. To assess changes in disparities 'controlling' for changes in the educational distribution, we estimated the Relative Index of Inequality (RII), regressing mortality on the mid-point of the cumulative distribution of education, thereby taking into account the size of each educational group [28 29]. Values higher than 1 indicate educational inequalities favouring the higher educated.

We evaluated if RRs significantly changed over time and within periods on continuous scales, which was not the case (results not shown). We calculated RII for three 5-year periods (1998-2002, 2003-2007, and 2008-2012) and for three age groups (20-34, 35-49, and 50-64) in order to identify differences in inequalities along age (Figure 2).

To compare the contribution of each cause of death to mortality disparities for non-communicable diseases (classified by their ICD-10 codes, see Appendix-table 1) we calculated the Slope Index of Inequality (SII) (Figure 4). The SII is a measure of absolute disparities that represents the difference in mortality between the population at the top and the bottom of the educational distribution [28]. Further details on the RII and SII are available elsewhere [28].

RESULTS

Table 1 shows counts of cancer deaths and population at ages 20-64 years between 1998 and 2012 in Colombia. After excluding non-imputed cases (1.5%), 106,199 cancer deaths occurred from 1998 to 2012 among women while 81,892 occurred among men, with age-standardized cancer mortality rates (ASMR, per 100,000 person-years) of 58 among women and 49 among men. Men and women with lower levels of education had higher cancer mortality rates than their higher-educated counterparts. In addition, ASMR were larger among women than among men in each educational level.

The risk of dying was significantly and consistently higher among the lower educated. The RRs show clearly and statistically significantly increased risks of dying among the lower educated compared to the highest educated, this tendency was stronger in women ($RR_{primary}$=1.49; $RR_{secondary}$=1.22, both $p<0.0001$) than in men ($RR_{primary}$=1.35; $RR_{secondary}$=1.11 both $p<0.0001$). In order to formally test this higher female risk, we calculated Rate Ratios between sexes by educational levels, using men as reference category. For

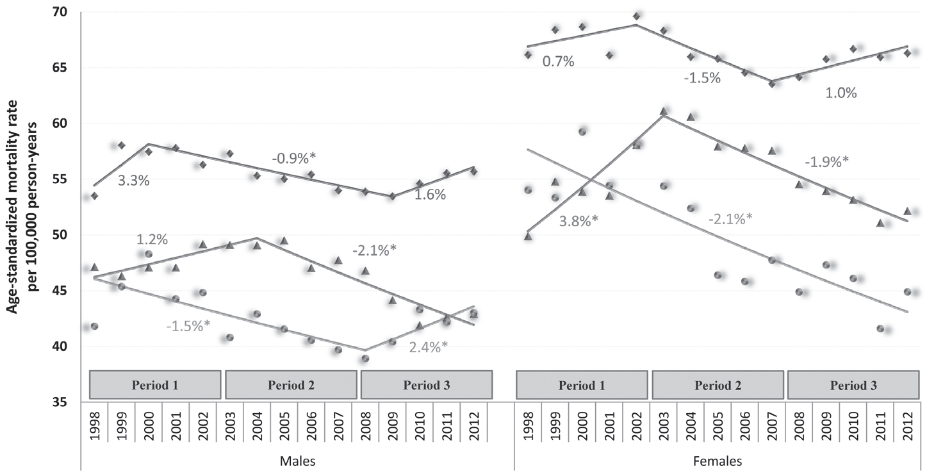

Figure 2. Age-standardized cancer mortality trends, including APC based on joinpoint models, by sex and educational level

Markers: Observed age-standardized cancer mortality rates. Lines: modelled age-standardized cancer mortality trends. Estimates are results from 5 databases generated by multiple imputations, appropriately reflecting uncertainty attributable to missing values. The points represent ASMR, lines represent the trend-lines between joinpoints. Blue, diamonds: maximum primary education; Red, triangles: secondary education; Green, circles: tertiary education. Numbers adjacent to the lines represent estimates annual percent change (EAPC) during the corresponding periods, based on joinpoint modelling; a star indicates statistical significance at α 0.05.

all educational levels, women had significant larger rate ratios (results not shown). We also found a consistent and slight increase in rate ratios from first, to second, and then to the third period (appendix-table 2) among both men and women and for primary and secondary education compared to higher educated, but the confidence intervals overlap, indicating the differences do not reach statistical significa

During the 15 years of observation, the general tendency was for age-standardized cancer mortality rates to decline, with recent stabilizations, reaching an average ASMR in 2012 of 47.3 per 100,000 males and 55.2 per 100,000 females. Average EAPC for males in the periods defined by joinpoint were: 1998-2000: 2.4% (95% CI -2.0; 7.0), 2000-2012: -0.92% (95% CI -1.2; -0.7); for females 1998-2003: 0.7 (95% CI -0.7; 2.1), 2003-2006: -2.8% (95% CI -8.2; 2.9), 2006-2012 -0.6 (95% CI -1.5; 0.3). The general tendency for a declining trend in mortality was not reflected equally by educational level and sex (figure 2). Women had higher mortality rates than men. No significant increases or declines over time were observed in the lowest educated groups, whereas in the middle and high educated groups there was at least one period with significantly declining cancer mortality rates. In these groups, tendencies were for mortality to decrease substantially in the period after 2002/2003, with the exception of the highest educated males who showed recent increases. The strongest declines in cancer mortality over time were observed in the group of women with secondary or tertiary education. The most consistent declines

Table 1. Descriptives of the study: deaths, population and rates separately by sex and educational level, Colombia, 1998-2012

Sex	Educational level [a]	Cancer deaths [b]	Population size	ASMR [c]	(95% Confidence Intervals)
Men	Primary	50,126	67,815,336	54.0	(53.5, 54.5)
	Secondary	22,273	67,742,806	45.1	(44.4, 45.8)
	Tertiary	9,493	30,715,631	41.4	(40.5, 42.3)
	Total	***81,892***	***166,273,773***	***48.9***	***(48.8, 49.1)***
Women	Primary	65,336	68,637,666	64.7	(64.2, 65.2)
	Secondary	30,414	72,387,214	54.2	(53.5, 54.9)
	Tertiary	10,449	35,149,442	47.2	(46.2, 48.3)
	Total	***106,199***	***176,174,322***	***57.8***	***(57.6, 58.0)***

[a]: Educational attainment values registered after final imputation. Primary = up to elementary or primary school; secondary = any level of high-school; tertiary = any level of postsecondary education after high school including college and university.
[b]: Cancer deaths after imputation.
[c]: ASMR: Age standardized mortality rates per 100,000 population; Estimates (WHO standard population 1997) for educational level combine results from 5 databases generated by multiple imputations, appropriately reflecting uncertainty attributable to missing values.

in cancer mortality rates for all educational levels in both sexes were observed in the period 2003-2007, the period with rapid inceases in HIC, particularly among the poor.

RII initially decreased from 1998-2002 to 2003-2007 (reaching significance among women), but then in the period 2008-2012 they increased back to its previous levels (Figure 3, left panel). Trends in the joinpoint for RII are in line with this finding: no significant change was found for educational inequalities among men, whereas there was an initial significant decline (-7.6%) among women up to 2004 followed by a significant increase (+3.8%) in the period 2004-2012 (Appendix-Figure 2). RII also showed that inequalities were significantly higher for the younger age categories compared to older ones and tended to be higher for women (Figure 3, right panel).

Figure 4 shows the contribution to absolute differences in ASMR by education as measured by the SII for non-communicable diseases (appendix-table 1). Cancer was the second largest cause, after cardiovascular disease: explaining 20% of male differences (SII=20.5 deaths per 100,000 population) and 24% of female differences (SII=28.5). Absolute differences in cancer mortality were 39% larger for women than for men (28.5 vs. 20.5), while this difference was only 14% for all non-communicable diseases (SII= 103.2 and 120.3 respectively).

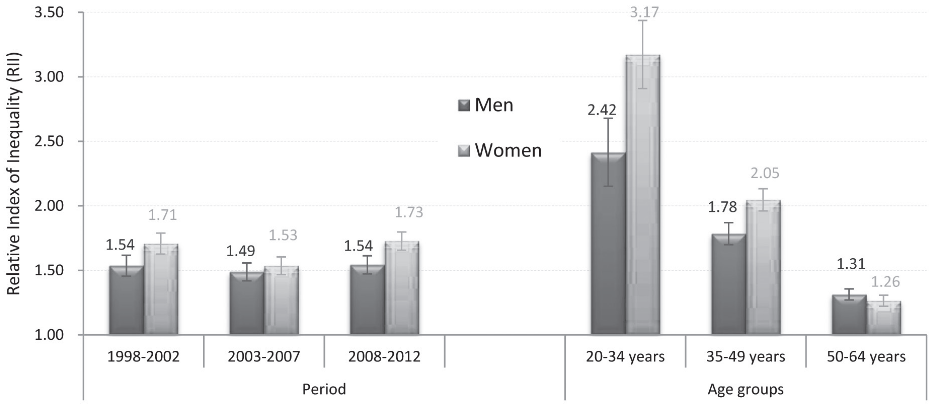

Figure 3. Sex-specific Relative Index of Inequality by period and age group
Estimates from combined results from 5 databases resulting from multiple imputations, appropriately reflecting uncertainty attributable to missing values.

DISCUSSION

We observed strong and persistent educational differences in cancer mortality rates in Colombia. These differences appeared to be diminishing in the period 2002-2007 [3] when healthcare insurance coverage largely grew, especially for the most disadvantaged part of the population. But in recent years, despite the achievement of almost universal HIC, inequalities were widening, particularly among women, with rates in the lowest educational groups being stable or increasing and those in the higher educated groups gradually declining. This means that the lowest educated part of the population is increasingly lagging behind in the progress against cancer, despite the increase in insurance coverage.

Explanation of results
Educational level was found to be previously as a good proxy variable for Socioeconomic Status (SES) [13]. Lower SES is associated with a higher prevalence of cancer risk factors (such as smoking, alcohol, obesity, occupational risk factors, housing circumstances), and less healthcare utilization (because of lower resources but also lower awareness and poorer access due to longer distances or high impact of family income when taking time off to visit a doctor) [30-32].

Not only absolute cancer mortality rates, but also inequalities in mortality were largely higher for women than for men. In a previous paper we showed this to be almost entirely attributable to cervical cancer mortality, which accounted for 51% of inequalities in total female cancer mortality in 1998-2007 at 25-64 [3]. The consistently higher RR for women than men are unique to cancer in Colombia; studies evaluating other causes of death

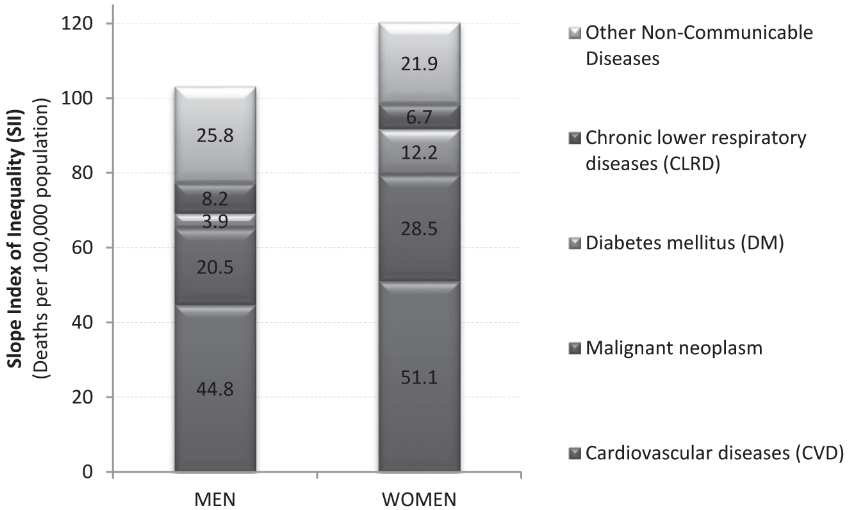

Figure 4. Slope Index of Inequality (SII) for non-communicable diseases
See Appendix-Table 1 for International Classification of Diseases (ICD-10) codes for non-communicable diseases

consistently show a higher mortality risk for men [1 2], which also coincides with the usually lower life expectancy of men. This illustrates the high burden of certain cancers which are strongly SES related, probably mainly cervical and breast cancer, which, if diagnosed late, have a very poor prognosis even though early detection possibilities are ample. Several Colombian studies have identified that both characteristics of the health system such as access and delays in diagnosis and treatment, and characteristics of the populations of lower socioeconomic classes contribute to the higher burden of cervical cancer mortality [33 34]. A previous study showed that lower access to mammography screening for early detection of breast cancer was associated with lower education, affiliation to the subsidized regime or being unaffiliated [35]. In general, financial access to healthcare has been more limited to women [36 37] which potentially limits access to expensive cancer therapies, particularly for most deprived women.

We also observed clearly increased educational differences in cancer mortality for the youngest age groups, in which mortality from cancer is a relatively rare event. Among males, leukaemias, stomach cancers and Non-Hodgkin lymphomas are important cancer causes of deaths in the age groups 15-39 years (representing 44% of all cancer deaths in this age group); for females these include cervical cancer and leukaemias as well as non-Hodgkin lymphomas (representing 38%) [38]. Previous studies have shown that mortality or survival of these cancer types is very much dependent on socioeconomic status [3 14 39]. As these tumours explain an important proportion of cancer deaths in these ages, this probably explains the high RII in the younger age groups as compared to the higher age categories. Nevertheless we cannot discard that, at least partially, the strong inequalities in younger groups are due to the fact that, when rates are low, relative inequalities tend to show an increasing pattern [40].

In order to test if RII is a good indicator of changes in inequalities [40], we compared trends in relative and absolute measures of inequalities (RII and SII), which were almost identical (results not shown). Mackenbach hypothesized that, in the case of declining mortality rates, RIIs are exaggerating the differences [40], but this was clearly not the case in our study, probably because reductions in premature mortality rates of cancer were relatively smooth, and not very strong and not very divergent between educational levels, with the exception of tertiary educated women. Among women we only found a clear reduction in inequalities during the period 1998-2004, owing to a clearly divergent pattern between educational levels: A rapid significant decrease of ASMRs in the higher socioeconomic group (tertiary educated) and an opposed rapid significant increase of ASMRs among those with secondary education. We have illustrated in previous work that these trends are most likely due to large changes in Cervical cancer mortality [3].

Our results clearly illustrate that an almost complete coverage does not necessarily reduce inequalities in health [41 42]. Particularly, having health insurance may be universal, but depending on income the type of health insurance is different (subsidized, contributory and special or exceptional regimes), with the wealthy population often buying additional private health assurance to ensure rapid and more broad access [43]. The quality of care provided by the insurance (translating into early and timely diagnosis and adequate treatment) is not guaranteed with complete coverage, as seems to be the case: To warrant rights to get access to expensive treatments and medication, as usual in cancer, exceptional legal mechanisms are frequently launched in Colombia: Technical-scientific committees of health assurers, and an action for protection so-called "tutela" [43 44]. A study shows that those affiliated to the contributory regime are more likely to warrant additional rights more efficiently [44], potentially increasing inequalities between regimes. Also, clear differences in gastric cancer survival by type of health insurance affiliation have been documented in a population-based Colombian study, clearly illustrating that, even though in theory there is access to care for all, this does not translate to equal outcomes [45].

In parallel with the increases in HIC, other changes in the Colombian health care system occurred, including increases in investments in care [5 46]. Therefore, our results reflect the impact of the entire reform rather than only the increased coverage in health insurance. However, based on our analyses, it is safe to conclude that all these reforms have not resulted in reducing inequalities in cancer mortality. This is not unique to Colombia; in several countries, as diverse as Taiwan, Thailand and European countries, inequalities in health increased upon reaching almost universal coverage [47-52].

Strengths and weaknesses

This is one of few studies investigating educational differences in mortality using population-based mortality and population-based educational level. Despite several strengths, some limitations should be considered in our study: We did not correct for misclassification within the cancer groups, but since we studied the group of cancer deaths overall, regardless of the subtype of cancer, most of these errors are cancelled out. In general "cancer" as cause of death is correctly coded [53], and most likely particularly in setting of ages under 65.

Data on mortality were obtained from mortality registries, while data on the population distribution by education were obtained from censuses and demographic projections. This may have led to the so-called numerator/denominator bias, which generally results in an overestimation of disparities [17]. Furthermore, for some years, data on population size were obtained from demographic projections combined with distributions of education from surveys. To assess the impact of this potential bias, we experimented with different education distributions from multiple data sources [54-56], showing that the overall trends in our study were robust to different assumptions on the distribution of education [3].

Potentially, there has been substantial under-registration of deaths in some regions. Previous studies comparing national mortality rates with indirect estimates from census [57 58] suggest that underregistration is particularly important in the poorest regions, implying that estimates of disparities in mortality by educational level are likely to be an underestimation, because those with lower education are more likely to live in areas with higher underregistration rates. This may also have led to underestimation of the extent to which inequalities have increased, because underregistration decreased over the study period [57 58]. Our results, therefore, are indicative of potentially larger inequalities in mortality by education, which continue to increase.

Information on education was missing for 16.5% of cancer deaths, potentially leading to an underestimation of disparities, as missing values are usually more common in the least educated [59]. However, we imputed values for educational level for individuals with missing educational information based on a information on age, sex marital status, region and urban/rural residence, thereby limiting the potential impact of this source of bias.

Unanswered questions and future research

Socioeconomic inequalities in mortality of non-communicable diseases have been associated with the unequal distribution of behavioural risk factors, such as smoking, alcohol consumption, an unhealthy diet, sedentary lifestyle higher risk of injuries [2 60]. This implies underlying inequalities in exposure to risk factors and incidence of these diseases. However, data on the incidence of disease and prevalence distribution of all those behavioural and poverty risk factors by socioeconomic status are largely lacking in Colombia and most developing countries. Studies on the mechanisms underlying the way these risk factors contribute to inequalities in mortality are scarce, even in developed countries. We previously described not only large inequalities in mortality of cancers with a primary infectious aetiology such as gastric cancer [3], but also documented inequalities in survival of gastric cancer measured by both type of health insurance and socioeconomic stratum [14]. These findings indicate that both access and quality of care (health insurance) as other factors related to socioeconomic status independently affect survival for the lower socioeconomic classes negatively. Detailed studies are needed on both types of factors: which barriers exist for timely diagnosis and adequate treatment in situations with universal health coverage and how can they be tackled? And on which other factors related to socioeconomic stratum can interventions be designed? The answers to these questions will be various and, depending on the specific disease, will be quite different in character. It is of high importance that data on socioeconomic indicators are collected in a standard way, so that for example cancer registries can calculate incidence rates by socioeconomic stratum, which, at this moment, is not possible in Colombia [61].

Socioeconomic differences were substantially larger for women than for men, in our previous study this difference was almost entirely attributable to inequalities in cervical cancer mortality [3]. In this more recent study we see that the gender inequalities grew despite the virtually universal HIC since 2008. Gender inequalities were larger for cancer than for other non-communicable diseases according SII; more detailed analyses are needed to assess to which extent the growing inequalities are due to an increase in cervical cancer mortality amongst less favoured.

Conclusions

The recent negative curbs in mortality among the lowest educated groups, resulting in increasingly differences between educational groups, are a call for attention by the Colombian health authorities to take measures in both primary prevention, access to early detection and timely and adequate treatment. Underlying causes of the observed differences are multiple, from differences in housing, lifestyle, health-related beliefs, to differences in access to diagnostic facilities and high-quality treatment, which all should be of concern to those in charge [62]. Insurance coverage is clearly not enough to counterbalance the deleterious effects of decreases in spending on primary prevention and other social and economic conditions which determine the growing levels of educational inequalities in cancer.

FOOTNOTES

Data sharing statement:

No additional data are available

Funding statement:

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors. The salaries of the investigators were provided directly by their employers.

Competing interests statement:

The authors have no competing interests to report

Ethics committee approval:

This article is based on secondary analysis of data on deaths and population counts in aggregate form made publically available by the National Statistics Office in Colombia. Ethical approval for this study was not required.

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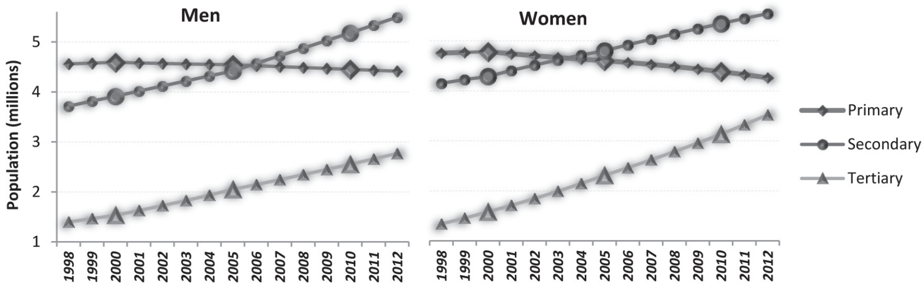
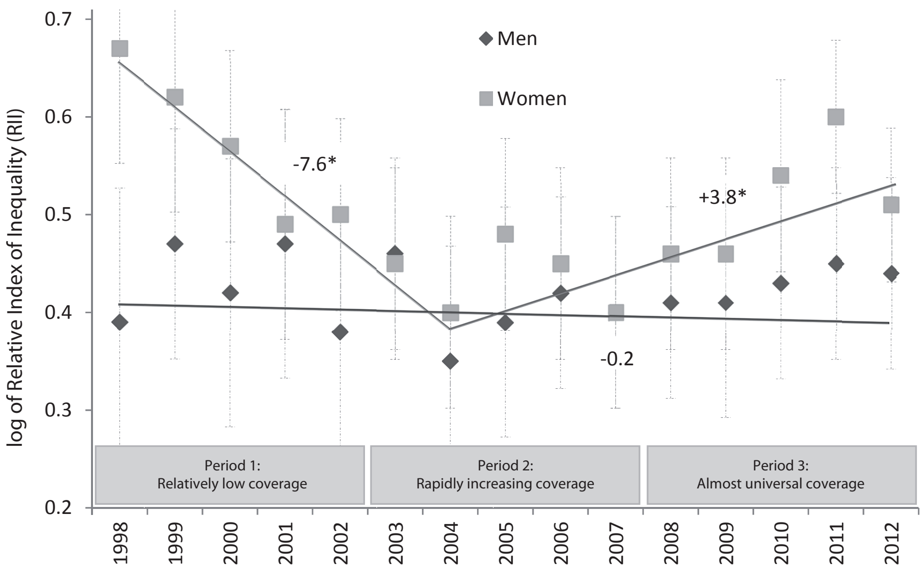
Appendix



Appendix-Figure 1. Educational level trends over time, Colombia, 1998-2012
The thicker markers are those from the year with real data available (source: Colombian Demography Health Surveys in 1995, 2000, 2005 and 2010). The points in between were interpolated (see methods)



Appendix-Figure 2. Sex-specific Relative Index of Inequality (RII) trends including APC based on joinpoint models
Markers: Annual observed cancer mortality RII. Lines: modelled RII trends. Estimates are results from 5 databases generated by multiple imputations, appropriately reflecting uncertainty attributable to missing values.

Appendix-Table 1. Classification of Causes of death, International Classification of Diseases (ICD-10) codes for non-communicable diseases

Non-Communicable Diseases		ICD-10 codes
Cardiovascular diseases		I00-I99
Malignant neoplasm		C00-D48
Diabetes mellitus		E10-E14
Chronic lower respiratory diseases (CLRD)		J40-J47
Other Non-Communicable Diseases	Mental and behavioural disorders	F00–F99
	Diseases of the nervous system	G00–G99
	Diseases of the digestive system	K00–K93
	Diseases of the genitourinary system	N00–N99
	Congenital malformations, deformations and chromosomal abnormalities	Q00–Q99

Appendix-Table 2. Rate ratio in premature cancer mortality by educational level by 5-years periods and separately for men and women at 20–64 years, Colombia 1998-2012

		Period 1 (1998-2002): Relatively low coverage		Period 2 (2003-2007): Rapidly increasing coverage		Period 3 (2008-2012): Almost universal coverage	
MEN	Tertiary (Ref)	1.00		1.00		1.00	
	Secondary	1.08	(0.89,1.30)	**1.19**	**(1.14,1.24)**	**1.31**	**(1.14,1.52)**
	Primary	**1.32**	**(1.11,1.56)**	**1.37**	**(1.31,1.43)**	**1.42**	**(1.23,1.63)**
	Year	1.01	(0.98,1.04)	0.99	(0.96,1.02)	1.02	(1.00,1.04)
	Secondary*Year	1.00	(0.96,1.03)	1.00	(0.97,1.04)	**0.96**	**(0.94,0.99)**
	Primary*Year	1.00	(0.96,1.03)	1.00	(0.97,1.03)	0.99	(0.96,1.02)
WOMEN	Tertiary (Ref)	1.00		1.00		1.00	
	Secondary	1.10	(0.91,1.33)	**1.27**	**(1.22,1.32)**	**1.29**	**(1.13,1.47)**
	Primary	**1.25**	**(1.04,1.51)**	**1.44**	**(1.39,1.50)**	**1.45**	**(1.28,1.65)**
	Year	1.03	(1.00,1.07)	0.98	(0.96,1.01)	1.00	(0.98,1.02)
	Secondary*Year	0.99	(0.96,1.03)	1.01	(0.98,1.04)	0.99	(0.97,1.02)
	Primary*Year	0.97	(0.94,1.01)	1.00	(0.97,1.02)	1.01	(0.98,1.03)

Chapter 6

Health insurance coverage, neonatal mortality and caesarean section deliveries: an analysis of vital registration data in Colombia

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Health insurance coverage, neonatal mortality and caesarean section deliveries: an analysis of vital registration data in Colombia
[Submitted]

** Contributed equally (both are first author)*

ABSTRACT

Objective

Recent health care reforms have increased health insurance coverage and access to care in Colombia, but whether coverage is associated with improved neonatal survival has not been examined. We examined the association between health insurance coverage and neonatal mortality.

Design

Population-based cross-sectional study.

Setting

Colombia.

Population

All live births (2,506,920) and neonatal deaths (17,712) from national vital registration system, 2008-2011.

Methods

We used Poisson regression models to examine the association between health insurance coverage status and neonatal mortality, distinguishing individuals insured via the contributory scheme (40%, financed through payroll and employer's contributions), Government subsidized insurance (47%), and the uninsured (11%).

Main Outcome Measure

Neonatal mortality rate (NMR).

Results

The NMR was lower among babies born to mothers in the contributory scheme (6.13/1000) than in the subsidized scheme (7.69/1000) or the uninsured (8.38/1000). Controlling for socioeconomic characteristics, NMRs were higher for those insured through the subsidized scheme (1.09, 95%CI 1.05-1.14) and the uninsured (1.16, 95%CI 1.10-1.23) than for those in the contributory scheme. These differences increased in models that additionally controlled for C-section delivery, reflecting the higher fraction of C-section deliveries among mothers in the contributory scheme (49% of births) as compared to those in the subsidized scheme (34%) and the uninsured (28%), as well as the higher NMR associated with C-section delivery.

Conclusions and Relevance

Health insurance coverage is associated with lower neonatal mortality, albeit differences are small. Unnecessary C-sections among women with contributory insurance may offset some of the positive effects of improved access to care through health insurance on neonatal survival.

INTRODUCTION

Many low- and middle-income countries are far from achieving the Millennium Development Goal target of reducing under-five mortality by two-thirds between 1990 and 2015.[1] Most newborn and maternal deaths are preventable through adequate health care.[2, 3], yet few studies have examined whether health insurance coverage reduces newborn mortality. Expansion of health insurance coverage has become a priority for governments around the Globe,[4-9] but to our knowledge, only one recent study has examined this question in the context of Thailand's 30 Baht program.[10] Findings from this study suggest that significant improvements in newborn survival can be achieved by expanding health insurance coverage, but the extent to which these findings are generalizable to other countries is unkown.

Colombia offers a unique setting to study this question. Through a major reform in 1993, universal health insurance was gradually introduced to provide all citizens with a comprehensive health benefit package. A decentralization reform in early 2000[11] is believed to have improved efficiency and equity of resource allocation,[12] contributing to a substantial increase in insurance coverage (Figure 1). Individuals participate in one of two health insurance schemes based on their income: (i) the contributory scheme, which covers workers and their families with an income above a cut-off and is financed through payroll and employer's contributions; and (ii) the subsidized scheme, which subsidizes the poor as identified through a proxy means test, and is mainly tax-funded.[13] In theory, everyone, irrespective of insurance status, has access to free maternity care, also uninsured women. In practice, there are differences in quality of care for people in different schemes and between the insured and uninsured, and additional financial barriers may limit access to care among the uninsured.[14]

Despite the obvious benefits of health insurance coverage expansion, a potential concern is that increased coverage in a pay-for-performance system may lead to a rise in unnecessary procedures. In Brazil, for example, an increase in preterm births has been associated with increased rates of induced labor and C-section deliveries in the period of health insurance expansion.[15] In Colombia, vital registration system data suggest that there has been a sharp rise in the fraction of caesarean section (C-section) deliveries during the period of expansion of health insurance coverage (Figure 1). While medically indicated C-sections can save newborn lives, unnecessary C-sections may be harmful for newborn survival.[15]

We use vital registration data to examine the association between health insurance coverage and neonatal mortality in Colombia. We focus on neonatal mortality because it is particularly sensitive to quality of care.[16, 17] We expected health insurance, particularly via the contributory scheme, to be associated with lower maternity and better neonatal care, including access to emergency obstetric care. However, we also expected mothers in the contributory scheme to deliver more often through elective C-section, reducing some of the protective effects of insurance on neonatal survival.

METHODS

Data

Vital registration data comprising individual records of all registered births and deaths in the period 2008 (when the vital registration bases in Colombia were harmonized) to 2011 were obtained from the National Administrative Department of Statistics' official registries.[18] For all deaths under 28 days (n=22,879) and all live births (n=2,734,478), information was recorded on characteristics of the child (year of birth, region of birth, sex, gestational age, birth weight), the mother (insurance status, age, marital status, rural/urban residence), and the delivery (singleton/multiple birth, mode of delivery (C-section or vaginal)). Cause-of-death data were coded according to the International Classification of Diseases (ICD-10) (Appendix-Table 1).[19]

8.3% of births and 38.7% of deaths had a missing value for at least one covariate. To minimize bias due to missing observations, we used multiple imputation methods developed by Raghunathan and colleagues[20] to impute values for education, marital status, and maternal age in deaths records. This method consists of fitting a sequence of regression models and drawing values from the corresponding predictive distributions, using observed values. The procedure was applied based on a model that included urban/rural residence, county of residence, sex of the baby, age of the baby at neonatal death, and year of death as covariates. We obtained five imputed databases based on five iterations. We excluded 3,701 death records (16%) for which at least one missing variable could not be imputed, yielding a sample of 19,178 neonatal deaths (83.8%).

Personal identifiers were not available for birth and death records. Therefore, we first aggregated the databases to obtain counts of live births and neonatal deaths according to health insurance status [contributory scheme, subsidized scheme, other schemes, uninsured], infant's sex, year of birth, region of residence, mother's age [≤19, 20-34, and 35 years+], maternal education [lower secondary or less, upper secondary or higher], marital status [married, non-married], rural/urban residence, singleton/multiple birth, mode of delivery [vaginal delivery, C-section], gestational age at birth [very and extremely preterm (< 32weeks), moderate preterm (32-36 weeks), early preterm (37-38 weeks), term (39-41 weeks), post-term (42 or more)], and birth weight [very and extremely low birthweight (< 1500g), low birthweight (1500-2499g), normal birthweight (2500-2999g), high normal birthweight (3000-3499g), moderate high birthweight (3500-3999g), high birthweight (4000g or more)]. We then matched the birth and death databases based on aggregation variables to obtain a single merged database with both neonatal deaths

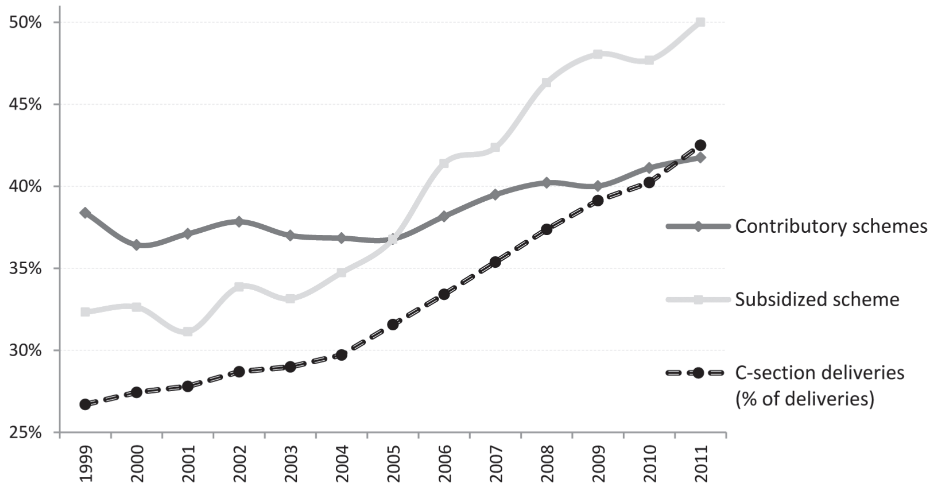


Figure 1. Trends in health insurance coverage and C-section deliveries among women giving birth (national vital registration system data), Colombia 1999-2011

(numerators for the rate) and live births (denominators for the rate). 1,466 deaths (7.7%) could not be linked to the birth dataset, and were therefore excluded. The final dataset for analysis comprised 2,506,920 (91.7% of total) live births and 17,712 deaths (77.4%). Because birth weight and gestational age were measured at birth and recalled by relatives at death, the risk of mismatching is large. To reduce this problem, we aggregated these variables using the broad categories mentioned above. Detailed categories for these variables as given in Table 1 were only retained when analyzing the birth database.

Analysis

First, we estimated crude neonatal mortality rates (NMR), defined as the number of deaths under 28 days of life per 1,000 live births (Table 2), the definition used by the Colombian authorities. This definition is slightly different from the more common definition that includes the 28th day of life, but this should not bias our estimates as the definition was applied uniformly across all regions and time periods. To explore the association between neonatal mortality and health insurance, we used Poisson regression models that included the number of deaths as dependent variable, the natural log of birth counts as offset variable, and health insurance status as independent variable. In some models, we also explored the association between mode of delivery and health insurance status using logistic regression.

We used a step-wise approach to modeling the association between health insurance status and neonatal mortality on the basis of our conceptualized causal framework (Annex Figure 1). Our basic model (Table 3, Model 0) included health insurance status and elementary confounders (year of birth, region of birth, sex of the infant, single/multiple

Table 1. Distribution of live births by risk factors for neonatal death by health insurance status, Colombia, 2008-2011

	HEALTH INSURANCE STATUS							
	Contributory scheme		Subsidized scheme		Uninsured		TOTAL	
	Live births	%	Live births	%	Live births	%	Live births	%
All live births (%) by scheme		**40%**		**47%**		**11%**		**100%**
Distribution per insurance scheme	**990,495**	**100%**	**1,183,741**	**100%**	**268,990**	**100%**	**2,506,920**	**100%**
Year								
2008	251,720	**25%**	288,902	**24%**	79,581	**30%**	634,091	**25%**
2009	246,256	**25%**	299,368	**25%**	73,802	**27%**	634,740	**25%**
2010	240,899	**24%**	284,047	**24%**	65,603	**24%**	607,107	**24%**
2011	251,620	**25%**	311,424	**26%**	50,004	**19%**	630,982	**25%**
Sex of baby								
Male	509,203	**51%**	609,757	**52%**	138,849	**52%**	1,290,584	**51%**
Female	481,292	**49%**	573,984	**48%**	130,141	**48%**	1,216,336	**49%**
Maternal age								
19 years or less	136,965	**14%**	351,697	**30%**	89,726	**33%**	586,630	**23%**
20 to 34 years	730,261	**74%**	734,432	**62%**	162,120	**60%**	1,673,618	**67%**
35 years and more	123,269	**12%**	97,612	**8%**	17,144	**6%**	246,672	**10%**
Residence area of mother								
Urban	926,738	**94%**	805,746	**68%**	206,063	**77%**	1,998,008	**80%**
Rural	63,757	**6%**	377,995	**32%**	62,927	**23%**	508,912	**20%**
Marital status of mother								
Married	689,976	**70%**	675,743	**57%**	136,807	**51%**	1,554,347	**62%**
Not married	300,519	**30%**	507,998	**43%**	132,183	**49%**	952,573	**38%**
Maternal education								
Primary school or less	73,079	**7%**	396,692	**34%**	86,315	**32%**	559,597	**22%**
Lower secondary	206,748	**21%**	412,172	**35%**	92,778	**34%**	723,091	**29%**
Upper secondary	342,707	**35%**	331,561	**28%**	77,408	**29%**	774,596	**31%**

Table 1. Distribution of live births by risk factors for neonatal death by health insurance status, Colombia, 2008-2011 (continued)

	HEALTH INSURANCE STATUS							
	Contributory scheme		**Subsidized scheme**		**Uninsured**		**TOTAL**	
	Live births	**%**	**Live births**	**%**	**Live births**	**%**	**Live births**	**%**
Tertiary education	367,961	**37%**	43,316	**4%**	12,489	**5%**	449,636	**18%**
Singleton/multiple birth								
Singleton	971,556	**98%**	1,163,313	**98%**	264,808	**98%**	2,462,120	**98%**
Multiple birth	18,939	**2%**	20,428	**2%**	4,182	**2%**	44,800	**2%**
Mode of delivery								
Vaginal delivery	505,624	**51%**	776,300	**66%**	193,116	**72%**	1,506,467	**60%**
C-section	484,871	**49%**	407,441	**34%**	75,874	**28%**	1,000,453	**40%**
Gestational age								
<32weeks	13,774	**1%**	14,178	**1%**	4,071	**2%**	32,834	**1%**
32-36 weeks	82,993	**8%**	82,783	**7%**	21,190	**8%**	191,665	**8%**
37-38 weeks	359,241	**36%**	355,832	**30%**	81,101	**30%**	817,583	**33%**
39-41 weeks	532,760	**54%**	720,892	**61%**	160,365	**60%**	1,450,597	**58%**
42 or more	1,727	**0%**	10,056	**1%**	2,263	**1%**	14,241	**1%**
Birthweight								
<1500g	12,240	**1%**	11,103	**1%**	3,196	**1%**	27,232	**1%**
1500- 2499g	83,634	**8%**	87,002	**7%**	22,349	**8%**	197,564	**8%**
2500-2999g	268,634	**27%**	297,107	**25%**	73,904	**27%**	655,002	**26%**
3000-3499g	418,366	**42%**	497,125	**42%**	111,249	**41%**	1,053,997	**42%**
3500-3999g	178,044	**18%**	242,381	**20%**	49,200	**18%**	482,839	**19%**
4000g or more	29,577	**3%**	49,023	**4%**	9,092	**3%**	90,286	**4%**

birth, and maternal age). To examine the extent to which mortality disparities by health insurance status were explained by socioeconomic factors, we incorporated adjustment for maternal education, marital status, and rural/urban residence (Model 1). Then, we included mode of delivery (vaginal/C-section) as potential mediator of the association between health insurance status and neonatal mortality (Model 2). In Model 3, we included birth weight and gestational age as additional potential mediators. We also carried out separate analyses by cause-of-death.

Regression analyses were conducted using each of the five multiple databases generated by the multiple imputation process, using standard techniques in the PROC MIANALYZE procedure in SAS to combine estimates from all databases and adjust standard errors to account for uncertainty in the imputation.[21] This procedure reads the parameter estimates and associated covariance matrix for each imputed data set, and then derives valid multivariate inferences for these parameters. This allows for valid statistical inference that appropriately reflects uncertainty due to missing values.[21]

All analyses were conducted in SAS® version 9.2.

RESULTS

47% of births were to mothers with subsidized health insurance, 40% to mothers in the contributory scheme, and 11% to uninsured mothers (Table 1). 2.5% of births were to mothers with another type of health insurance – a heterogeneous group that comprised a high percentage of mismatched deaths (33.5%) (results not shown). This group was therefore excluded from the presentation of findings.

Teenage motherhood, lower education, rural residence and being unmarried were more common among uninsured mothers and those with a subsidized health insurance, except for the percentage of mothers aged 35 years and older, which was higher among women in the contributory scheme. The fraction of babies delivered through C-section was higher among mothers insured in the contributory scheme (49%), than among mothers in the subsidized scheme (34%) or uninsured mothers (28%). 46% of babies born to mothers in the contributory scheme were born before 39 weeks of gestational age, versus 38% in the subsidized scheme and 40% born to uninsured mothers. The prevalence of low birth weight (<2500g) was roughly similar across babies born to mothers with different insurance status (contributory scheme 10%, subsidized scheme 8%, uninsured 9%).

The crude NMR was lower among babies born to mothers in the contributory scheme (6.13/1000) than among babies born to mothers in the subsidized scheme (7.69/1000) and uninsured mothers (8.38/1000) (Panel 1). While these differences were observed for all age-at-death groups, over three-quarters of the absolute difference occurred in the

Table 2. Association between neonatal mortality and health insurance status (HIS), Colombia 2008-2011

	Model 0		**Model 1**		**Model 2**		**Model 3**	
HEALTH INSURANCE STATUS								
Contributive (Ref)	**1**		**1**		**1**		**1**	
Subsidized	**1.27**	**(1.22,1.31)**	**1.09**	**(1.05,1.14)**	**1.17**	**(1.12,1.22)**	**1.20**	**(1.15,1.25)**
Uninsured	**1.36**	**(1.30,1.43)**	**1.16**	**(1.10,1.23)**	**1.27**	**(1.20,1.35)**	**1.20**	**(1.14,1.28)**
YEAR								
2008	1.06	(1.01,1.10)	1.01	(0.97,1.06)	1.04	(1.00 ,1.08)	1.07	(1.03,1.12)
2009	1.02	(0.97,1.06)	0.99	(0.95,1.04)	1.01	(0.97 ,1.05)	1.02	(0.98,1.06)
2010	0.94	(0.90,0.98)	0.93	(0.89,0.97)	0.94	(0.90 ,0.98)	0.95	(0.91,1.00)
2011 (ref)	1		1		1		1	
MATERNAL AGE								
19 years or less	1.08	(1.04,1.12)	0.94	(0.90,0.98)	0.94	(0.91 ,0.98)	0.83	(0.80,0.87)
20-34 years (Ref)	1		1		1		1	
35 years and more	1.25	(1.19,1.31)	1.23	(1.18,1.30)	1.18	(1.12 ,1.23)	1.00	(0.95,1.05)
SEX								
Female (Ref)	1		1		1		1	
Male	1.26	(1.23,1.30)	1.26	(1.23,1.30)	1.25	(1.22 ,1.29)	1.29	(1.25,1.33)
SINGLETON/MULTIPLE BIRTH								
Singleton (Ref)	1		1		1		1	
Multiple birth	4.00	(3.76,4.24)	3.99	(3.76,4.24)	3.17	(2.98 ,3.36)	0.59	(0.55,0.62)
MATERNAL EDUCATION								
Lower secondary or less			1.54	(1.42,1.68)	1.60	(1.47 ,1.74)	1.57	(1.44,1.71)
Upper secondary or post-secondary (Ref)					1		1	
MARITAL STATUS								
Married (Ref)			1		1		1	
Non-married			1.26	(1.21,1.30)	1.25	(1.21 ,1.30)	1.11	(1.07,1.14)
RESIDENCE AREA								
Rural (Ref)			1		1		1	
Urban			0.88	(0.84,0.92)	0.92	(0.88 ,0.95)	0.94	(0.90,0.98)
MODE OF DELIVERY								
Vaginal delivery (Ref)					1		1	
C-section					1.75	(1.69 ,1.80)	1.05	(1.02,1.09)
GESTATIONAL AGE								
Preterm							6.21	(5.95,6.49)
Term or post-term (Ref)							1	
BIRTHWEIGHT								
Low birthweight							7.54	(7.21,7.88)
Normal or high birthweight (Ref)							1	

Variables in the models:
Model 0: Health insurance status, year, maternal age, sex of baby, singleton/multiple birth
Model 1: Model 0 + maternal education, marital status, and rural/urban residence
Model 2: Model 1 + mode of delivery
Model 3: Model 2 + gestational age, birthweight
All models control for region (Bogota district capital and 32 departments).

Table 3. Distribution (%) of birth weight and gestational age at birth by health insurance status and mode of delivery, Colombia 2008-2011

	Contributory scheme		Subsidized scheme		Uninsured		
	Vaginal	C-section	Vaginal	C-section	Vaginal	C-section	Population
GESTATIONAL AGE AT BIRTH							
< 32weeks	0.7%	2.1%	0.8%	1.9%	1.1%	2.5%	32,023
32-36 weeks	5.7%	11.2%	5.4%	10.0%	6.6%	11.0%	186,966
37-38 weeks	31.5%	41.3%	27.6%	34.8%	28.7%	33.7%	796,174
39-41 weeks	62.0%	45.2%	65.4%	52.4%	62.7%	51.8%	1,414,017
42 or more	0.2%	0.2%	0.8%	0.9%	0.8%	1.0%	14,046
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**2,443,226**
BIRTHWEIGHT							
< 1500g	0.5%	2.0%	0.5%	1.7%	0.7%	2.3%	26,539
1500-2499g	6.1%	10.9%	5.7%	10.4%	6.9%	11.9%	192,985
2500-2999g	28.9%	25.2%	25.5%	24.4%	28.1%	25.9%	639,645
3000-3499g	45.3%	39.1%	43.8%	38.5%	43.1%	37.0%	1,026,740
3500-3999g	17.1%	18.9%	20.7%	20.1%	18.2%	18.5%	469,625
4000g or more	2.2%	3.8%	3.7%	4.9%	3.0%	4.4%	87,692
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**2,443,226**

early neonatal period (first week), in particular in the first 24 hours after birth (50%). For most causes of death, except for congenital and chromosomal abnormalities, the crude NMR was higher for babies born to uninsured mothers and to women with a subsidized insurance. Deaths due to respiratory disorders, mostly respiratory distress related to conditions around delivery, contributed most to the absolute mortality difference by insurance status.

Results from the basic model suggest that, compared with babies born to mothers with a contributory insurance, the NMR was 27% higher (95%CI 1.22-1.31) among those born to mothers in the subsidized scheme, and 36% higher (95%CI 1.30-1.43) among babies born to uninsured mothers (Table 3, Model 0). These differences were partly explained by socioeconomic factors, but significant differences remained after socio-economic adjustment (rate ratio [RR] uninsured, 1.16 [95%CI 1.10-1.23]; RR subsidized scheme, 1.09 [95%CI 1.05-1.14]) (Table 3, Model 1). When examining cause-specific mortality, we noted a strong association between health insurance status and mortality from respiratory disorders (RRsubsidized vs. contributory schemeModel 1: 1.22 [95%CI 1.14-1.31]; RRuninsured vs. contributory scheme Model 1: 1.37 [95%CI 1.25-1.50]) (Appendix table 2).

To examine the role of C-section delivery, we first examined the association between insurance status and delivery mode. Figure 2 shows that the odds of C-section delivery were much lower for uninsured mothers (OR: 0.61 [95%CI 0.60-0.62]) and mothers in the subsidized scheme (OR 0.76 [95%CI 0.75-0.77) than for women with a contributory insurance. Results in Table 3 show that being born before 39 weeks of gestational age and having low birth weight were more common for C-section deliveries than vaginal deliveries, irrespective of insurance scheme. 50.7% of C-section births occurred before 39 weeks, versus 35.5% of vaginal births. Differences in birth weight and gestational age were small between insurance schemes when controlling for mode of delivery.

Table 2 (model 2) shows that adjusting for delivery mode increased the mortality advantage of babies born to mothers in the contributive scheme (RR uninsured, 1.27 [95%CI 1.20-1.35]; RR subsidized scheme, 1.17 [95%CI: 1.12-1.22]). Table 2 shows that the NMR was 75% (95%CI 1.69-1.80) higher among C-section births than among vaginal births, after adjusting for sex, year, region, maternal age, education, rural/urban residence, and insurance status. However, the higher mortality among C-section births was substantially attenuated after controlling for gestational age and birth weight (ARR 1.05 [95%CI 1.02-1.09]) (Table 2, Model 3). Controlling for gestational age and birth weight also attenuated the increased mortality risk for the uninsured, but not for those in the subsidized scheme (Table 2, Model 3). In sum, these patterns suggest that the higher C-section delivery rate among infants from mothers in the contributory scheme may paradoxically diminish their mortality advantage as compared to infants from mothers with subsidized insurance or uninsured women.

DISCUSSION

Summary of main findings

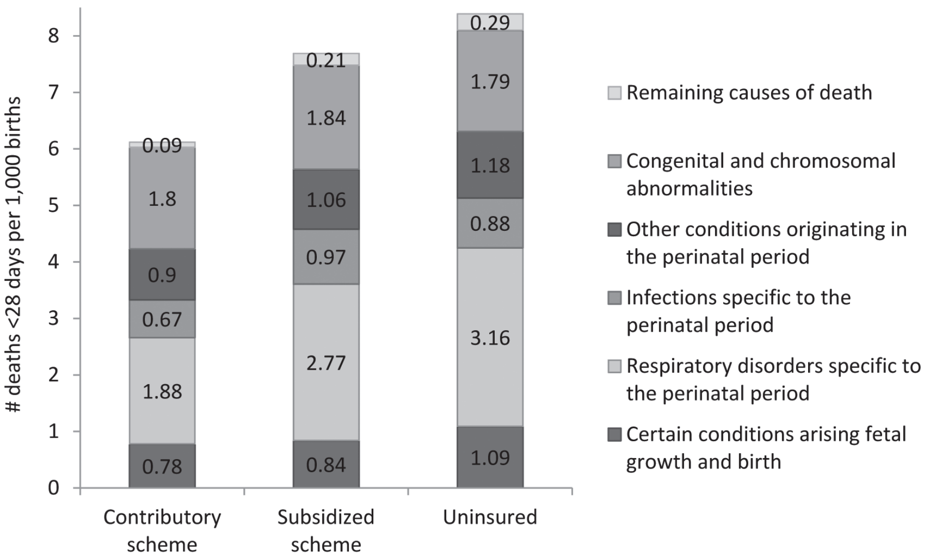
Our study shows that neonatal mortality was higher among babies from uninsured mothers and those with a subsidized insurance than among babies from mothers with a contributory insurance. After adjusting for socioeconomic factors, these mortality differences were attenuated but not eliminated. While possibly due to residual confounding, the remaining mortality disparities may also reflect differences in access to and quality of care. This hypothesis is supported by our finding that a substantial proportion of the mortality difference was attributable to deaths in the first 24 hours and to respiratory distress during delivery. Interestingly, mortality differences by insurance status became larger after adjusting for C-section delivery. This was due to the higher C-section rates among insured mothers, especially those in the contributory scheme - a practice that was associated with premature birth and higher neonatal mortality. This suggests that some of the benefits of a contributory health insurance may be offset by higher rates of medically unnecessary C-sections.

Panel 1. Neonatal mortality rate (number of deaths under 28 days per 1,000 live births) by health insurance status - total and by age-at-death and cause-of-death, Colombia 2008-2011

BY AGE-AT-DEATH

	Contributory scheme	Subsidized scheme	Uninsured	TOTAL
Less than one hour	0.63	0.89	1.04	0.79
Between 1-23 hours	1.19	1.76	1.98	1.54
Between 1-6 days	2.37	2.75	3.05	2.60
Between 7-27 days	1.94	2.29	2.31	2.13
TOTAL	6.13	7.69	8.38	7.07

BY CAUSE-OF-DEATH



Strengths and limitations

Missing values, mismatching, and under-registration of deaths may have led to an underestimation of average NMR and differences in NMR by insurance status. While under-registration of deaths is a problem in many low- and middle-income countries,[22] it has strongly declined in Colombia and vital registration coverage was high in the years we included.[23] Under-registration of deaths was largest in deprived areas with more uninsured people and those with a subsidized insurance, and may have led to an underestimation of mortality disparities.[24, 25] Mismatching and missing values may have also contributed to underestimated mortality differences, in particular between the uninsured and the insured.

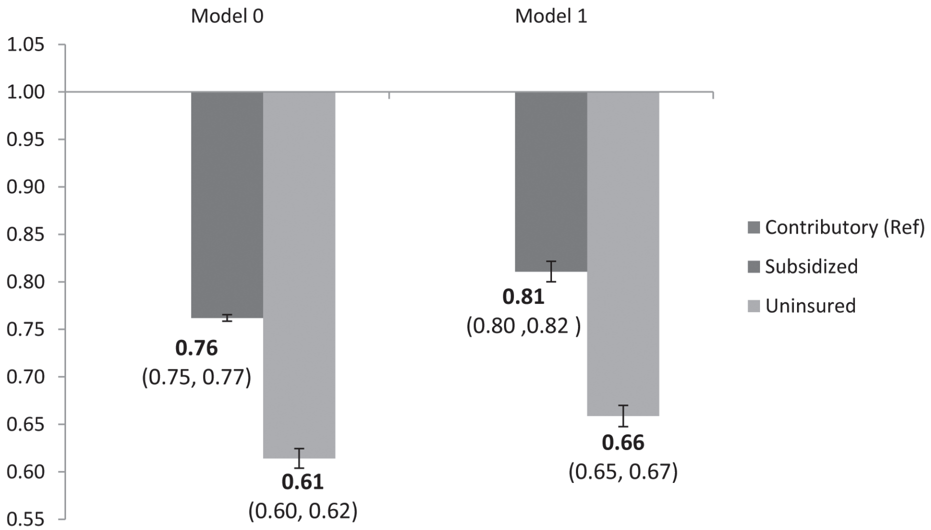


Figure 2. Association between C-section delivery and health insurance status (odds ratios with 95%CI), Colombia 2008-2011
Variables in the models:
Model 0: Health insurance status, year, maternal age, sex of baby, singleton/multiple birth
Model 1: Model 0 + maternal education, marital status, rural/urban residence
Both models also control for region (Bogota district capital and 32 departments).

We conducted three sensitivity analyses to evaluate the effect of mismatching and missing values. First, to limit the problem of mismatching and missing values in the covariates, we constructed a dataset with insurance status, year, and sex only (3.4% of deaths were excluded due to missing values). The rate ratios for the uninsured became higher than those in Table 2, Model 0 (RR uninsured: 1.62 [95%CI 1.55-1.68]); RR subsidized scheme: 1.28 [95%CI 1.25-1.32]), suggesting that the mortality differences between the uninsured and contributory scheme were underestimated. Second, to evaluate the effect of missing values for health insurance status, we estimated (i) a conservative model in which all deaths with missing values for insurance status were attributed to the contributory scheme and all births with such missing values to the uninsured, yielding a RR of 1.33 (95%CI 1.28-1.39); (ii) a model that attributed all deaths with a missing value for insurance status to the uninsured group, and births with missing values for insurance status to the contributory scheme, yielding a RR of 2.07 (95%CI 1.99-2.15). As the uninsured were more likely to have missing values for insurance status, the latter may provide a closer approximation of the actual mortality differences. Finally, we re-ran the models in Table 2 for the five richest and largest regions with much higher quality of vital registration (Antioquia, Bogota, Cundinamarca, Valle, Atlántico), which comprised 46% of all deaths (Web-Appendix Table 3). Here, only 7% of deaths were dropped due to missing values or mismatching. The mortality differences between the uninsured and contributory schemes were slightly higher than those in Table 2. Overall, these findings suggest that our results provide a conservative estimate of mortality differences by insurance status.

Finally, we evaluated the effect of missing values and mismatching on our conclusions about the contribution of C-section births to the mortality differences by insurance status. To limit the problem of mismatching and missing values in the covariates, we constructed a dataset with health insurance status and delivery mode only. These models confirmed that C-section was associated with higher NMR than vaginal birth (RR 1.54 [95%CI 1.50-1.58]). Furthermore, we checked if missing values in delivery mode could explain the higher risk of death among C-section births. Even when using the extreme assumption that all deaths with missing values for delivery mode were attributable to vaginal deliveries and all births with such missing values to C-section births, C-section delivery was associated with excess mortality (OR 1.41 [95%CI 1.38-1.45]).

Interpretation

The higher mortality risk associated with being uninsured or belonging to the subsidized scheme was substantially attenuated after adjusting for socioeconomic factors. By contrast, socioeconomic indicators such as maternal education remained strong predictors of neonatal mortality in models that controlled for health insurance status (Table 3). This implies that universal health insurance may not be sufficient to close the gap in newborn mortality between socioeconomic groups. Additional barriers to care seeking, such as supply-side problems,[14] may affect the poor more; and other factors, such as poverty, knowledge and health related behaviors, might contribute to higher neonatal mortality among the lower socioeconomic groups.

The small remaining excess mortality among the uninsured and subsidized scheme after adjusting for confounding might be reflective of differences in access to or quality of care. Although 98% of women deliver in a health facility assisted by a doctor, insufficient provision of services or distance to facilities especially affecting the uninsured may still contribute to higher neonatal mortality.[14, 26-28] It is noteworthy that half of the mortality difference between infants born to uninsured mothers and those in the contributory scheme was attributable to deaths in the first 24 hours after birth. Furthermore, the differences were largest for disorders related to respiratory distress during delivery, suggesting that quality of care during delivery may play a role in explaining excess mortality.

We found that mortality differences by insurance status would have been larger if babies of uninsured mothers and those in the subsidized scheme had the same C-section rate as mothers in the contributory scheme. C-sections were associated with birth before 39 weeks of gestational age, lower birth weight, and higher newborn mortality. Prematurity is the leading cause of newborn death worldwide[16, 29]; even births at 37 to 39 weeks have sub-optimal outcomes and C-section is not recommended before 39 weeks unless medically necessary.[32] Furthermore, low birth weight babies are on average 20 times more likely to die than heavier babies.[30] Unfortunately, we had no data on whether C-sections were medically necessary or elective. However, C-section rates are exceptionally high in Colombia[31] and other Latin American countries, where a large proportion of C-sections is known to be elective.[32, 33] Our finding that C-section delivery is associated with higher newborn mortality corresponds with other studies in settings with very high C-section rates.[33] Barros et al,[15] for instance, report a stagnation in the newborn mortality decline in urban Brazil because of an increase in preterm births caused by a strong increase in induced labor and C-section rates. These authors conclude that in Brazil, excessive medicalization led by an unregulated private sector drives these trends.[15] Likewise, high C-section rates in Colombia may be driven by pay-for-performance mechanisms that favor contributory scheme patients, offsetting potentially positive health effects of improved access to maternity care through health insurance.

Conclusions

Our study is important in the light of many low- and middle-income countries currently undergoing major health care reform. Statutory free maternity care may contribute to better newborn survival, as suggested by the small mortality differences between insurance status groups after adjusting for confounders. Nevertheless, statutory free maternity care is not enough to close the gap in newborn mortality between socioeconomic groups. While maternity care in Colombia is free for all, in practice, differences in access to and quality of care between insurance status groups remain.[27] Our findings also suggest that unnecessary C-sections may offset positive effects of improved access to maternity care through insurance. Countries undertaking health care reform should anticipate and counteract increasing rates of medically unnecessary procedures that may accompany the expansion of health insurance coverage and that may dampen positive health effects of expanded insurance coverage.[34]

FOOTNOTES

Disclaimer

Ivan Arroyave had full access to all data used in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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Ethics committee approval

This article is based on secondary analysis of data on deaths and population counts in aggregate form made publically available by the National Statistics Office in Colombia. Ethical approval for this study was not required.
Conflict of interest statements
There are no conflicts of interest related to this paper.

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The sponsors of the authors had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

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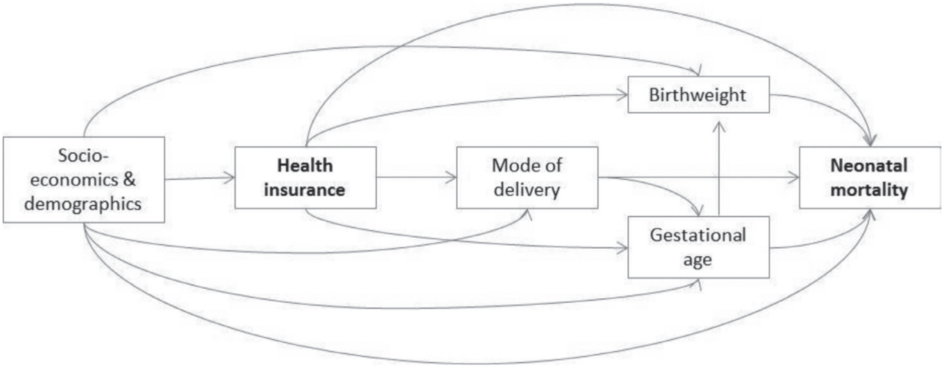
WEB-APPENDIX



Appendix Figure 1. A conceptual framework of the relationships between health insurance status and neonatal mortality

Appendix Table 1. Causes of death in this study according International Classification of Diseases (ICD-10)

Chapter	Blocks	Title	Cause of death in this paper	CIE-10 codes
XVI	P00-P96	Certain conditions originating in the perinatal period	**Certain conditions arising fetal growth and birth**	P00-P01, P03-P05, P07, P10-P15
			Respiratory disorders specific to the perinatal period	P20-P28
			Infections specific to the perinatal period	P35-P39
			Other conditions originating in the perinatal period	P08, P29, P50-P61, P70-P74, P76-P78-P96
XVII	Q00-Q99	Congenital malformations, deformations and chromosomal abnormalities	**Congenital and chromosomal abnormalities**	Q00-Q18, Q20-Q28, Q30-Q99
I-XV	A00-O99		**Remaining causes of death**	A00-O99
XVIII-XIX	R00-Y98			R00-Y89.9

Appendix Table 2. Association between neonatal mortality by cause of death and health insurance status, Colombia 2008-2011

	Model 0		Model 1		Model 2		Model 3	
Certain conditions arising fetal growth and birth								
Contributive (Ref)	1		1		1		1	
Subsidized	1.19	(1.07,1.32)	1.02	(0.91 ,1.13)	1.07	(0.96,1.20)	1.11	(0.99,1.24)
Uninsured	1.42	(1.24,1.63)	1.20	(1.04 ,1.40)	1.29	(1.11,1.49)	1.20	(1.03,1.39)
Respiratory disorders specific to the perinatal period								
Contributive (Ref)	1		1		1		1	
Subsidized	1.42	(1.33,1.51)	1.22	(1.14 ,1.31)	1.27	(1.19,1.36)	1.31	(1.22,1.40)
Uninsured	1.61	(1.48,1.75)	1.37	(1.25 ,1.50)	1.45	(1.32,1.59)	1.36	(1.24,1.49)
Infections specific to the perinatal period								
Contributive (Ref)	1		1		1		1	
Subsidized	1.39	(1.25,1.54)	1.20	(1.07 ,1.35)	1.29	(1.15,1.45)	1.33	(1.18,1.49)
Uninsured	1.26	(1.08,1.47)	1.07	(0.92 ,1.26)	1.19	(1.01,1.39)	1.12	(0.96,1.31)
Other conditions originating in the perinatal period								
Contributive (Ref)	1		1		1		1	
Subsidized	1.17	(1.06,1.28)	1.03	(0.93 ,1.15)	1.10	(0.99,1.23)	1.13	(1.02,1.26)
Uninsured	1.30	(1.14,1.48)	1.14	(0.99 ,1.31)	1.24	(1.07,1.43)	1.17	(1.02,1.35)
Congenital and chromosomal abnormalities								
Contributive (Ref)	1		1		1		1	
Subsidized	1.09	(1.02,1.17)	0.94	(0.87 ,1.02)	1.06	(0.98,1.15)	1.07	(0.99,1.16)
Uninsured	1.05	(0.94,1.16)	0.89	(0.80 ,0.99)	1.04	(0.93,1.16)	1.00	(0.90,1.11)
Remaining causes of death								
Contributive (Ref)	1		1		1		1	
Subsidized	2.25	(1.74,2.91)	1.77	(1.35 ,2.33)	1.82	(1.38,2.40)	1.86	(1.41,2.45)
Uninsured	3.34	(2.43,4.57)	2.63	(1.89 ,3.66)	2.73	(1.96,3.80)	2.64	(1.90,3.67)

Variables in the models:
Model 0: Health insurance status, year, maternal age, sex of baby, singleton/multiple birth
Model 1: Model 0 + maternal education, marital status, and rural/urban residence
Model 2: Model 1 + mode of delivery
Model 3: Model 2 + gestational age, birthweight
All models control for region (Bogota district capital and 32 departments).

Appendix Table 3. Association between neonatal mortality and health insurance status for five major Colombian regions, 2008-2011

	Model 0		Model 1		Model 2		Model 3	
HEALTH INSURANCE STATUS								
Contributive (Ref)	1		1		1		1	
Subsidized	1.27	(1.21,1.33)	1.09	(1.03,1.15)	1.18	(1.11,1.24)	1.19	(1.13,1.26)
Uninsured	1.41	(1.32,1.51)	1.21	(1.13,1.30)	1.33	(1.24,1.43)	1.27	(1.18,1.36)
YEAR								
2008	1.04	(0.98,1.11)	0.99	(0.94,1.06)	1.02	(0.97,1.09)	1.07	(1,1.13)
2009	0.95	(0.90,1.01)	0.93	(0.88,0.99)	0.95	(0.89,1.01)	0.97	(0.91,1.03)
2010	0.90	(0.85,0.96)	0.89	(0.84,0.95)	0.90	(0.85,0.96)	0.92	(0.87,0.98)
2011 (ref)	1		1		1		1	
MATERNAL AGE								
19 years or less	1.05	(1.00,1.11)	0.92	(0.87,0.98)	0.94	(0.89,1.00)	0.83	(0.79,0.88)
20-34 years (Ref)	1		1		1		1	
35 years and more	1.32	(1.24,1.41)	1.30	(1.21,1.39)	1.21	(1.13,1.29)	1.04	(0.97,1.11)
SEX								
Female (Ref)	1		1		1		1	
Male	1.25	(1.20,1.31)	1.25	(1.20,1.31)	1.24	(1.19,1.30)	1.28	(1.23,1.34)
SINGLETON/MULTIPLE BIRTH								
Singleton (Ref)	1		1		1		1	
Multiple birth	4.88	(4.51,5.28)	4.89	(4.52,5.29)	3.62	(3.35,3.93)	0.70	(0.65,0.76)
MATERNAL EDUCATION								
Lower secondary or less			1.57	(1.44,1.72)	1.63	(1.49,1.78)	1.60	(1.46,1.74)
Upper secondary or post-secondary (Ref)					1		1	
MARITAL STATUS								
Married (Ref)			1		1		1	
Non-married			1.18	(1.13,1.24)	1.19	(1.13,1.24)	1.06	(1.01,1.11)
RESIDENCE AREA								
Rural (Ref)			1		1		1	
Urban			0.92	(0.85,0.99)	0.95	(0.88,1.02)	1.01	(0.94,1.09)
MODE OF DELIVERY								
Vaginal delivery (Ref)					1		1	
C-section					2.04	(1.95,2.14)	1.16	(1.11,1.21)
GESTATIONAL AGE								
Preterm							6.47	(6.07,6.90)
Term or post-term (Ref)							1	
BIRTHWEIGHT								
Low birthweight							7.55	(7.07,8.07)
Normal or high birthweight (Ref)							1	

Variables in the models:

Model 0: Health insurance status, year, maternal age, sex of baby, singleton/multiple birth
Model 1: Model 0 + maternal education, marital status, and rural/urban residence
Model 2: Model 1 + mode of delivery
Model 3: Model 2 + gestational age, birthweight
All models control for the regions included (Antioquia, Atlántico, Bogotá D. C., Cundinamarca, and Valle).

Appendix Table 4. Association between C-section delivery and health insurance status (odds ratios with 95%CI), Colombia 2008-2011

	Model 0		Model 1	
HEALTHCARE INSURANCE STATUS				
Contributive (Ref)	**1.00**		**1.00**	
Subsidized	**0.76**	**(0.75,0.77)**	**0.81**	**(0.80,0.82)**
Uninsured	**0.61**	**(0.60,0.62)**	**0.66**	**(0.65,0.67)**
SEX				
Female (Ref)	1.00		1.00	
Male	1.03	(1.02,1.04)	1.03	(1.02,1.04)
YEAR				
2008	0.84	(0.83,0.85)	0.84	(0.83,0.86)
2009	0.89	(0.88,0.91)	0.89	(0.88,0.91)
2010	0.94	(0.93,0.96)	0.94	(0.93,0.96)
2011 (Ref)	1.00		1.00	
MATERNAL AGE				
19 years or less	0.93	(0.92,0.94)	0.94	(0.93,0.95)
20-34 years (Ref)	1.00		1.00	
35 years and more	1.21	(1.19,1.23)	1.23	(1.21,1.25)
SINGLETON/MULTIPLE BIRTH				
Singleton (Ref)	1.00		1.00	
Multiple birth	4.37	(4.24,4.49)	4.41	(4.29,4.54)
RESIDENCE AREA				
Urban (Ref)			1.00	
Rural			0.76	(0.75,0.77)
MATERNAL EDUCATION				
Primary			0.76	(0.75,0.78)
Lower secondary			0.90	(0.88,0.91)
Upper secondary			0.98	(0.96,0.99)
Tertiary level (Ref)			1.00	
MARITAL STATUS				
Married (Ref)			1.00	
Non-married			1.02	(1.01,1.03)

Variables in the models:
Model 0: Health insurance status, year, maternal age, sex of baby, singleton/multiple birth
Model 1: Model 0 + maternal education, marital status, rural/urban residence
Both models also control for region (Bogota district capital and 32 departments).

Section IV

Macro-economic fluctuations and mortality trends in Colombia

Chapter 7

The public health impact of economic fluctuations in a Latin American country: mortality and the business cycle in Colombia in the period 1980–2010

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The public health impact of economic fluctuations in a Latin American country:
mortality and the business cycle in Colombia in the period 1980-2010
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ABSTRACT

Introduction

Studies in high-income countries suggest that mortality is related to economic cycles, but few studies have examined how fluctuations in the economy influence mortality in low- and middle-income countries. We exploit regional variations in gross domestic product per capita (GDPpc) over the period 1980–2010 in Colombia to examine how changes in economic output relate to adult mortality.

Methods

Data on the number of annual deaths at ages 20 years and older (n = 3,506,600) from mortality registries, disaggregated by age groups, sex and region, were linked to population counts for the period 1980–2010. We used region fixed effect models to examine whether changes in regional GDPpc were associated with changes in mortality. We carried out separate analyses for the periods 1980–1995 and 2000–2010 as well as by sex, distinguishing three age groups: 20–44 (predominantly young working adults), 45–64 (middle aged working adults), and 65+ (senior, predominantly retired individuals).

Results

The association between regional economic conditions and mortality varied by period and age groups. From 1980 to 1995, increases in GDPpc were unrelated to mortality at ages 20 to 64, but they were associated with reductions in mortality for senior men. In contrast, from 2000 to 2010, changes in GDPpc were not associated with old age mortality, while an increase in GDPpc was associated with a decline in mortality at ages 20–44 years. Analyses restricted to regions with high registration coverage yielded similar albeit less precise estimates for most sub-groups.

Conclusions

The relationship between business cycles and mortality varied by period and age in Colombia. Most notably, mortality shifted from being acyclical to being countercyclical for males aged 20–44, while it shifted from being countercyclical to being acyclical for males aged 65+.

Keywords:

Mortality, Economic recession, Colombia, Developing countries, Health insurance

INTRODUCTION

A series of studies in high-income countries found that mortality is procyclical — it decreases when the economy contracts and increases when the economy expands [1–12]. A common interpretation of this finding is that during times of intense economic activity, individuals have less flexibility in making time allocation decisions, leading to behavioral changes such as declines in the time spent exercising and cooking healthy foods, or scheduling medical appointments [1, 13]. Recent evidence suggests, however, that this relationship may not hold for recent periods in high-income countries [12]. In addition, little is known about this relationship in low- or middle-income countries, with the few studies conducted yielding contradictory findings [14–17].

A difference in the relationship between economic cycles and mortality between high- and low- or middle-income countries may exist for several reasons. High-income countries have well-developed social safety nets and healthcare systems [18, 19]. Given that most low- and middle-income countries still lack comparable systems, their populations may be more vulnerable to the negative effects of economic downturns [20]. Furthermore, in high-income countries, non-communicable diseases are believed to be important drivers of the association between business cycles and mortality [21]. While non-communicable diseases are increasingly important in low- and middle-income countries, communicable diseases and injuries remain an important cause of death in Colombia [22]. Many of these causes of death are amenable to medical intervention, suggesting that not only non-communicable disease risk factors but also health protection systems may be important drivers of a potential relationship between mortality and the economy. As a result, the relationship may be different for low- and middle-income countries.

The purpose of this study is to assess the association between regional economic conditions and mortality in the periods 1980–1995 and 2000–2010. We follow the approach of previous studies and exploit regional variations over time in economic conditions [1, 5, 21] to provide further insights into this relationship in a middle-income, Latin American country. Colombia offers a unique setting to assess this relationship due to several reasons. Gross domestic product (GDP) almost tripled from 1980 to 2010, yet Colombia witnessed major oscillations in the economy with troughs in real GDP growth in 1982, 1991 and 1999, and peaks in 1986, 1995 and 2007 [23]. Since the early 1990's, Colombia also initiated a major health care reform culminating in the introduction of mandatory health insurance coverage in 1993 [24]. The reform assigned citizens to either a contributory scheme (for employed workers and their families) or a subsidized scheme (for poor individuals not in formal employment and their families) and led to an increase in health insurance coverage from 23.7 % in 1993, to 93.4 % by 2009 [25], mostly attributable to an increase in subsidized insurance coverage from 2000 onwards [24]. In addition, social expenditure per capita tripled from 1991 to 2008, reflecting an expansion of social protection programs for vulnerable Colombians [26]. Since 2000, several poverty reduction programs have been introduced which include conditional cash transfer programs, social housing, non-contributory pensions and food programs [27, 28]. We examine how the relationship between regional economic conditions and mortality changed in Colombia before and after 2000, when most of these programs were introduced.

METHODS

Population counts

Data were obtained from the National Statistics Office [29]. Data on population counts for 5-year age groups, sex and region came from censuses and corresponding official demographic projections. Because data were only available since 1985, we performed additional demographic projections to obtain population counts for the years 1980–1984. Based on data from the national census of 1985 we ran a back-projection of the Colombian regional population by sex and 5-year age group [30] using the software PASEX (Population Analysis System) developed by the of the United States Census Bureau [31]. This program interpolates between two population age structures. The values of age-sex-specific population data for years not given as input are linearly interpolated between input values, and values before the first input value and values after the last input value are held constant at the level of the nearest input value [32]. Additional details on the procedure are available elsewhere [32].

Mortality data

Data on deaths between 1980 and 2010 were collected and harmonized by the National Statistics Office for all regions based on international guidelines [29]. Information on sex, age and year of death were missing for 7.6 % of all deaths (289,429 out of 3,796,029 deaths). We excluded these deaths from the analysis because of lack of sufficient information to perform multiple imputations.

Data on death and population counts were grouped and linked by region, year, sex and 5-year age group combination from 1980 onwards [29]. We used death and population counts to obtain crude mortality rates for every 5-year age group, sex, year and region combination for the periods 1980–1995 and 2000–2010. Following the approach of earlier studies [10, 12, 18, 19], we then age-standardized mortality rates using the WHO standard population of 1998 in order to take into account changes over time in the population age structure [33].

Regional GDP per capita

Data on regional GDP in constant Colombian Pesos (COP) of 2005 were obtained from the National Statistics Office [34]. We chose GDP as an indicator of regional economic conditions because it was the only regional economic indicator with complete and comparable data for a sufficiently extended period. Other indicators disaggregated by region such as the unemployment rate were only available for recent years. Regional GDP per capita (GDPpc) was obtained by dividing yearly regional GDP over the total regional population. Information on GDPpc was in principle available for three separate series: 1980–1995, 1990–2005 and 2000–2010. Although the correlation between the series in the overlapping years was very high, existing differences in the method used by National Statistics to estimate GDP prevented us from merging the three series. For this reason we performed the analysis separately for the first (1980–1995) and last series (2000–2010). The end of the first series coincides with the passing of the health care reform law in 1993 [24], while the second series coincides with the start of major decentralization reforms to transfer national resources to the regions, a rapid expansion of health insurance coverage [24] and the introduction of poverty reduction programs [27].

Our approach exploits variations over time in economic output within each region. From 1980 to 1990, Colombia was divided into 33 administrative regions: 23 departments, the District Capital of Bogota and nine independent territories (one archipelago and eight extensive and sparsely-populated territories of plains and forests). The National Statistics Office reports population and mortality statistics separately for each of these regions, except for the independent territories, which are grouped together albeit differently across the periods studied: From 1980 to 1995, statistics are reported for 25 regions (the district capital, 23 regions, and all the former independent territories grouped). From 2000 to 2010, statistics are reported separately for 29 regions (the district capital, 27 regions, and the Amazonia region, which encompasses five former independent territories). This implies we have a slightly different number of regions for each series. In sensitivity analyses, however, we found that excluding units that were differently grouped across period yielded virtually the same results as those presented here.

Methods of analysis

We implemented ordinary least squares (OLS) regression models with the natural logarithm (log) of the annual mortality rate (per 100,000) as the dependent variable and the log of regional GDPpc as the key independent variable. Following the approach used in previous studies [1], we applied a region fixed effect model stratified by sex and age groups to examine how changes in regional GDPpc were associated with changes in mortality. The basic model specification is as follows:

$$\log(\text{deaths/population})_{jt} = \propto_t + \beta_1 X_{jt} + \beta_2 \text{LogGDPpc}_{jt} + \beta_3 \text{Region}_j + \beta_4 \text{Region}_j {*} \text{Year} + \varepsilon_{jt} \quad (1)$$

where j denotes region and t year, Log(Deaths/Population) is the natural logarithm of the age-adjusted mortality rates; X is a vector of regional socio-demographic controls (college enrolment, health insurance coverage and transfers from central government to regions); LogGDPpc is the logarithm of regional GDPpc; Region is a fixed-effect for each region, $\propto$ is a vector of year fixed effects; R is a region-specific intercept; Region*Year is a region-specific linear time trend; and ε is the error term. The year effect controls for factors that vary uniformly across regions over time, while region fixed effects control for time-invariant factors that differ across regions. This model effectively controls for all time-invariant differences among regions. We clustered standard errors by region to obtain unbiased standard errors in the presence of serial correlation. Following the approach of previous studies, we weighted models by the square root of population to account for heteroskedasticity [1].

The association between regional economic conditions and mortality is identified out of variations in GDPpc over time within a given region relative to changes in other regions, controlling for national trends as well as region-specific linear time trends. The purpose of this strategy is to identify the impact of the business cycle, namely the repeated sequences of economic expansions and contractions, rather than the impact of economic growth. By incorporating region and year fixed effects as well as regional linear trends our model captures the cyclical component from the increasing secular trend in the log of GDP for each region. Estimates can therefore be interpreted as the impact of regional annual deviations from the linear regional trend in GDPpc on annual deviations in mortality.

Following the specifications of previous studies [1, 2, 6, 7, 11] we implemented models separately for three age groups: 20–44 (representing the young adult population), 45–64 (middle aged working individuals), and 65+ (corresponding to the senior population). To test whether there was a significant difference in the association between business cycles and mortality between the two periods, we pooled data into a single series and incorporated an interaction term between period and GDPpc, allowing for interactions between all control variables and period.

Assessing the impact of mortality under-registration

A common concern with data on mortality in low- and middle-income countries is under-registration [35], which varies across Colombian regions and has generally improved over time [36]. In order to test the effect of under-registration on our estimates, we carried out analyses in a restricted sample of years for which levels of registration were 70 % or higher across all age and sex groups in each region. To identify levels of registration for each region, we followed the approach proposed by the Pan American Health Organization [37] and previously applied in Colombia [36, 38]. This approach estimates the expected number of deaths for each region and year based on inter-censual changes in population. In a first step, life tables including yearly number of deaths by 5-year age groups, sex and region were calculated for each region for the census years 1985, 1993, and 2005 [39]. Using the cohort component method, the mid-year populations were projected forward for the years 1987, 1992, 1997, 2002, and 2007. In a second step, based on the mortality rates obtained from the projected mid-year populations (and the most recent life-table), we used linear extrapolation to calculate the expected number of deaths for each year, 5-year age group, sex and region. Registration levels were calculated based on the ratio of registered deaths (according to the National Statistics Office) to expected deaths (based on the inter-censual changes in population) for each year, 5-year age group, sex and region.

Additional control variables

To test the robustness of our results to factors other than the economy (which varied over time across regions), we incorporated the following time-varying confounders for each region: college enrolment (percentage of enrolled students among the population aged 16–24) [40], the percentage of population with government-subsidized health insurance [41], and the percentage of population with contributive health insurance [41]. Furthermore, we controlled for yearly financial transfers for health from the central government to each region entered in the model as the log of constant Colombian pesos (COP) in 2005 [42]. Health transfers include funds transferred from the national government for increasing subsidized health insurance coverage, public health programs and to address the needs of the uninsured population. These transfers, however, only represent a part of the total funding for health expenditures in each region, which also include funding from regional budgets. Unfortunately, there are no detailed data on regional funding allocations for health care. These variables were chosen because they are potentially associated with mortality and not directly related to the business cycle. Unfortunately, data on these variables were only available for the second period (2000–2010), which prevented us from incorporating these controls in analyses for the period 1980–1995. However, results for the years 2000–2010 indicate that controlling for these variables had only a very small impact on the estimates. Table 1 provides an overview of the exact definitions, source and years covered for the variables used in the models.

For comparability with earlier studies [1, 12], we summarize results from models excluding regional trends (Table 2). In our case, however, regional linear trends are essential to capture the impact of yearly deviations from the average trend in GDPpc within each region, more closely measuring the business cycle. In addition, regional linear trends enable us to control for some of the unobserved regional variables that changed linearly over time and were not controlled for in the models. Importantly, regional linear trends may also capture some of the effect of secular improvements in under-registration, minimizing bias that these changes may introduce in the relationship between changes in GDPpc and mortality. As in previous studies [1, 12], we base our interpretation on estimates with linear trends, as these are considered a more stringent specification relative to models without linear trends. All analyses were conducted in SAS® version 9.2.

Table 1. Description of the yearly regional variables used in the models, Colombia 1980–2010

Variable	Period available	Units	Source
Registry of deaths [29]	1979–2012	Number of deaths	National Office of Statistics [DANE]
Population (censuses and estimations) [29]	1985–2020	Inhabitants	
GDP per capita [51]	1980–1995 and 2000–2013	Constant 2005 Colombian Pesos (COP)	
Enrolment to college [40]	2000–2012	Percentage of enrolled students to post-secondary education among the population aged 16–24	Ministry of education
Subsidized regime – affiliated population [41]	1995–2010	Percentage of population insured in the subsidized scheme over total population	National Department of Planning [DNP]
Contributive regime – affiliated population [41]	1996–2010	Percentage of population insured in the contributive scheme over total population	
Transfers to health [42]	1994–2013	Constant 2005 Colombian Pesos (COP)	

For comparability with earlier studies [1, 12], we summarize results from models excluding regional trends (Table 2). In our case, however, regional linear trends are essential to capture the impact of yearly deviations from the average trend in GDPpc within each region, more closely measuring the business cycle. In addition, regional linear trends enable us to control for some of the unobserved regional variables that changed linearly over time and were not controlled for in the models. Importantly, regional linear trends may also capture some of the effect of secular improvements in under-registration, minimizing bias that these changes may introduce in the relationship between changes in GDPpc and mortality. As in previous studies [1, 12], we base our interpretation on estimates with linear trends, as these are considered a more stringent specification relative to models without linear trends. All analyses were conducted in SAS® version 9.2.

RESULTS

Table 3 shows means and standard deviations of regional age-standardized mortality rates by sex, age-group and period. As expected, mortality rates were higher for men than for women, and they increased steadily with age. Mortality rates decreased from the first period to the second for each sex and age group. The Table also shows means and standard deviations of regional per capita GDP and control variables. Average regional per capita GDP increased by about 70 % between the first and the second period.

Table 2. Association between regional Gross Domestic Product (GDP) per capita and all-cause mortality for age groups excluding regional linear trend, Colombia, 1980–2010

	Men			**Women**		
	Estimate	**SE**	**p value**	**Estimate**	**SE**	**p value**
20–44 years						
Men	−0.0031	0.0149	*0.83*	−0.0014	0.0034	*0.68*
Women	−0.0060	0.0088	*0.5*	0.0015	0.002	*0.45*
45–64 years						
Men	0.0064	0.0149	*0.67*	0.0055	0.0169	*0.75*
Women	−0.0007	0.0121	*0.95*	0.0082	0.0109	*0.45*
65+ years						
Men	0.0434	0.0976	*0.66*	−0.0211	0.0842	*0.8*
Women	0.0428	0.082	*0.6*	0.1127	0.0586	*0.05*
Region dummies		Yes			Yes	
Year dummies		Yes			Yes	
Regional linear trends		No			No	

OLS estimates and robust standard errors (SE)

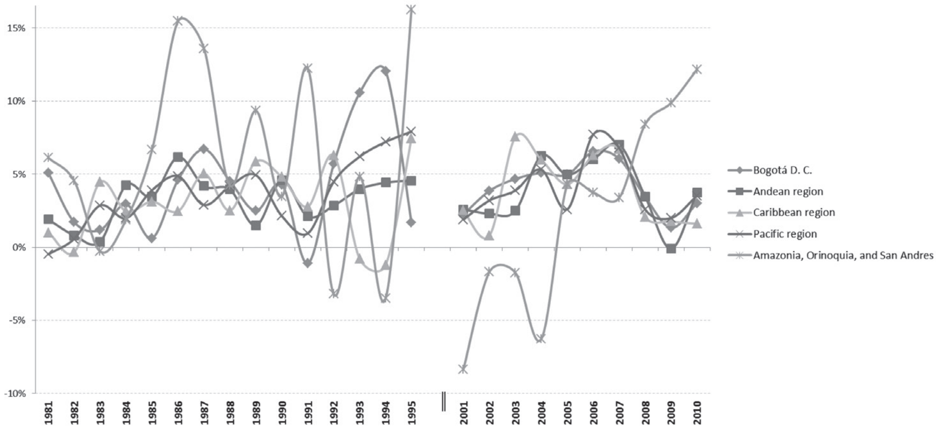

Figure 1. National trends of total GDP growth among major regions - Colombia (1981–1995, 2001–2010). The capital of the country, Bogota DC, is one region. The Andean region encompasses Antioquia, Boyacá, Caldas, Cundinamarca, Huila, Norte ..

Colleague enrollment rates were around 17 % in both periods, and on average around 75 % of the population in each region had some form of health insurance.

Figure 1 shows growth in GDPpc during the years 1980–2010 for the five largest regions in Colombia. While there are common periods of recessions and booms, there were large variations in economic output across these regions, suggesting that there is sufficient variation to identify the effect of GDPpc on mortality.

Table 4 shows estimates from equation 1 for mortality at ages 20–44 separately by sex. As the results suggest, GDPpc was not significantly associated with mortality at ages

Table 3. Descriptive statistics for the periods 1980–1995 and 2000–2010, ages >20 years, Colombia

	1980–1995		2000–2010	
	Mean	**Standard deviation**	**Mean**	**Standard deviation**
Response variable:				
Mortality rates (per 100,000 population)*				
Men				
20–44 years	75.59	11.22	68.19	12.21
45–64 years	201.39	8.59	158.7	15.07
65+ years	1009.54	68.79	932.02	18.43
Women				
20–44 years	24.26	2.65	18.58	1.6
45–64 years	141.38	10.31	98.76	8.81
65+ years	824	54.68	743.92	13.97
Explanatory variables:				
Economic conditions				
GDP per capita – year (constant thousands of 2005 COP: Colombian Pesos)	4420	1634	7381	5022
Control variables				
College enrollment rate			17.9 %	17.2 %
Percentage of affiliation to subsidized scheme			47.7 %	19.2 %
Percentage of affiliation to contributive scheme			26.6 %	13.6 %
Health transfers (constant million of 2005 COP)			101235	0.0022

* Average age-standardized mortality rates for each sex and age group separately by period

20–44 in the period 1980–1995 (column 1). In contrast, during the period 2000–2010, a one-point percentage increase in GDPpc was associated with a 0.03 % decline in male mortality at ages 20–44, and a 0.005 % decline in female mortality in the same age group (column 2). For women this effect was not significant at the 0.05 level when controlling for regional level confounders (column 3), while the effect was significant for men when including all controls. Table 5 shows results of identical models for mortality at ages 45–64. Although the sign of the coefficients is negative in tendency, estimates were not significant suggesting that regional GDPpc was unrelated to mortality in both periods.

Table 6 summarizes the results for mortality at ages 65 and older. From 1980 to 1995, a one-point percentage increase in GDPpc was associated with a 0.17 % reduction in old age male mortality (-0.1659, $p = 0.04$). A similar effect was observed for females, although estimates were not significant at the 0.05 level (-0.1115, $p = 0.09$). In contrast, in the more recent period (2000–2010), none of the estimates were significant, suggesting that there was no relationship between regional GDPpc and mortality from 2000 to 2010.

To assess whether the association between GDPpc and mortality changed over the two periods, we pooled data for both series and implemented a set of models that included interaction terms between period and each of the variables in the models. Table 7 shows the estimates of the interaction between period and GDPpc. There was no interaction

Table 4. Association between regional Gross Domestic Product (GDP) per capita and all-cause mortality at ages 20–44, Colombia, 1980–2010

	1980–1995			2000–2010					
	Model 1			Model 1			Model 2		
20–44 years	**Estimate**	**SE**	**p value**	**Estimate**	**SE**	**p value**	**Estimate**	**SE**	**p value**
Men									
Log GDP per capita	−0.0053	0.01	*0.59*	−0.0272	0.0119	*0.02*	−0.0246	0.0114	*0.03*
College enrollment rate							0.0152	0.0132	*0.25*
% subsidized insurance							−0.0038	0.0135	*0.78*
% contributive insurance							0.0216	0.0214	*0.31*
Health transfers (log)							0.0232	0.0134	*0.08*
Women									
Log GDP per capita	−0.0024	0.0022	*0.26*	−0.0049	0.0024	*0.05*	−0.0043	0.0024	*0.07*
College enrollment rate							−0.0001	0.0017	*0.93*
% subsidized insurance							0.0022	0.0024	*0.36*
% contributive insurance							0.0085	0.0049	*0.08*
Health transfers (log)							0.0039	0.0015	*0.01*
Region dummies		Yes			Yes			Yes	
Year dummies		Yes			Yes			Yes	
Regional linear trends		Yes			Yes			Yes	

OLS estimates and robust standard errors (SE)

between GDPpc and period for mortality at younger (20–44) or middle-ages (45–64). In contrast, there was a significant and positive interaction between period and GDPpc for mortality at older ages among men (0.233, $p=0.02$) and women (0.213, $p=0.01$). This suggests that old-age mortality shifted over time from being countercyclical in 1980–1995 to being essentially unrelated to economic conditions in 2000–2010.

Robustness checks

A potential concern is that improvements in the coverage of death registration over time may be driving some of the relationships between GDPpc and mortality rates. While some of these secular improvements in death registration coverage are captured by regional linear trends and time fixed effects, if GDPpc was related to death coverage registration, this would result in biased estimates of the relationship between regional GDPpc and mortality. To assess the impact of this potential bias, we conducted a robustness checks with a restricted sample of years in each region for which registration levels were 70 % or higher across all age and sex combinations.

Table 8 shows overall average levels of registration for each region across all years, sex and age groups in each period. Regions with no years with levels of registration of at least 70 % in all age and sex groups are excluded from the restricted sample. The final sample includes 12 regions in period 1 and 13 regions in period 2. Table 8 shows that coverage of death registration gradually increased over the study period. Between

1980–1995 and 2000–2010, average levels of registered deaths increased from 60.8 to 73.1 %. At the same time, levels of registration improved in 18 out of 25 regions over time. As a sensitivity analysis, Table 9 shows the results of models that restrict the sample to years of coverage in the registration of deaths of at least 70 % in all sex and age groups in a given period. For comparison purposes, estimates from this restricted sample are presented alongside estimates for the full sample of all regions and years. To better illustrate differences, Figure 2 also plots estimates from Table 9 and incorporates 95 % Confidence Intervals for each estimate.

The first point to note is that estimates from the restricted sample are less precise than estimates from the full sample, reflecting the smaller sample size in the restricted sample. A second point to note is that there are no significant differences between estimates for the restricted sample and estimates for the full sample for any of the sub-groups. In most cases, estimates for the restricted and full sample are in fact very close if one considers the uncertainty around some of these estimates. Nevertheless, there are two exceptions in the second period: the estimate for men ages 20–44 is negative and significant for the full sample, but it is close to zero and non-significant in the restricted sample. For males ages 65+ (bottom bars of the Figure, left Panel), the estimate is positive but not significant in the full sample; while it is also positive in the restricted sample, the estimate is larger and approaches statistical significance at the 0.05 level for the restricted sample. For all other sub-groups, estimates for the restricted and full sample are in fact very close.

Table 5. Association between regional Gross Domestic Product (GDP) per capita and all-cause mortality at ages 45–64, Colombia, 1980–2010

	1980–1995			**2000–2010**					
	Model 1			**Model 1**			**Model 2**		
45–64 years	**Estimate**	**SE**	**p value**	**Estimate**	**SE**	**p value**	**Estimate**	**SE**	**p value**
Men									
Log GDP per capita	–0.0227	0.0155	*0.14*	–0.0038	0.0137	*0.78*	–0.0049	0.0126	*0.7*
College enrollment rate							0.0173	0.0091	*0.06*
% subsidized insurance							–0.0011	0.0145	*0.94*
% contributive insurance							0.0234	0.0262	*0.37*
Health transfers (log)							–0.0010	0.0136	*0.94*
Women									
Log GDP per capita	–0.0106	0.0147	*0.47*	–0.0011	0.0085	*0.9*	–0.0016	0.0081	*0.84*
College enrollment rate							0.0063	0.0057	*0.27*
% subsidized insurance							0.0136	0.008	*0.09*
% contributive insurance							–0.0028	0.0249	*0.91*
Health transfers (log)							–0.0005	0.0055	*0.93*
Region dummies		Yes			Yes			Yes	
Year dummies		Yes			Yes			Yes	
Regional linear trends		Yes			Yes			Yes	

OLS estimates and robust standard errors (SE)

Table 6. Association between regional Gross Domestic Product (GDP) per capita and all-cause mortality at ages 65+, Colombia, 1980–2010

	1980–1995			**2000–2010**					
	Model 1			**Model 1**			**Model 3**		
65+ years	**Estimate**	**SE**	**p value**	**Estimate**	**SE**	**p value**	**Estimate**	**SE**	**p value**
Men									
Log GDP per capita	−0.1659	0.082	*0.04*	0.056	0.0454	*0.22*	0.0515	0.0474	*0.28*
College enrollment rate							−0.1363	0.0444	*0*
% subsidized insurance							0.0707	0.0585	*0.23*
% contributive insurance							0.1683	0.1373	*0.22*
Health transfers (log)							0.0054	0.038	*0.89*
Women									
Log GDP per capita	−0.1115	0.0667	*0.09*	0.0557	0.0514	*0.28*	0.0427	0.0526	*0.42*
College enrollment rate							−0.0144	0.0317	*0.65*
% subsidized insurance							0.1365	0.06	*0.02*
% contributive insurance							0.1901	0.1303	*0.14*
Health transfers (log)							−0.0059	0.0283	*0.84*
Region dummies		Yes			Yes			Yes	
Year dummies		Yes			Yes			Yes	
Regional linear trends		Yes			Yes			Yes	

OLS estimates and robust standard errors (SE)

Table 7. Association between regional Gross Domestic Product per capita (GDPpc) and all-cause mortality between periods, interaction term, Colombia, 1980–2010

	Men			**Women**		
20–44 years	**Estimate**	**SE**	**p value**	**Estimate**	**SE**	**p value**
Log GDPpc * Period	−0.0124	0.0202	*0.54*	−0.0018	0.0044	*0.69*
Log GDPpc (Period 1)	−0.0044	0.0101	*0.66*	−0.0024	0.0022	*0.26*
45–64 years						
Log GDPpc * Period	0.0168	0.0254	*0.51*	0.0167	0.0189	*0.38*
Log GDPpc (Period 1)	−0.0230	0.0156	*0.14*	−0.0107	0.0145	*0.46*
65+ years						
Log GDPpc * Period	0.2327	0.1017	*0.02*	0.2126	0.0774	*0.01*
Log GDPpc (Period 1)	−0.1665	0.082	*0.04*	−0.1125	0.0664	*0.09*
Region dummies		Yes			Yes	
Year dummies		Yes			Yes	
Regional linear trends		Yes			Yes	

OLS estimates and robust standard errors (SE); estimates are for the impact of a one-point increase in the log of GDPpc on mortality; variables included in each model are listed but their estimates are omitted from table

The variable Period was coded 0 for the years 1980–1995 and 1 for the years 2000–2010. The coefficient for the term 'Interaction: Log GDPpc * Period' thus refers to the interaction between the variables Log GDPpc and Period. The coefficient for the variable Log GDPpc refers to the effect of GDPpc on mortality in the first period (1980–1995)

Table 8. Average levels of registration of the mortality database for all regions, Colombia, 1980–2010

Region	1980–1995	2000–2010
Antioquia	43.6 %	47.7 %
Atlántico	70.4 %	83.7 %
Bogotá	89.4 %	97.7 %
Bolívar	69.7 %	69.6 %
Boyacá	93.8 %	86.2 %
Caldas	87.0 %	95.4 %
Caquetá	59.1 %	72.5 %
Cauca	72.2 %	74.3 %
Cesar	48.7 %	80.0 %
Córdoba	48.4 %	64.5 %
Cundinamarca	79.3 %	86.3 %
Chocó	44.0 %	58.7 %
Huila	90.2 %	91.5 %
La Guajira	25.9 %	47.6 %
Magdalena	48.6 %	79.7 %
Meta	54.9 %	84.9 %
Nariño	79.1 %	83.0 %
Norte de Santander	85.5 %	86.6 %
Quindío	76.4 %	89.2 %
Risaralda	87.4 %	95.6 %
Santander	86.6 %	90.1 %
Sucre	56.5 %	68.4 %
Tolima	72.0 %	83.3 %
Valle	89.9 %	98.2 %
Arauca		83.6 %
Casanare		59.4 %
Putumayo		60.8 %
San Andrés y Providencia Archipelago		48.8 %
Amazonia		55.6 %
Independent territories	36.0 %	
Colombia	60.8 %	73.1 %

(i) Overall, coverage of death registration gradually increased over the study period. Between 1980–1995 and 2000–2010, average levels of registered deaths increased from 60.8 to 73.1 %. At the same time, levels of registration improved in 18 out of 25 regions over time. The restricted subsample includes 12 regions in period 1 (Bogotá, Boyacá, Caldas, Caquetá, Cauca, Huila, Nariño, Norte de Santander, Quindío, Risaralda, Santander, and Valle) and 13 regions in period 2 (Atlántico, Bogotá, Boyacá, Caldas, Cundinamarca, Huila, Meta, Norte de Santander, Quindío, Risaralda, Santander, Valle, and Arauca). (iii) We allowed regions with levels of registration higher than 70 % in some -but not all- of the years to contribute to the restricted sample, but only for the years in which they had registration of 70 % of higher. For example, in period 1 Bogota had registration coverage above 70 % for years 1980–1994, but not in 1995. We therefore included only years 1980–1994 for Bogota and excluded 1995. (iv) Even if some regions had average levels of registration higher than 70 %, they had no years for which registration levels were above 70 % in all sex and age groups for at least one year, and therefore were not included in the restricted sample, e.g., Atlántico in the first period.(v) Likewise, some regions had average levels of registration lower than 70 % (e.g., Caquetá, 44 % in the first period), yet they had at least one year for which registration was higher than 70 % in all sex and age groups, and were therefore part of the restricted sample in those years

Table 9. Sensitivity analysis for under-registration for the association between regional Gross Domestic Product (GDP) per capita and all-cause mortality for sex and age groups, Colombia, 1980–2010

Log GDP per capita	1980–1995						2000–2010					
	Full			Registration > =70 %			Full			Registration > =70 %		
	25 regions			12 regions			29 regions			13 regions		
	Estimate	SE	pvalue	Estimate	SE	pvalue	Estimate	SE	pvalue	Estimate	SE	pvalue
20–44 years												
Men	–0.0053	0.01	*0.59*	0.0299	0.0203	*0.14*	–0.0272	0.0119	*0.02*	–0.0028	0.0167	*0.87*
Women	–0.0024	0.0022	*0.26*	0.0038	0.005	*0.44*	–0.0049	0.0024	*0.05*	–0.0025	0.0048	*0.61*
45–64 years												
Men	–0.0227	0.0155	*0.14*	0.0055	0.0358	*0.88*	–0.0038	0.0137	*0.78*	–0.0100	0.0293	*0.73*
Women	–0.0106	0.0147	*0.47*	–0.0208	0.0196	*0.29*	–0.0011	0.0085	*0.9*	–0.0128	0.015	*0.39*
65+ years												
Men	–0.1659	0.082	*0.04*	–0.1554	0.1328	*0.24*	0.056	0.0454	*0.22*	0.1585	0.083	*0.06*
Women	–0.1115	0.0667	*0.09*	–0.1216	0.0905	*0.18*	0.0557	0.0514	*0.28*	0.0728	0.0614	*0.24*

OLS Estimates and robust standard errors (SE). All models adjusted by region dummies, year dummies, and regional linear trends

DISCUSSION

Summary

The purpose of this study was to assess the relationship between business cycles and mortality in Colombia during two periods. Contrary to some studies in high-income countries, we found no evidence of procyclical mortality in Colombia. We found some evidence that mortality at older ages was countercyclical from 1980 to 1995, but there was no relationship between GDPpc and mortality for older ages from 2000 to 2010, suggesting that old age mortality may have changed from being countercyclical to being unrelated to the business cycle. Likewise, mortality at ages 20–44 was unrelated to GDPpc from 1980 to 1995, but it was countercyclical from 2000 to 2010, although the two estimates were not significantly different from each other.

Explanation of results

Our findings for mortality at the younger ages (20–44), and especially for men, contrast with results from most studies in high-income countries suggesting that mortality for this age group is generally procyclical [1,2, 5, 8]. This discrepancy may be due to differences in the distribution of causes of death. However, in the US, for example, pro-cyclical mortality is especially pronounced for mortality from cardiovascular disease, homicide and (vehicle) accidents, which are also leading causes of death in Colombia [43]. Another explanation for the discrepant findings is a difference in the association between business cycles and specific causes of death. Our analysis only focused on total mortality given the poor quality of data on specific causes, but a potential hypothesis is that mortality from these leading causes of death is not procyclical in Colombia. Differences between results for Colombia and high-income countries may also be due to differences in the period of study, as well as the fact that we use GDP per capital as indicator of economic conditions, while several studies in the US and Europe use unemployment rates.

We found that the economic expansions were associated with decreased old age mortality from 1980 to 1995, whereas old-age mortality was unrelated to the regional economy from 2000 to 2010. This finding is in line with recent evidence that the association between the business cycle and mortality shows some instability over time. For the US, recent findings by Ruhm [12] suggest that a potential explanation for the emergence of counter-cyclical cancer mortality in recent years is the increasing importance of financial resources in receiving sophisticated and expensive therapies. In Colombia, financial resources may have been more important to access sophisticated and expensive therapies in the first period, during which health insurance coverage was limited. In contrast, in the second period, the expansion of health insurance coverage [24, 25] implies that individuals may more easily have access to these therapies irrespective of the business cycle. This may explain the shift from countercyclical to acyclical mortality for older males between the first and second period.

Our findings are at odds with a previous study showing that infant mortality in Colombia increased when economic conditions improved [44]. However, our study focused on mortality at ages 20 years and above, which may show a different association with business cycles than infant mortality. The finding that infant mortality is pro-cyclical has been shown to be partly attributable to selection (compositional changes in the pool of mothers conceiving during recessions and booms). For example, in the US, African-American mothers of children born during times of high unemployment tend to be more educated than African-American mothers of children born during low unemployment, which contributes to lower mortality during recessions [45]. While changes in behavior may also be part of the mechanism leading to lower infant mortality during recessions, this illustrates the fact that the mechanisms underlying the relationship between business cycles and mortality may differ by age and cause of death.

Although for most sub-groups our analyses restricted to regions with higher levels of registration yielded similar estimates as those for the full sample, differences in estimates for young (20–44) and older men (65+) deserve some explanation. Some of this difference may be due to the smaller sample size and higher standard errors in the restricted sample analysis. Nevertheless, it appears that the estimates for the restricted sample are in tendency more positive than estimates for the entire sample. This pattern may be due to compositional differences between the full and restricted sample. Overall, the restricted sample contains regions from all major geographical zones (Caribbean, Pacific, Andean, and Western plains), but regions in this restricted sample are slightly more affluent than regions excluded due to their lower registration levels. Average

GPDpc is 15 to 22 % higher in regions with registration higher than 70 % as compared to the other regions (4841 thousand Pesos in the regions with higher registration versus 4180 thousand Pesos in those with lower registration-levels in the first period, versus a difference of 8262 thousand Pesos to 6759 thousand Pesos in the second period). This may imply that estimates from the restricted sample capture the relationship between business cycles and mortality in regions that are at a relatively higher level of economic development. This is consistent with previous evidence suggesting that mortality is procyclical in highly developed regions but countercyclical in less developed regions within Mexico [15].

Limitations

Some limitations should be considered in our study. A major concern is the under-registration of mortality in many regions of Colombia [36], which we addressed by restricting the sample in sensitivity analyses to regions that had relatively high registration coverage in all years (Table 9). These results yielded mixed results. On the one hand, although standard errors are very large, estimates were in tendency similar to those we observed for the full sample in two ways: first, we found no evidence of procyclical mortality in any group or period as it has been observed for high-income countries. Second, there is an indication of a changing relationship between GDP and mortality at ages 65+ between the first and the second period. On the other hand, the large uncertainly around these estimates suggest that some caution should be exercised given the potential that changes in under-registration might remain important. Although we found no correlation between the business cycles and rates of under-registration, estimates of under-registration may be imperfect and a full assessment requires a more detailed study.

We used GDPpc as a proxy for macro-economic conditions in our study. Unfortunately, there are no reliable time series on unemployment rates at the regional level covering sufficiently extended periods. Estimates are therefore not directly comparable to estimates from earlier studies in high-income countries which primarily have used unemployment rates as indicators of macro-economic conditions [2, 8, 10, 11, 18], sometimes controlling for GDP [1, 4, 5]. Yet, while unemployment rates may be the preferred measure of the business cycle in high-income countries, unemployment rates are often considered a poor measure of the business cycle in less developed countries. Similar to their Mexican counterparts [15], Colombian workers can experience changes in earnings but continue to be classified as employed because of the large share of the work force in self-employment, and the fact that many laid-off workers quickly turn to self- or part-time employment in the absence of unemployment benefits [46]. This relates also to the fact that a large share of workers are in the informal sector (60% in 2009 [47]) [46, 48], with a changing proportion over time, making it difficult to use a common definition of unemployment over an extended period. Although informal sector [49]. Informal sector workers lack regular social benefits and do not contribute social security contributions [46], they represent an important share of the Colombian economy making it difficult to quantify in unemployment statistics based on survey data.

We incorporated controls for regional variables such as college enrolment, health insurance coverage and transfers from central government to regional areas. Unfortunately we were only able to obtain reliable data on these regional variables for the period 2000–2010 (see Table 1). As a result, we were unable to directly control for regional factors that may have affected mortality in the period 1980–1995. However, we expect fixed effects for calendar years to control for unmeasured confounders that varied systematically across all regions. In addition, region-specific time trends control for factors linearly associated with mortality in each region. Although we cannot discard the possibility that unmeasured factors could have influenced our results, it is reassuring that associations for the period 2000–2010 were largely unchanged after incorporating a wider set of regional control variables.

We found that increasing coverage for subsidized health insurance as well as health transfers were associated with increased mortality at ages 45–64 (Table 5) and 65+ (Table 6). In the context of our region and year fixed effect models, this implies that regions that had a faster increase in subsidized health insurance coverage between 2000 to 2010 experienced higher mortality increases than regions that had slower increases in insurance coverage. Although this seems counterintuitive, the rates of expansion of subsidized health insurance as well as transfers from the government were selective with worse-off regions being the focus of larger efforts towards expanding coverage [49]. Increases in coverage may thus have been larger in less healthy regions, so that they do not necessarily reflect the causal impact of increasing insurance coverage. Thus, while useful as a control variable, it is difficult to interpret estimates of health insurance coverage in our models as evidence of a causal effect of increasing health insurance coverage. In fact, the existing evidence suggests that increased access to subsidized health insurance in Colombia is associated with reduced infant mortality [50] and improved adult health [17].

Conclusions

Notwithstanding the limitations of registry data in low- and middle-income countries, our results suggest that contrary to some studies in high-income countries, there is no evidence of procyclical mortality in Colombia. In contrast, we find evidence that mortality at older ages was countercyclical from 1980–1995. However, business cycles and mortality appear to be unrelated in the more recent period also among the more affluent regions with better mortality registries.

FOOTNOTES

Authors' contributions

IA was the leading author and developed the article idea, constructed and analyzed the data set, and wrote drafts of article. PH participated in the design of the study, the interpretation of the results as well as the writing of the manuscript. AB contributed to interpretation of results and commented on all drafts. JR carried out the adjustment for under-registration. DC contributed to the quantitative analysis and commented on all drafts of the article. MA analyzed data, wrote sections of the article, and contributed to the coordination of all steps of the analysis and article preparation. All authors are aware that the manuscript is being submitted to the journal. All authors read and approved the final manuscript.

Competing interests

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Abbreviations

GDP	Gross domestic product
GDPpc	Gross domestic product per capita
OLS	Ordinary least squares

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Section V

General Discussion

Chapter 8

Discussion

8.1. MAIN FINDINGS

Main findings

This thesis aimed to contributing to understanding socioeconomic differences in mortality in Colombia, estimating the contribution of healthcare insurance coverage to these inequalities, and assessing the association of mortality with the state of the economy. The studies in this thesis are based on data from the official Colombian statistics agency, including vital statistics (mortality and newborn datasets), census and official economic indicators. In this discussion, the main findings of this thesis will first be summarised. This will be followed by an analysis of data sources and methodological limitations relevant to the interpretation of results. Thirdly, the possible explanations and interpretation of findings will be discussed. This chapter ends with a discussion of the public health implications of these studies, as well as recommendations for future research.

Research question 1. Have socioeconomic inequalities in all-cause and cause-specific mortality by socioeconomic status changed in the period from 1998 to 2012?

Results from the studies in this thesis suggest that socioeconomic inequalities in mortality have changed over the last two decades for some causes of death, while remaining stable for other causes of death. Overall, socioeconomic inequalities in all-cause mortality increased over the period.

In particular, the studies in this thesis suggest that: (i) There is a 'double burden' of inequalities in premature mortality in Colombia, which combines a pattern of inequalities in both chronic disease as well as injury and infectious disease mortality, which exacerbated over the study period [1]; (ii) There are particularly large inequalities in mortality from homicide for men, which increased from 1998 to 2002, but started to decline thereafter [1, 2]; (iii) inequalities by education have increased over time for all-cause and cause-specific mortality, particularly for mortality from injury, non-communicable disease [1], cardiovascular disease [3] and cancer [4, 5]; (iv) there are large inequalities by educational level in infection-related cancer mortality, particularly cervical and stomach cancer, which represent a large share of socioeconomic inequalities in total cancer mortality. Inequalities in cancer mortality have been remarkably stable over time, with the notable exception of cervical cancer, for which mortality declines have been particularly marked in the lower education groups [5].

Results from this thesis also provide some specific insights into the evolution of socioeconomic inequalities in mortality over the past two decades. First, results suggest that higher educational level was associated with reduced mortality at ages 25-64 years at any given year between 1998 and 2007. Differences in mortality by educational level are larger for men than for women, owing to the higher burden of male mortality from injuries (almost half of deaths), in particular homicide (as detailed below). Non-communicable diseases are the first cause of death among women at 25-64 and second among men, while communicable diseases represent a relatively small share of deaths for both men and women [1]. Inequalities in mortality by educational level in Colombia widened between 1998 and 2007, due to larger mortality declines among higher-educated Colombians than among those with primary and secondary education. It is noteworthy that mortality from injuries, primarily homicide, explained more than half of inequalities in total mortality by educational level among men [1, 2]. During 1998-2012, men and women aged 20-64 with some primary education had higher homicide rates than those with some post-secondary education (RRmen=4.22, [95%CI]: 4.10, 4.34; RRwomen=3.57, 95%CI: 3.27, 3.90). Homicide rates decreased after a peak in 2002 among the least educated while declining steadily for those with secondary and tertiary education. As a result, inequalities became larger despite overall declining homicide rates, and have only started to decline in recent years [2].

We found large inequalities in cervical cancer among women at 1998-2007 (contributing 51% of cancer inequalities) and stomach cancer, both predominantly infection-related cancers. There were no clear inequalities in colorectal and breast cancer (predominantly associated with non-communicable disease risk factors). Among men, there were inequalities in all but colorectal and prostate cancers, with stomach and lung cancer having the largest inequalities [5]. Total cancer mortality rates declined significantly in all education groups, but they declined faster among those with higher education. Mortality by infection-related cancers declined more rapidly in lower-educated Colombians[5].

Research question 2. Has the expansion of health insurance coverage contributed to decreasing trends in socioeconomic differences in mortality over the last two decades?

Results from the studies in this thesis suggest that: (i) While health insurance coverage has significantly increased in recent decades, inequalities in premature mortality for cardiovascular disease and all causes by educational level have increased over time. Yet, the expansion of health insurance coverage was found to be associated with a slower rate of increase in socioeconomic inequalities in mortality. Although expanding coverage did not eliminate inequalities, health care coverage may have contributed to curbing widening inequalities [3]; (ii) inequalities in premature mortality for cancer have remained stable over time, without a clear declining or increasing trend [6]. (iii) Health insurance coverage is associated with lower neonatal mortality (2008-2011), but the type of insurance matters: Children from mothers with Government subsidized insurance have higher neonatal mortality rates than children of mothers with contributory insurance [7].

In the period 1998-2002, men with only primary education had twice higher mortality rates than those with completed tertiary education. Mortality declined significantly during the study period, but significantly larger declines were observed among those with tertiary education as compared to those with secondary or primary education only [3]. These trends continued in 2003-2007, a period of a rapid increase in coverage among the poor through the subsidized scheme. Despite a general trend of increasing inequalities, there was a significantly less accelerated increase in inequalities in mortality during the period of sharp increase in HIC as compared to the period 1997-2002, which presented virtually no change in HIC [3]. Similar trends were found in premature (20-64 years) cancer mortality during 1998-2012: Results showed higher risks of death among those with lower education than among the higher educated, particularly for women. Initially, inequalities decreased from 1998-2002 to 2003-2007, but from 2008-2012, when virtually universal HIC was achieved, they increased significantly and reached previous levels [6]. In summary, while inequalities for CVD mortality declined during 2003-2007, they increased for cancer during the period of virtual universal insurance coverage (2008-2012) [3, 6].

During the period 2008-2011, the neonatal mortality rate (NMR) was 8.38/1,000 among the uninsured, compared to 7.69/1000 for those in the subsidized scheme and 6.13/1,000 for those insured through the contributory scheme. Larger differences were found for deaths by respiratory distress during delivery while there were no differences by insurance status for congenital malformations [7]. C-sections were much higher for deliveries in the contributory scheme (49% of births) than for those among the uninsured (28%) and those in the subsidized scheme (34%), and they were associated with a higher odds of newborn death compared with vaginal deliveries. While health insurance coverage was associated with higher newborn survival, the benefits of insurance were partly offset by the higher rate of -medically unnecessary- C-sections [7].

Research question 3. What was the impact of macro-economic fluctuations (business cycles as measured by regional GDP) on mortality trends in Colombia in the period from 1980 to 2010?

Results in this thesis suggest that macro-economic fluctuations are an important determinant of mortality in Colombia. Yet, findings show a complex picture of the association between economic fluctuations and mortality over the last three decades. First, mortality among senior men (65+) decreased when the economy temporarily improved (i.e., countercyclical mortality) in 1980-1995 while in 2000-2010 no relationship was found (acyclical mortality) [8]. In turn, the association was acyclical in the first period for the young population (25-44 years), while increases in GDP were associated with reductions in mortality among young men and women in 2000-2010 [8]. Results suggest that these associations are partly driven by a strong negative association between economic cycles and homicide mortality (countercyclical homicide mortality) [9].

From 1980 to 1995, there were no associations between short-term economic fluctuations, in terms of changes in GDPpc, and mortality among young (20-44 years) and middle-aged [45-64] men and women, while a one-point percentage increase in GDPpc was associated with a reduction in old age (65+) male mortality, despite the weaker labour market attachment of this older group. This overall pattern changed for the period 2000-2010 when changes in GDPpc were not associated with old age mortality, but increases in GDPpc were significantly associated with declines in mortality among young (25-44 years) men and women. Similar results were found when controlling for regional level confounders (health care insurance coverage, colleague enrolment and Health transfers) [8]. Preliminary findings suggest that homicide mortality is an important driver of this pattern: For the period 2000-2010, an increase in GDPpc was associated with a decline in female homicide at ages 20-44, and a decline in male homicide mortality. These results did not change when controlling for regional level confounders (colleague enrolment and health transfers) [9].

8.2. INTERPRETATION OF FINDINGS

8.2.1. Trends in socioeconomic inequalities in mortality in Colombia

Socioeconomic inequalities in overall mortality have generally widened over the past two decades in Colombia. However, a key conclusion from the studies in this thesis is that the magnitude and direction of trends in socioeconomic inequalities in mortality varied by cause of death. In this section, I discuss the interpretation of findings separately for each cause of death.

There are large inequalities in premature cancer mortality by educational level in both men and women in Colombia. Different types of cancer were analysed based on their aetiology (infectious, non-communicable and others) and shifting patterns in inequalities were found, probably owing to a combination of different exposures to risk factors, and differences in access to health care and early detection programs [5].

We found large differences in mortality from cervical cancer by educational attaiment in Colombia [5], which may be associated with an unequal distribution of early detection interventions [10]. Stomach cancer mortality also showed large educational inequalities, which may be explained by differences in exposure to risk factors (H. pylori bacteria, cigarette smoking and overweight). Overweight and obesity have increased over the last years in Colombia and Latin America [11], and these factors have been implicated in the etiology of stomach, colorectal, postmenopausal breast and potentially prostate cancer as well as other cancer types [12, 13]. Yet, results show that educational inequality in cancers associated with behavioural risk factors remain relatively stable, possibly reflecting no changes in inequalities in these determinants[5]. Recent reports show indeed that educational inequalities in body mass have remained stable over time [11], consistent with findings for cancers associated with overweight and obesity. There are also important socioeconomic differences in smoking prevalence in Colombia [14], but the consequence of these inequalties on inequalities in lung cancer are likely to be reflected in future decades due to the long lag period between smoking and lung cancer.

In high-income countries, socioeconomic inequalities in mortality are largely attributable to non-communicable diseases [15-20]. Likewise, in Colombia, we found that non-communicable diseases are the leading contributor to inequalities in mortality by educational level among women, and the second largest contributor among men [1]. In Colombia, a larger prevalence of smoking was found among those with lower education [21]. Similar results were found by evaluating a set of risk factors for cardiovascular disease, which were found to be more prevalent among lower-educated Colombians [22]. In addition, despite the lower educated population reporting poorer health status than their higher educated counterparts, their utilization of health services is lower [23].

It is noticeable that this pattern of inequalities in behavioural risk factors in Colombia is very similar to that observed in high-income countries. For instance, smoking, obesity, and physical inactivity account for a considerable share of socioeconomic inequalities in mortality among middle aged men and women (51-65 years) in the USA [24], while inequalities in smoking and physical inactivity have increased in countries such as England [25] and South Korea [26]. Based on this evidence, it has been proposed that targeted interventions towards socioeconomic disadvantaged groups are required to reduce socioeconomic inequalities in CVD [27]. Proposed strategies to target the socially disadvantaged groups have included partnerships between health and nonhealth sectors as well as comprehensive public health approaches such as surveillance, community-based strategies and clinical interventions [28].

The declining trends in infectious diseases that were observed in Colombia likely reflect the successes of both preventive and curative medicine. Socioeconomic differences in mortality by infectious diseases, however, increased over the study period, and there was no clear pattern of change in the rate of increase in the period after the introduction of the health care reform [1]. Evidence of risk factors underlying inequalities in infectious diseases among adults is scarce, owing to the low burden of infections in high-income and even some middle-income countries today [29]. Nevertheless, available evidence suggests that populations in the most economically deprived areas have a higher burden of premature mortality from infections [29], and that poverty is an important factor underlying high mortality from infections [30]. The NHS-2007 in Colombia reported high prevalence of several risk factors such as poverty; households without running water, sewage lines, adequate walls, and with dirt floors; as well as large regional and urban/rural differences [23]. In addition, mortality from infectious diseases has proved to be higher in poorer municipalities [31]. Socio-economic inequalities in access and use of health care services for infectious diseases have also been documented [32]. All these factors likely contribute to the increasing inequalities in premature mortality from infectious diseases.

Traffic accidents account for 5% of inequalities in total mortality by education. Vehicle safety infrastructure is less well-developed in deprived areas, and individuals may be less likely to comply with safety regulations on seat belt use, drinking and driving, and speed limit enforcement [23, 33, 34].

Homicide rates progressively rose until 2002 and steadily decreased afterwards. Yet, this decrease is associated with increasing inequalities, because the reduction in lethal violence since 2002 has been larger for the higher educated [2]. Despite declining trends over the past decades [35], the homicide rate in Colombia is among the highest worldwide[29]. Results corroborate previous findings that homicide is concentrated primarily among lower-educated young men [35, 36], and it is often linked to adverse social and economic conditions [36]. In Colombia, lower-educated men are more likely than other groups to be exposed to crime and violence, poverty, unemployment, social disarray, and alcohol and drug use [36, 37]. Therefore, the explanation of the large inequalities in homicide in Colombia mirrors the evidence from the USA, where men with low education face higher levels of poverty, unemployment, social disruption and risky behaviours (e.g., alcohol, drug use, smoking), and are more likely to live in areas of high crime and diminished economic opportunities [37]. A specific factor within Colombia is the armed conflict which takes a toll on young men with a low educational background living in economically deprived rural areas [38].

Low-crime nations have in common a shared normative system and strong social control systems that maintains cohesion and normative integration [39]. In Colombia, it has been suggested that the weakness of Government institutions is a more important cause of homicide than social inequality per se [40]. Overall, our findings suggest that the strenghtening of institutions may be necessary not only to reduce homicide, but also to reduce socioeconomic inequalities in homicide mortality, which expanded despite declining trends in homicide.

The remarkable finding that homicide is the largest contributor to socioeconomic inequalities in premature mortality among men suggests that an important part of the causes of socioeconomic inequalities in mortality in Colombia are likely to fall outside the health care system. Firearms are involved in as much as 77.6% of homicides in Colombia [36], so that quality of trauma care is likely to be less important than incidence of interpersonal violence in explaining mortality variations.

In conclusion, socioeconomic inequalities in mortality in Colombia are strongly linked to interpersonal violence (homicide, traffic accidents), poor behavioural choices (smoking, obesity, physical inactivity); and social inequalities. To address health inequalities in Colombia and possibly other middle-income countries, it is essential to adopt a public health approach that focuses on the major underlying causes for inequalities in mortality. Yet, even this approach may be too optimistic: For example, there is no convincing evidence that countries with strong welfare state arrangements such as those in Northen Europe have succeded in reducing health inequalities over the last decades. If anything, evidence suggests that countries like Denmark and Finland have larger health inequalities than countries in southern Europe, which have traditionally had less generous welfare state systems [41]. Further evidence is necessary to identify the actual roots of those profound inequalities in the specific context of Colombia and middle-income countries.

8.2.2. The relationship between health care insurance coverage (HIC) and socioeconomic inequalities in mortality in Colombia

The main conclusion from studies in this thesis is that although expanding coverage did not eliminate health inequalities, health care coverage may have contributed to curbing widening inequalities. Other studies have reported similar findings. A previous study concluded that decreases in overall mortality in Colombia during the 1990s were not a consequence of health care reform [42]. Other studies have also reported the existence of large inequalities in Colombia in access and use of health services, which could contribute to inequalities in mortality [43-46]. Other studies found that despite significant increases in HIC among lower SES groups in Colombia, this does not seem to have translated into improved access to healthcare in these groups [47-49]. Several explanations may account for this, including costs associated with accessing care even in the context of universal coverage, less knowledge of available care among the lower educated and less investment in care and prevention in these groups.

There may be some exceptions, however, whereby access to health care may be key to reducing socioeconomic inequalities in mortality from certain causes. In particular, the finding of a larger reduction in cervical cancer rates among less educated women [5] might be attributable to strategies to improve secondary prevention (screening and early treatment) during the period of expansion of health insurance coverage [3]. This pattern is also reflected in declining population-based regional incidence rates [50, 51]. The observed declines in educational differences in cervical cancer mortality may also reflect changes in follow-up care from detection to intervention in early stages of cervical cancer. There are indications for improvements in access to cytology and subsequent treatment for the poorest segments of the population, potentially as a result of the rapidly increasing health insurance coverage of the population in this period [52]. Nevertheless, we found that educational inequalities in mortality from some other cancers have continued to grow, particularly among women. These results suggest that insurance coverage does not guarantee smaller health inequalities or, alternatively, that it requires a substantial time window before insurance coverage can reduce health inequalities [53, 54]. In addition, several characteristics of the Colombian health care system make it likely that inequalities in healthcare access may in fact increase in some cases. For example, those with contributory insurance have more access to some forms of healthcare [55], and they also have more knowledge of their own legal rights, and they may therefore benefit disproportionately from insurance coverage [55, 56].

In summary, results from this thesis are consistent with previous studies in developing countries [57, 58], Europe [59-62] and the USA [63, 64] which suggest that coverage only partially explains socioeconomic inequalities in health care utilization. Therefore, it is not surprising that the reform has not substantially reduced inequalities in mortality in Colombia as these are likely the result of life-course processes that involve more than access to care.

The study on neonatal mortality and HIC showed that health insurance coverage and type was associated with lower newborn mortality, with those with subsidized insurance having worse outcomes than those with contributory insurance [7]. Differences between the subsidized and contributory scheme are unlikely to be caused by differences in the benefit plan, because by law both plans require equal provision of services for obstetric care, C-sections, paediatric care and family planning [65]. This mandate is important, but clearly not sufficient, as inequalities between insurance schemes remain. Problems with health care provision might still contribute to mortality inequalities between insurance schemes, with insufficient provision of services and distance to facilities disproportionately affecting those in the subsidized regime, which also tend to live more often in rural areas [65, 66]. Furthermore, health insurance may not compensate transport costs and illegal charges for free services [65].

C-section rates in Colombia are comparable to those in other Latin American countries [67], where a large proportion of C-sections is elective, rather than indicated [68]. The finding that C-sections can have negative effects on newborn health outcomes is consistent with studies in other countries with very high C-section rates [68]. Depending on the health system in place, it might increase the medicalization of birth when health care staff is paid per procedure [69]. In urban Brazil, increases in elective C-section rates were strongly associated with increased mortality by preterm births [70]. Like Colombia, Brazil has undergone a major health system reform, and the evidence so far suggests that excessive medicalization in a relatively unregulated private sector may have contributed to the increase in unnecessary C-sections [70].

8.2.3. Macro-economic fluctuations and mortality trends in Colombia

A key finding from this thesis is that the relationship between economic cycles and mortality changes over time and varies by sex and age. Among younger men and women (20-44 years), mortality was acyclical (i.e., not associated with economic cycles) from 1980 to 1995, but it was countercyclical, i.e., decreases during economic upturns and increases during economic downturns, from 2000 to 2010. By contrast, among men older than 65+ years, mortality was countercyclical in the first period but acyclical in the second period [8].

One possibility is that these inconsistences reflect changes in under-registration of deaths or other data quality problems. Although this possibility cannot be discarded, findings are in line with a growing literature suggesting changing associations. For example, in a recent paper Ruhm [71] investigates whether the association between unemployment rates and mortality in the USA has changed in the period 1976-2009. His findings suggest that total mortality shifted from being strongly procyclical at the beginning of the period to being unrelated to macroeconomic conditions during the first decade of the 21st century. Importantly, the change in the impact of unemployment on mortality differed by cause of death: While deaths due to cardiovascular disease and transport accidents continued to be strongly procyclical, cancer and accidental poisoning became countercyclical over time. A similar shift has been documented for the association between state unemployment rates and infant mortality in the USA from 1980 to 2004 [72].

An important question is how the pattern of growing socioeconomic inequalities in mortality observed in this thesis (research questions 1 and 2) relate to the observed association between business cycles and mortality. A potential hypothesis is that business cycles are an important determinant of mortality fluctuations [73], in particular for homicide [9], and that this pattern is associated with the observed increase and subsequent decline in homicide inequalities in Colombia. Contrary to evidence for high-income countries showing that mortality declines during recessions [74-84], we found that mortality is not consistently procyclical in Colombia, and it is either countercyclical or acyclical depending on the period, sex and age group.

In general, the mechanisms that may explain these period and cross-country differences in the association between short-term economic fluctuations and mortality are not yet well understood [85-87]. However, studies note that the effects of economic fluctuations on health may depend –at least partly- on the levels of economic and 'human' development [88]. For instance, mean average GDP-per capita grew 77% from the first to second period [89], and social protection expanded considerably during the study period [90, 91]. Social protection programs in high income countries may mitigate the adverse effects of economic downturns [76, 80, 92]. Improvements in income and social protection programs in Colombia, therefore, could explain the changing association between short-term economic fluctuations and mortality in recent years. This may be particularly the case for older people, which is generally characterized by low attachment to the labour market, which suggests that the potential health-effects of economic fluctuations may operate through mechanisms not directly related to work. For example, previous studies have speculated that procyclical mortality among seniors in the US may be due to more availability of higher-skilled workers to care for the elderly during recessions [81, 82, 84], as well as a decline in the opportunity costs of time during recessions which results in more time spent with older parents [76].

The shift from acyclical to countercyclical mortality in Colombia is puzzling. Plausible explanations may include reduced exposure to hazardous working conditions, and diminishing opportunity costs of time leading to increased use of preventive services [80, 82, 87, 92-94]. Earlier studies suggest that the impact of downturns on living conditions in high-income countries may be partly offset by social protection programmes such as unemployment or healthcare insurance, social benefits as well as support from family members [87, 92, 93, 95]. In contrast, most low- and middle-income countries lack comparable safety nets to mitigate the social and economic impact of economic downturns [87]. A potential hypothesis is that populations in low- and middle-income countries are more vulnerable, so that any decreased mortality during economic downturns is outweighed by strong negative effects on living conditions relevant to health [85, 86]. This difference in living standards is also reflected in the different composition of causes of death across high-, middle- and low-income countries [96], which may lead to different associations with economic cycles [87]. Because the impact of economic fluctuations on mortality differs for different causes of death [94], the countercyclical mortality at younger ages in 2000-2010 in Colombia [73] was probably driven by the strong countercyclical relationship of homicide particularly among young working-age men [9], which make up a large share of all-cause mortality at younger ages. The larger contribution of homicide to overall mortality in Colombia [1, 2] may yield different associations for total mortality than in high-income countries, where homicide represents a relatively smaller share of all deaths.

8.3. EVALUATION OF DATA AND METHODS

8.3.1. Limitations of data sources

Bias related to the data used in this thesis may arise from at least two sources: problems in the Colombian mortality dataset (under-registration, missing values, and changes in coding of causes of death) and the limitations inherent to the 'unlinked data' approach, whereby information on socioeconomic status comes from different sources for the mortality and for the population denominators.

A key limitation the Colombian data, as well as data from other low- and middle-income countries, is the large under-registration of deaths in some regions [97]. Previous studies comparing national mortality rates with indirect estimates from census [21, 22] suggest that under-registration is particularly important in the poorest regions. Previous studies estimated the magnitude of under-registration in Colombia by comparing counts of deaths with deaths expected from census projections for 1990 [98] and 2000 [99]. These studies used standard techniques proposed by the Pan American Health Organization [100]. According to these studies [98, 99] under-registration declined in the period 1900-2000 from 78.2% to 75% in Chocó, one of the poorest regions, while in prosperous regions like Caldas under-registration declined from 40.1% to 11.8%. This implies that estimates of inequalities in mortality by educational level are likely to be underestimated, because those with lower education are more likely to live in areas with higher under-registration rates. This may also have led to underestimation of the extent to which inequalities have increased, because under-registration decreased over the study period [21, 22].

To address bias due to underregistration in the analysis of economic cycles (1980-2010), an adjustment factor for under-registration was included, by using the approach proposed by PAHO [100] and applied in earlier studies [99]. The approach is based on the assumption that regional differences in under-registration can be captured using weights based on external estimates of the level of under-registration for each region, age and sex combination based on information obtained from censuses [101]. Including this adjustment factor did not lead to a notable change in the results, suggesting that the latter are not driven by variations in under-registration. A possible explanation for the small impact of under-registration is the fact that differences between regions are captured by region fixed effects whereas overall improvements in vital registration systems are captured by time fixed effects. Finally, region-specific trends in under-registration are likely captured by region specific linear trends. Nevertheless, weights to correct for under-registration for specific causes of death were not available.

There was a large proportion of deaths with missing information on educational level. Roughly, information on educational attainment was missing for 34.2% of death records for ages 25-64 years in the period 1998-2007 [1, 3, 5], and for 33.4% of deaths during 1999-2012 [2, 6]. Information on maternal education was missing for 26.5% of neonatal deaths (under 28 days) in 2008-2011. This may have led to underestimation of inequalities, as missing values are likely to be more common in the least educated [99]. To partly address this bias, we used multiple imputation methods based on a limited set of variables [102], particularly to avoid bias due to the potentially higher rates of missing education for lower educated individuals, and to minimize the potential for numerator/denominator bias [103]. Missing values were more common in deprived regions and they decreased over time, which suggest that inequalities were underestimated and that this underestimation was larger for more recent periods. In sensitivity analyses, we compared relative measures of inequalities using imputed datasets with a dataset that did not use imputation but excluded deaths with missing information. In most cases, confidence intervals of estimates overlapped, suggesting no significant difference in estimates based on these datasets. In general, our sensitivity analyses seem to coincide with the hypothesis that our data generally underestimates inequalities, and that this underestimation declined over time, which partly contributed to the pattern of growing inequalities. It is unlikely, however, that improvements in under-registration are sufficiently large to explain observed changes in socioeconomic inequalities in mortality over the study period.

Changes in coding of causes of death practices may also have generated biased. However, since our study focused primarily on broad categories of death, changes in diagnostic practices are unlikely to influence estimates of inequalities in most analyses, with the exception of specific cancer tumours [5]. We introduced adjustments for coding changes by reassigning deaths due to cancers of the cervix uteri or corpus uteri, as well as other adjustments for unknown age, certificates filled by non-medical personnel, and ill-defined causes of death. These methods have been shown to perform well in controlling for changes in coding practices[104].

Despite these adjustments, ill-defined causes, which decreased steadily over the study period, represented an important source of bias in our data. Deaths with ill-defined cause corresponded to 19% of all deaths in 1982, while between 1998 and 2010 the share of this category decreased from 3% to 2.1%. In general, Colombia has acceptable levels of quality of registration for international standards [105]. As quality of registration is expected to be better in more prosperous regions, this may also have led to underestimation of the extent to which inequalities in specific causes have increased, as deaths are more likely to be coded as ill-defined in less economically well-off regions. This data problem, however, does not affect estimates of inequalities for total mortality.

As the birth and death databases could not be linked directly using individual identifiers, our databases are of the 'unlinked' type [60, 106]. Newborn counts were obtained by aggregating deaths by social and demographic variables as recorded in the birth database, while death counts were obtained separately by aggregating the mortality database by the same variables as recorded in the death certificates. Numerators and denominators were subsequently linked. Mismatching, however, was an important problem: a substantial proportion of deaths could not be linked to any birth according to the variables of interest, leading to a drop of 7.6% of deaths [7]. Mismatching can occur because of imprecise imputation of missing values or because of inaccuracies in the death records. Birth weight and gestational age, for instance, had a high percentage of missing values, as this information was measured at birth and recalled by relatives at death.

Data on mortality were obtained from mortality registries, while data on the population counts were obtained from censuses and demographic projections [9, 73]. Information in death and birth registries is registered by a doctor or an assistant based in information given by relatives. This may have led to the so-called numerator/denominator bias inherent to unlinked datasets [60, 106]. Previous evaluations in European countries estimated the magnitude of this bias by comparing estimates of inequalities based on both linked and unlined databases. These studies concluded that it is difficult to estimate the extent and direction of bias, but most often the numerator/denominator bias is believed to lead to overestimation of inequalities.

Finally, data quality may also be compromised if the measurement of variables is different across information sources. However, comparability of information in newborn and death databases is relatively high from 2008 onwards given the effort for harmonization across registries by the National Statistics Office (DANE) [107]. Populations counts given by DANE can be harmonized with the death database to calculate mortality rates [9, 73]. To minimize bias due to small differences in coding, we used broad categories of educational level across death registries and population counts, thus minimizing the influence of small differences in the coding of educational level across sources [2-5].

Three problems may have influenced findings for neonatal mortality: under-registration of deaths, missing values and the numerator/denominator bias. Three sensitivity analyses were conducted to further evaluate the effect of these problems [7]. Based on these additional analyses, we concluded that the effect of data problems on the mortality differences adjusted for socio-economic and socio-demographic confounders is likely to be relatively small. For instance, when a dataset for the five richest regions was used (with small levels of missing information), overall patterns and conclusions remained the same. The effect of these sources of bias on conclusions on the contribution of C-section deliveries to the mortality differences between insurance schemes was also evaluated; we found little evidence that our conclusions would change dramatically under different scenarios.

8.3.2. Methodological considerations and validity of results

Our estimates of the impact of health care insurance coverage (HIC) on inequalities in mortality by educational level are limited by the lack of data on mortality rates disaggregated by both educational level and insurance status [3, 6, 7]. In addition, the lack of a control group implies that we cannot fully attribute changes in inequalities in mortality to the expansion of health insurance. Conclusions on the impact of coverage should therefore be interpreted with caution. In addition, we assume a common trend in unobserved factors over the periods. Although it is reassuring that findings were robust to adjustment for several national-level variables such as GDP growth and employment rates, the possibility that other time-varying covariates contributed to trends in educational differences in mortality cannot be discarded. For example, HIC increases occurred parallel to other changes in the health care system such as increases in investments in care [47, 108]. Results may thus reflect the impact of the entire reform rather than only the increased coverage in health insurance.

Several proxy variables have been used to measure the relationship between short-term economic fluctuations and mortality. Although several studies in low- or middle-income countries have used GDP as indicator of economic conditions [85, 86, 109, 110], most studies in high-income countries are based on fluctuations in unemployment rates [74, 79, 81, 88, 111, 112], sometimes controlling for GDP [77, 80, 82, 113, 114]. GDP per capita was the only consistent measure of macro-economic conditions for the period in our study (chapter 7) [8], but future studies should examine whether results might differ for unemployment rates or other indicators of economic output.

Finally, an important limitation in the study of health insurance and neonatal mortality is the fact that unobserved differences between individuals with different health insurance coverage may partly explain observed differences in mortality. Although we controlled for several demographic factors, the fact that health insurance is not randomly assigned implies that bias from unmeasured variables may remain. Results should therefore be interpreted with caution.

8.4. NEW INSIGHTS AND RECOMMENDATIONS

8.4.1. New insights from the studies in this thesis

- Differences in patterns and trends of inequalities could be explained by several proximal and intermediate determinants which are linked either to behavioural risk factors or to conditions related to poverty [1]
- Cardiovascular disease is the largest contributor to premature (25-64 years) mortality inequalities among women in Colombia and the second one among men, while homicide is the largest contributor to inequalities in premature mortality among men [1]
- Educational inequalities in premature cancer mortality differ by cancer type with larger inequalities in predominantly infection-related cancers (cervical and stomach cancer), while there were no clear inequalities in cancers associated with behavioural risk factors [5].
- Large educational inequalities in premature mortality (total, cardiovascular, cancer) persisted and continued to increase despite a major increase in health insurance coverage (HIC) in Colombia [3, 5, 6]. While increasing HIC may not have reduced inequalities, it may have contributed to curbing growing socioeconomic inequalities in mortality [3].
- Increased medicalization of births and increased C-section rates in Colombia may have diminished the positive effects of improved access to maternity care through health insurance [7].
- The relationship between business cycles and adult mortality in Colombia changes over time, and differs by sex and age. Senior (65+) mortality changed from being countercyclical (i.e., decreases in mortality when economy improves) to having no relationship with economy, possibly owing to improvements in wealth and social protection safety nets [8].

- Mortality from homicides is strongly countercyclical (i.e., it increases when the economy contracts) in Colombia and may contribute to countercyclical overall mortality for young men [8, 9], among whom homicide is one of the leading causes of death [1].

Recommendations

8.4.2. Recommendations for public health policy

- The increasing contribution of non-communicable diseases to health inequalities among men and women calls for urgent prevention policies in Colombia that target behavioural risk factors (smoking, alcohol abuse, unhealthy diet, sedentarism), especially among the lower socioeconomic groups [1, 2].
- Large inequalities in cervical cancer, despite declines amongst the lower educated groups [5], highlight the need for extending prevention efforts to reduce infection by HPV with a focus on the lower socioeconomic groups. Prevention of HPV infection may prove useful to reduce inequalities in cervical cancer mortality.
- Large inequalities in stomach cancer in both men and women highlight the need for identifying effective early detection and cost-effective strategies to eradicate H. pylori [5].
- The striking contribution of homicide to socioeconomic differences in all-cause mortality among young men [1, 2] and the increased inequality in a period of enormous reduction in lethal violence (after 2002) [2] highlight the need for policies outside public health that address the determinants of violence for those most at risk, i.e. lower educated young men.
- Stronger regulation in the health care system might be considered as a strategy to avoid perverse incentives in the Colombian health system, such as the incentive to perform unnecessary C-sections.
- Expanding social protection programmes may reduce the toll of mortality associated with fluctuations in the regional economy[8].
- Countries should place greater emphasis in those illnesses and causes of death that contribute most to health inequalities between more and less advantaged groups.

8.4.3. Recommendations for future research

- Further research should identify the specific incentives for differential treatment (C-sections) by insurance regime [7].
- Data on incidence of disease and prevalence of behavioural risk factors by socioeconomic status are lacking in Colombia and most developing countries. New studies must tackle this limitation, by carrying out regular monitoring of disease incidence and risk factor surveillance by socioeconomic measures.

- The effects of distal and intermediate determinants of health (e.g., poverty, behavioural risk factors, social inequalities, institutions) on inequalities in mortality for different causes of death should be established to better understand the mechanisms and pathways underlying inequalities.
- Linked registry databases or cohort studies are necessary to strengthen knowledge on the role of health insurance coverage in health inequalities in Colombia [3, 6, 7]
- Future studies in Colombia and other Latin American countries should examine how results from "unlinked" studies compare to more precise results from data linked based on individual identifiers [103, 115]
- Equity in health care delivery could be improved by introducing socioeconomic variables (SES) as risk factors in clinical guidelines. This could be especially useful in low and middle-income countries such as Colombia, where health gradients and social gaps have shown to be particularly pronounced. Introducing SES variables in risk profiles may have a profound impact on the effectiveness of treatments in low-income settings.

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Summary

SOCIOECONOMIC INEQUALITIES IN MORTALITY IN COLOMBIA: TRENDS, HEALTH INSURANCE COVERAGE AND ECONOMIC CYCLES

Section I. Introduction

The overall aim of this thesis is to examine socioeconomic inequalities in mortality in Colombia and how their evolution relates to the expansions of health insurance coverage and changing macro-economic conditions over the last two decades. An important organizing principle and end goal of this thesis is to provide a road map of potential policies to reduce health inequalities in Colombia. For this purpose, this thesis addresses the following specific research questions: [1] Have socioeconomic inequalities in all-cause and cause-specific mortality by socioeconomic status changed in the period from 1987 to 2012? [2] Has the expansion of health insurance coverage contributed to decreasing trends in socioeconomic differences in mortality over the past two decades? [3] What was the impact of macro-economic fluctuations (business cycles as measured by regional GDP) on mortality trends in Colombia in the period from 1980 to 2010?

To address these questions, this thesis used a variety of registry data sources linked to data from census, made available by the National Statistics Office (DANE): (a) individual registries of Vital Statistics, i.e., mortality database (1980-2012) and newborn databases (1999-2012); (b) total yearly population counts per year, 5-years age group, and sex (1980-2020), obtained from census combined with statistical projections; (c) proportion of individuals in each educational category by age and sex 5 year calendar years (1995, 2000, 2005, 2010) was estimated from Demography Health Surveys (DHS) or the IIASA/VID database on education attainment.

Based on these data, we estimated yearly sex and age rates by educational level (primary, secondary and tertiary) combining counts of deaths by educational level (using multiple imputation for missing values), and population estimates. We also used sex, age, region and year-specific mortality rates to assess the association between business cycles and adult mortality. In addition to all-cause mortality, we carried out analyses for specific causes of death, distinguishing three main groups: cardiovascular diseases (CVD), homicide and cancer. In order to evaluate the association between economic cycles and mortality, we used regional data for Gross Domestic Product (GDP) (1980-2012 in different periods) obtained from DANE databases. To estimate neonatal mortality rates we obtained yearly counts of deaths under 28 days of life, as well as newborn counts, according to characteristics of: (i) the child (year of birth, region of birth, sex, gestational age, birth weight), (ii) the mother (insurance status, age, marital status, rural/urban residence), and (iii) the delivery (singleton/multiple birth, mode of delivery (C-section or vaginal).

We estimated analytical indicators for inequalities in mortality as the relative index of inequality (RII) and the slope index of inequality (SII). We also assessed the trends of

these inequalities using different ways in each study: (i) by calculating and comparing indicators in different periods of time; (ii) by obtaining interaction terms for RII and year in order to evaluate the evolution of the inequalities over time; and (iii) by estimating joinpoint analyses. We particularly addressed the second question by comparing the trends of these educational inequalities in periods with different HIC (1998-2002, 2003-2007, 2008-2012), but also the differences in neonatal mortality according different insurance schemes in the Colombian health system (contributory, subsidized, uninsured). To address the third question we used region fixed effect models that exploit regional variations in GDP growth to estimate the effect of regional economic fluctuations on adult mortality (20-44, 45-64, 65+ years) in Colombia, separately for two periods: 1980-1995 and 2000-2010.

Section II. Trends in socioeconomic inequalities in mortality in Colombia

Large inequalities in mortality by educational level were found. Inequalities in mortality by education in Colombia widened since 1998, owing primarily to higher mortality from non-communicable diseases and injuries (intentional and unintentional ones) in men and women from lower education. Mortality rates for men and women with primary and secondary education remained relatively constant or grew for deaths from infectious disease and other causes, while rates for higher educated men steadily declined for all causes. Rates of mortality for injuries among women were similar for all educational levels, but there were large differences for men in both levels and trends. While mortality for injuries declined steadily in most years among men with middle and higher education, it increased during the first years for lower-educated men, and only started to decline in 2002, owing to a huge peak in homicide in this year. In sum, we found a double burden of inequalities with non-communicable diseases as the larger contributor to those inequalities among women and the second among men.

Similarly, we found variations in socioeconomic inequalities in premature cancer mortality according cancer type (1998-2007), being largest for cervical, stomach and lung cancer mortality, and non-existant for colorectal and breast cancer mortality. Differences in cancer mortality by educational level were larger for women than for men, which was largely attributable to the large share of inequalities attributable to cervical cancer mortality. This suggests that behavourial risk factors and infections may be the largest contributors to inequalities in cancer.

Burden of homicide on total inequities in young men warrants special focus. Our findings suggest a striking effect of homicide educational differences particularly among men, driven by both higher homicide rates and educational inequalities, and also by high homicide levels at early ages. We also found that, during a period of declining violence (2003-2012), homicide inequalities were higher than in the period of increasing violence (1998-2002). A potential explanation is that reductions in homicide rates benefitted more those with higher education than their lower educated counterparts. Our findings underscore the significance of social differences in homicide as a major public health problem.

Section III. The relationship between health care insurance coverage (HIC) and socioeconomic inequalities in mortality in Colombia

We examined the association between trends in HIC and educational level as proxy variable of Socioeconomic Status (SES) in premature mortality after the health care reform in Colombia. Our studies add to this literature by showing that despite decreases in mortality during this period, the reform did not clearly lead to a reduction of inequalities in mortality. Health insurance coverage may have contributed to curb the increasing trends in inequalities in non-communicable diseases in a period of steady increase of HIC (2003-2007), but it may offer only a small explanation for the large and consistent inequalities in mortality observed in our studies. Increasing levels of HIC were associated with an overall reduction in mortality, but among men, a significantly larger mortality reduction was observed in those at the top as compared to those at the bottom of the educational distribution. Furthermore, inequalities in premature cancer mortality (1998-2007) were in general stable over time except for cervical cancer mortality, which declined since 2002 among women with primary education, resulting in narrowing inequalities, which may reflect improved access and adherence to cytology and subsequent treatment following the larger expansion in health insurance coverage. Nevertheless this promising finding probably did not continue while in the period 2008-2012 total inequalities in premature cancer mortality increased significantly back to its previous levels.

We also found that having a health insurance was associated with lower newborn mortality, but the type of insurance matters mattered, so that those with subsidized insurance had worse outcomes than those contributing through their employer, and lower NMR than those uninsured. Newborn mortality in those with contributory insurance would have been even lower if benefits of insurance were not offset by their high rates of medically unnecessary C-section rates. These findings were robust when potential confounders were added to the model and suggest that while health insurance increases access to maternity care, it may also have adverse consequences.

Section IV. Macro-economic fluctuations and mortality trends in Colombia

We found that the relationship between economic cycles and mortality is instable over time and changes by sex and age group. Among younger men and women (25-44 years), mortality was acyclical from 1980 to 1995, but it was countercyclical (i.e., mortality decreases during economic upturns and increases during economic downturns) from 2000 to 2010. Besides, among older men (65+ years), mortality was countercyclical in the first period, but acyclical in the second period. These differences could reflect changes in under-registration of deaths or other data quality problems that changed over periods. Nevertheless, analyses restricted to regions with high registration coverage yielded similar albeit less precise estimates for most sub-groups.

Section V. Discussion

Earlier studies have documented large and persistent inequalities in mortality by educational level in high-income countries. However, there is a paucity of studies documenting socioeconomic inequalities in mortality in low- and middle-income countries. In high-income countries, socioeconomic inequalities in mortality are largely attributable to non-communicable diseases. Likewise, we found that non-communicable diseases are the leading contributor to inequalities in mortality by educational level among women, and the second largest contributor among men. Existing evidence suggests that, as in high income countries, lower education is associated with a worse risk factor profile in Colombia. Socioeconomic inequalities in unhealthy behaviours might thus explain the large contribution of non-communicable diseases to overall mortality inequalities. In particular, the increasing contribution of non-communicable diseases is the need to implement urgent prevention policies to curb the rise in the prevalence of risk factors in lower socioeconomic groups.

The distribution of cancer types in Colombia reflects the dual situation in many Latin American and other middle-income countries, with a relatively high burden of infection-related cancers combined with a growing burden of cancers associated with risk factors of non-infectious character. In particular, striking differences in mortality from cervical cancer among women in Colombia suggests that there are persistent barriers to access to medical services in the lower-educated groups, which are precisely the groups at highest risks of developing cervical cancer.

Studies in other countries with different levels of development support the notion that despite its benefits, health insurance access is insufficient to reduce inequalities in health, and may play only a minor role as compared to other factors that determine both access to high-quality care and mortality. Even in countries with universal health care coverage there are large inequalities in mortality that have persisted and increased during the last decades. Therefore, it is not surprising that the Colombian reform has not fully eliminated inequalities in mortality in Colombia as these are likely the result of life-course processes that involve more than access to care. The persistence of inequalities in the social and behavioural determinants of mortality may explain why inequalities in health persist even after universal access to care has been achieved.

Our finding of higher mortality among the uninsured corresponds with previous studies in Colombia, which found that the subsidized scheme has better health care access, lower out-of-pocket health expenditures, and higher birthweight and gestational age than the uninsured, but in our study this difference vanishes when we adjust for birthweight and gestational age. Previous studies show plausible mechanisms to explain the resilience of inequalities in NMR when poor population receives insurance coverage, even with identical benefits plan. Our findings underscore the importance of understanding the impact of social determinants other than health care insurance coverage in explaining inequalities in NMR gaps. Growing inequalities found in NMR are not entirely attributable to differences in healthcare insurance status

Instability found in the relationship between economic cycles and mortality over time and changes by sex and age group could be explained by inaccurate estimations based on short periods, improvements in the registration of mortality and the expansion of health insurance coverage and old-age protection programmes since 2000. Since the senior population is generally characterized by a low attachment to the labour market, this finding suggests that potential negative health-effects of recessions operate through mechanisms not directly related to work. Our findings are in line with prior evidence suggesting that this relationship has changed over time and it varies by level of economic development. As the composition of mortality causes varies across countries and regions, it is not surprising that the relationship between total mortality and economic cycles varies by country.

RESUMEN

INEQUIDADES SOCIOECONÓMICAS EN LA MORTALIDAD EN COLOMBIA: TENDENCIAS, COBERTURA DEL SEGURO DE SALUD Y CICLOS ECONÓMICOS

Sección I. Introducción

El objetivo general de esta tesis es analizar las inequidades socioeconómicas en la mortalidad en Colombia y cómo su evolución se relaciona con la expansión de la cobertura de seguro de salud y con los cambios de las condiciones macroeconómicas en las últimas dos décadas. Un importante principio de organización y objetivo final de esta tesis es proporcionar una hoja de ruta de posibles políticas para reducir las inequidades en salud en Colombia. Para ello, esta tesis aborda las siguientes preguntas de investigación específicas: [1] ¿Han cambado las inequidades por nivel socioeconómico en la mortalidad por todas las causas y por causas específicas en el período 1987-2012? [2] ¿La ampliación de la cobertura de seguro de salud contribuyó a la disminución de las tendencias en las diferencias socioeconómicas en la mortalidad en las últimas dos décadas? [3] ¿Cuál fue el impacto de las fluctuaciones macroeconómicas (ciclos económicos, medido por el PIB regional) sobre las tendencias de mortalidad en Colombia en el período 1980-2010?

Para abordar estas cuestiones, esta tesis utiliza una variedad de fuentes de datos de registro vinculadas a los datos de censo, puestos a disposición por el Departamento Nacional de Estadística (DANE): (a) los registros individuales de Estadísticas Vitales, es decir, las bases de datos de mortalidad (1980-2012) y de recién nacidos (1999-2012); (B) los conteos de la población total anual por grupos de 5 años de edad y sexo (1980-2020), que se obtiene a partir del censo combinado con proyecciones estadísticas; (C) la proporción de individuos en cada categoría educativa por grupos de 5 años de edad y sexo para cada 5 años (1995, 2000, 2005, 2010) a partir de las Encuestas de Demografía y Salud (EDS) y de la base de datos IIASA/VID de nivel educativo alcanzado.

Con base en estos datos se estimaron tasas anuales por sexo y edad para cada nivel educativo (primaria, secundaria y terciaria) combinando conteos de muertes por nivel educativo (utilizando imputación múltiple para los valores perdidos), y las estimaciones de población. También utilizamos sexo, edad, región y tasas de mortalidad anuales para evaluar la asociación entre los ciclos económicos y la mortalidad en adultos. Además de todas las causas de mortalidad, se realizó análisis de las causas específicas de muerte, distinguiendo tres grupos principales: enfermedades cardiovasculares (ECV), homicidio y cáncer. Con el fin de evaluar la asociación entre los ciclos económicos y la mortalidad, se utilizaron los datos regionales de Producto Interno Bruto (PIB) (1980-2012 en diferentes periodos) obtenida de las bases de datos del DANE. Para estimar las tasas de mortalidad neonatal se obtuvieron recuentos anuales de fallecimientos antes de los 28 días de vida, así como el recuento de recién nacidos, según características de: (i) el bebé (año de nacimiento, región de nacimiento, sexo, edad gestacional, peso al nacer) , (ii) la madre (tipo de seguro de salud, edad, estado civil, residencia rural/urbana), y (iii) el parto (parto simple/múltiple y tipo de parto -cesárea o vaginal-).

Estimamos indicadores analíticos de las inequidades en la mortalidad como el Índice Relativo de Inequidad (IRD) y el Índice de Inequidad de la Pendiente (IDP). También se evaluaron las tendencias de estas inequidades de diferentes maneras en cada estudio: (i) mediante el cálculo y la comparación de indicadores en diferentes períodos de tiempo; (Ii) mediante la obtención de los términos de interacción para IRD y año, a fin de evaluar la evolución de las inequidades en el tiempo; y (iii) mediante la estimación de análisis joinpoint. En especial abordamos la segunda pregunta comparando las tendencias de estas inequidades educativas en periodos con diferentes niveles de aseguramiento (1998-2002, 2003-2007, 2008-2012), así también como las diferencias en la mortalidad neonatal según el tipo de seguros en el sistema de salud colombiano (contributivo, subsidiado, sin seguro). Para hacer frente a la tercera pregunta se utilizaron modelos de efectos fijos regionales que explotan las variaciones regionales en el crecimiento del PIB para estimar el efecto de las fluctuaciones económicas regionales en la mortalidad en adultos (20-44, 45-64, 65+ años) en Colombia, por separado para dos períodos: 1980-1995 y 2000-2010.

Sección II. Tendencias de las inequidades socioeconómicas en la mortalidad en Colombia

Se encontraron grandes inequidades en la mortalidad por nivel educativo. Las inequidades en la mortalidad por la educación en Colombia se aumentaron a partir de 1998, debido principalmente al incremento de la mortalidad por enfermedades no transmisibles y las lesiones (intencionales y no intencionales) en hombres y mujeres de menor nivel educativo. Las tasas de mortalidad en hombres y mujeres con educación primaria y secundaria se mantuvieron relativamente constantes o aumentaron para enfermedades infecciosas y otras causas, mientras que las tasas para los hombres con educación superior disminuyeron de manera constante para todas las causas de muerte. Las tasas de mortalidad por lesiones entre las mujeres fueron similares para todos los niveles educativos, pero en cambio se hallaron grandes diferencias para los hombres en cuanto a niveles y a tendencias. Si bien la mortalidad por lesiones disminuyó de manera constante en la mayoría de los años entre los hombres con educación media y superior, aumentó durante los primeros años para los hombres con educación primaria y sólo comenzó a declinar en 2002, con un enorme pico en homicidios en este año. En suma, nos encontramos con una doble carga de las inequidades con las enfermedades no transmisibles como el contribuyente más grande para esas inequidades entre las mujeres y la segunda entre los hombres.

Del mismo modo, encontramos variaciones en las inequidades socioeconómicas en la mortalidad prematura de cáncer según tipo para 1998-2007, siendo mayores para la mortalidad por cáncer de cuello de útero, estómago y pulmón, y nulas en la mortalidad por cáncer colorrectal y de mama. Las diferencias en la mortalidad por cáncer por nivel educativo fueron mayores para las mujeres que para los hombres, lo que fue en gran parte debido a la gran proporción de las inequidades atribuibles a la mortalidad por cáncer de cuello uterino. Esto sugiere que los factores de riesgo de comportamiento y las infecciones pueden ser los mayores contribuyentes a las inequidades en cáncer.

La carga del homicidio en las inequidades totales en hombres jóvenes amerita atención especial. Nuestros resultados sugieren un efecto notable de las diferencias educativas en homicidio, en particular entre los hombres, impulsado por las tasas más altas de homicidios y las inequidades educativas, y también por los niveles altos de homicidios en edades tempranas. También se encontró que, durante un período de disminución de la violencia (2003-2012), las inequidades de homicidio fueron más altos que en el período de aumento de la violencia (1998-2002). Una posible explicación es que se beneficiaron mucho más de las reducciones en las tasas de homicidios aquellos con educación superior que sus contrapartes con menor nivel educativo. Nuestros resultados subrayan la importancia de las diferencias sociales en el homicidio como un importante problema de salud pública.

Sección III. La relación entre la cobertura de seguro de salud (HIC) y las inequidades socioeconómicas en la mortalidad en Colombia

Se examinó la asociación entre las tendencias en el nivel de cobertura de seguro de salud y el nivel educativo como variable proxy de estatus socioeconómico (ESE) en la mortalidad prematura después de la reforma de salud en Colombia. Nuestros estudios se suman a la literatura previa mostrando que a pesar de la disminución de la mortalidad durante este período, la reforma no llevó claramente a una reducción de las inequidades en la mortalidad. La cobertura de seguro de salud puede haber contribuido a frenar las crecientes tendencias de las inequidades en las enfermedades no transmisibles en un período de aumento constante de cobertura de seguro de salud (2003-2007), pero esto puede ofrecer sólo una pequeña explicación de los grandes y consistentes inequidades en mortalidad observadas en nuestros estudios. El aumento de los niveles de cobertura de seguro de salud se asoció con una reducción global en la mortalidad, pero, entre los hombres, se observó una reducción de la mortalidad significativamente mayor en aquellos en con mayor nivel educativo en comparación con aquellos con menor nivel educativo. Por otra parte las inequidades en la mortalidad prematura por cáncer (1998-2007) fueron en general estables en el tiempo a excepción de la mortalidad por cáncer de cuello uterino, que disminuyó desde 2002 entre las mujeres con educación primaria, lo que resulta en reducción de las inequidades, lo cual puede reflejar la mejora del acceso y la adhesión a la citología y tratamiento posterior tras la mayor expansión en la cobertura de seguro de salud. Sin embargo este prometedor hallazgo probablemente no persistió ya que en el período 2008-2012 las inequidades totales en la mortalidad prematura de cáncer aumentaron significativamente de nuevo a sus niveles anteriores.

También se encontró que el tener seguro de salud de la madre se asoció con una mortalidad neonatal más baja, pero el tipo de seguro de salud importa, de modo que aquellos con seguro subsidiado tuvieron peores resultados en mortalidad neonatal que los que contribuyen a través de su empleador, y mejores resultados que los no asegurados. La mortalidad neonatal para aquellos con régimen contributivo habría sido aún menor si los beneficios del seguro no hubieran sido contrarrestados con altos índices de cesáreas médicamente innecesarias. Estos resultados fueron robustos cuando se añadieron posibles factores de confusión al modelo, y sugieren que, si bien el seguro de salud aumenta el acceso a la atención de maternidad, también puede tener consecuencias adversas.

Sección IV. Fluctuaciones macroeconómicas y tendencias en mortalidad en Colombia

Se encontró que la relación entre los ciclos económicos y la mortalidad es inestable en el tiempo y varía de acuerdo al sexo y grupo de edad. Entre hombres y mujeres más jóvenes (25-44 años), la mortalidad fue acíclica 1980-1995, pero fue contracíclica (es decir, la mortalidad disminuye durante repuntes económicos y aumenta durante las recesiones económicas) entre 2000 y 2010. Además, entre los hombres de edad mayor (65 + años) la mortalidad fue contracíclica en el primer período, pero acíclica en el segundo período. Estas diferencias podrían reflejar los cambios en el subregistro de muertes u otros problemas de calidad de datos que cambiaron durante los períodos. Sin embargo, los análisis restringidos a regiones con alta cobertura de registro dieron resultados similares, aunque con estimaciones menos precisas para la mayoría de los subgrupos.

Sección V. Discusión

Evidencia previa ha dado cuenta de grandes y persistentes inequidades en la mortalidad por nivel educativo en los países de altos ingresos. Sin embargo, hay pocos estudios que documenten las inequidades socioeconómicas en la mortalidad en los países de bajos y medianos ingresos. En los países de altos ingresos, las inequidades socioeconómicas en la mortalidad son en gran parte atribuibles a las enfermedades no transmisibles. De modo semejante nuestros estudios muestran que las enfermedades no transmisibles son el principal contribuyente a las inequidades en la mortalidad por nivel educativo entre las mujeres, y el segundo mayor contribuyente entre los hombres. La evidencia existente sugiere que, como en los países de altos ingresos, un menor nivel educativo se asocia con un perfil de factores de riesgo más desfavorable en Colombia. Las inequidades socioeconómicas en las conductas poco saludables podrían por lo tanto explicar el gran aporte de las enfermedades no transmisibles a las inequidades globales de mortalidad. En particular, el aumento de la contribución de las enfermedades no transmisibles lleva a la necesidad de implementar políticas de prevención urgentes para frenar el aumento de la prevalencia de factores de riesgo en los grupos socioeconómicos más bajos.

La distribución de los tipos de cáncer en Colombia refleja la doble situación en muchos países de ingresos medios de América Latina y otras regiones que tienen una relativamente alta carga de cánceres relacionados con infecciones combinadas con una carga creciente de cánceres asociados con factores de riesgo de carácter no infeccioso. En particular, la enorme inequidad en la mortalidad por cáncer de cuello uterino entre las mujeres en Colombia sugiere que existen barreras persistentes de acceso a los servicios médicos en los grupos con educación más bajos, que son precisamente los grupos en riesgo más alto de desarrollar cáncer de cuello uterino.

Estudios realizados en otros países con diferentes niveles de desarrollo apoyan la noción de que a pesar de sus beneficios, el acceso seguro de salud es insuficiente para reducir las inequidades en salud, y puede desempeñar un papel menor en comparación con otros factores que determinan tanto el acceso a una atención de alta calidad como la mortalidad. Incluso en países con cobertura de atención médica universal existen grandes inequidades en la mortalidad que han persistido y aumentado en las últimas décadas. Por lo tanto no es sorprendente que la reforma colombiana no haya eliminado totalmente las inequidades en la mortalidad en Colombia, ya que éstas son probablemente el resultado de los procesos de ciclo de vida que implican más que el acceso a los servicios de salud y la atención. La persistencia de las inequidades en los determinantes sociales y de comportamiento de la mortalidad puede explicar por qué las inequidades en materia de salud persisten incluso después de que se ha logrado el acceso universal a la atención.

Nuestro hallazgo de una mayor mortalidad entre los no asegurados se corresponde con estudios previos en Colombia, el cual da cuenta de que el régimen subsidiado tiene mejor acceso a la atención en salud, menor gasto de bolsillo en salud, y mayores peso al nacer y edad gestacional que los no asegurados, pero en nuestro estudio esta diferencia desaparece cuando ajustamos por peso al nacer y edad gestacional. Estudios previos muestran mecanismos plausibles para explicar la resiliencia de las inequidades en la mortalidad neonatal cuando la población pobre recibe cobertura de seguro, incluso con planes de beneficios idénticos. Nuestros resultados ponen de relieve la importancia de comprender el impacto de los determinantes sociales distintos de la cobertura de seguro de salud en la explicación de las inequidades en las inequidades en mortalidad neonatal. Las crecientes inequidades que se encuentran en mortalidad neonatal no son enteramente atribuibles a diferencias en el estado seguro de salud

La inestabilidad que se encuentra en la relación entre los ciclos económicos y la mortalidad a través del tiempo y los cambios por sexo y grupo de edad podrían explicarse por estimaciones imprecisas sobre la base de períodos cortos, las mejoras en el registro de la mortalidad y la expansión de los programas de cobertura de seguro de salud y de protección a la vejez desde 2000. Dado que la población de adultos mayores se caracteriza generalmente por una bajo vinculación al mercado de trabajo, este hallazgo sugiere que los potenciales efectos negativos de las recesiones sobre la salud operan a través de mecanismos que no están directamente relacionados con el empleo. Nuestros resultados están en línea con evidencia previa que sugiere que esta relación ha cambiado con el tiempo y varía según el nivel de desarrollo económico. Como la composición de las causas de mortalidad varía según los países y regiones, no es de extrañar que la relación entre la mortalidad total y ciclos económicos varíe según el país.

The Author

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** Shared first authorship, both authors contributed equally*

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También tengo que hacer especial reconocimiento a mis papás, a mi padre fallecido hace 16 años, justo antes de nacer mi primer hijo, a quien le habría querido poner en sus brazos aunque fuera una vez. No ha existido padre tan noble y amoroso, todo lo que nos dio fue maravilloso, pero lo mejor de todo lo que nos dio fue a mi madre, que todavía nos acompaña y que sufrió y apoyó también estas luchas. Gracias, madre, gracias padre. Gracias a todos mis hermanos por su solidaridad.

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CURRICULUM VITÆ

Ivan Dario Arroyave-Zuluaga was born on 24 September 1971 in Medellin, Colombia. He finished his secondary education at the Calasanz School in 1988, after which he went on to study Dentistry at the University of Antioquia (graduated 1995). In 2011, he completed an MSc in Health Sciences degree with specialization in Public Health from the Netherlands Institute of Health Sciences (NIHES) and the Erasmus Medical Center (EMC). In 2014, he started his PhD at the Department of Public Health of the EMC. His PhD examines socioeconomic inequalities in health and mortality in Colombia in relation to recent reforms to the health care system in Colombia. Since 2014, Ivan is Assistant Professor at the National School of Public Health of the University of Antioquia (Medellin, Colombia).

Before entering academia, Ivan worked as a clinician dentist (1996-2001) and in management positions within the Colombian Health System (2002-2006). He was also lecturer at the Faculty of Medicine of the CES University (Medellin, Colombia), and researcher at the Public Health Observatory (2007-2012). He has published several papers and book chapters in Spanish and he has worked as consultant in projects with the national Health Ministry, and departmental and municipal health secretaries, among other major institutions. He has also lectured on the Colombian health system in several universities and institutions across Colombia since 1999. In 2009, he wrote an e-book about the organization of the health care system.

Ivan is also active in the art of short-story writing: He won a noteworthy short-story regional award (2004) with the tale "El Condenado" [The Condemned], and published a homonymous storybook (2009).

Iván Darío Arroyave-Zuluaga nació el 24 de septiembre de 1971 en Medellín, Colombia. Terminó sus estudios secundarios en el Colegio Calasanz en 1988, tras lo cual estudió odontología en la Universidad de Antioquia (graduado en 1995). En 2011, completó una maestría en Ciencias de la Salud con especialización en Salud Pública por el Instituto Holandés de Ciencias de la Salud (NIHES) y el Centro Médico Erasmus (EMC). En 2014, comenzó su doctorado en el Departamento de Salud Pública de la EMC. Su doctorado examina las inequidades socioeconómicas en salud y mortalidad en Colombia en relación con las recientes reformas al sistema de atención de la salud en Colombia. Desde 2014, Iván es profesor asistente en la Escuela Nacional de Salud Pública de la Universidad de Antioquia (Medellín, Colombia).

Antes de entrar en el mundo académico, Iván trabajó como odontólogo clínico (1996-2001) y en puestos de gestión dentro del Sistema de Salud colombiano (2002-2006). También fue profesor de la Facultad de Medicina de la Universidad CES (Medellín, Colombia), e investigador del Observatorio de Salud Pública (2007-2012) de esta universidad. Ha publicado artículos y capítulos de libros varios en español y ha trabajado como consultor en proyectos con el Ministerio de Salud, así como con secretarios de salud departamentales y municipales, entre otras importantes instituciones. También ha impartido clases en el sistema de salud colombiano en varias universidades e instituciones a lo largo del país desde 1999. En 2009, escribió un libro electrónico sobre la organización del sistema de salud.

Iván también está presente en el arte de la escritura de ficción: Ganó un importante premio regional de cuentos (2004), con el cuento "El Condenado", y publicó un libro de cuentos homónimo (2009).

PHD PORTFOLIO
Summary of PhD training and teaching

PhD training

Programme components	Code	ECTS
Erasmus Summer Programme: 8.4 ECTs		
Principles of Research in Medicine	ESP01	0.7
Clinical Decision Analysis	ESP04	0.7
Methods of Public Health Research	ESP11	0.7
Topics in Meta-analysis	ESP15	0.7
Health Economics	ESP25	0.7
Case-control Studies	ESP40	0.7
Introduction to Public Health	ESP41	0.7
Methods of Health Services Research	ESP42	0.7
Primary and Secondary Prevention Research	ESP45	0.7
History of Epidemiologic Ideas	ESP53	0.7
Demography of Ageing	ESP59	0.7
Social Epidemiology	ESP61	0.7
Core Curriculum: 22 ECTs		
Study Design	CC01	4.3
Classical Methods for Data-analysis	CC02	5.7
Modern Statistical Methods	EP03	4.3
Public Health Research Methods	HS02	5.7
International Comparison of Health Care Systems	HS03a	1.4
Site Visit to Municipal Health Service Rotterdam	PU03	0.3
Integration Module	PU04	0.3
Advanced short courses: 4.5 ECTs		
Medical Demography	HS04	1.1
Planning and Evaluation of Screening	HS05	1.4
Quality of Life Measurement	HS11	0.9
From Problem to Solution in Public Health	HS18	1.1
Skill courses: 2.65 ECTs		
Introduction to Medical Writing	SC02	1.1
Working with SPSS for Windows	SC04	0.15
Summer Course English	SC08	1.4
Research: 32.5 ECTs		
Development Research Proposal	DRP	2.5
Oral Research Presentation	PRES	1.4
Research Period	RP	28.6

CONFERENCES

Conferences: 2.7 ECTs	Year	ECTs
9° Congreso Internacional de Salud Pública. Facultad Nacional de Salud Pública. Medellín, agosto 19 de 2015	2015	0.3
British Council / Colciencias, visita de intercambio: Facultad de Medicina – Universidad CES & London School of Economics and Political Sciences (LSE) – LSE Health and Social Care. Determinantes sociales de la salud y políticas para reducir inequidades. Universidad CES, Medellín (Colombia)	2015	0.3
Masterclass/Conference: Crisis económicas, mortalidad y expansión de la cobertura del seguro de salud en Colombia. Universidad CES, Medellín (Colombia)	2013	0.3
Presentación de trabajos y experiencias nacionales. Sistema de Información Gerencial para la Salud y la Protección Social. Ministerio de Salud y Protección Social. Bogotá, Colombia	2013	0.3
European Population Conference – EPC 2012: Gender, policies and population. Stockholm, Sweden	2012	0.6
Masterclass/Conference: Las Inequidades de Salud en Colombia: Investigación desde la perspectiva de la escuela anglosajona. Universidad CES, Medellín (Colombia)	2012	0.3
International Conference in Social Determinants of Health. Special issue: Well-being and Social Policy. Inter-American Conference on Social Security (CISS) & Universidad Iberoamericana. CISS Headquarters, Mexico City	2011	0.6
MSc Thesis Defence. Erasmus University MC: Netherlands Institute for Health Sciences (NIHES). Department of Public Health, Rotterdam (The Netherlands)	2011	0.3

RESEARCH STAYS

Stays: 5 ECTs	Year	ECTs
Visitor in London School of Economics and Political Science (LSE), Health and Social Care. Supported by: Vereniging Trustfonds Erasmus Universiteit & Dirección de Investigaciones Universidad CES. Supervisor: Mauricio Avendaño Pabón PhD. London, UK	2012	5

Total:	78.05 ECTs
- **PhD training**	**70.35 ECTs**
- **Conferences:**	**2.70 ECTs**
- **Research stay**	**5.00 ECTs**