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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 (RR_{men} = 2.60, 95% confidence interval [CI]: 2.56, 2.64; RR_{women} = 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.

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; 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 Fig. 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; 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).

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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 Fig. 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.

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).

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 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.

Fig. 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 ($RR_{men} = 2.60$, 95% confidence interval [CI]: 2.56–2.64; $RR_{women} = 2.36$, 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 Fig. 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. Fig. 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

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)	9769	10,616	2.5%	5.3%	5.6	5.0
Chronic lower respiratory diseases (CLRD)	7298	5729	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	6373	7.4%	3.2%	33.1	6.8
Suicide	9399	1929	2.4%	1.0%	10.5	1.9
Homicide	121,983	9966	31.2%	4.9%	124.3	10.0
Other injuries	25,056	4057	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	4200	1861	1.1%	0.9%	4.0	1.9
HIV disease (AIDS)	14,369	3218	3.7%	1.6%	15.4	3.1
Pneumonia	5057	3494	1.3%	1.7%	4.9	3.0
Other infectious diseases	4894	3520	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	9602	13,309	2.5%	6.6%	9.8	14.1
Ill defined causes	5841	2877	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	12,849,341	13,079,674	14.7%	14.0%

[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.

widened over the first half of the period (1998–2003), but remained stable over the second half (2004–2007).

APC estimates in Fig. 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.

Fig. 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 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.

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

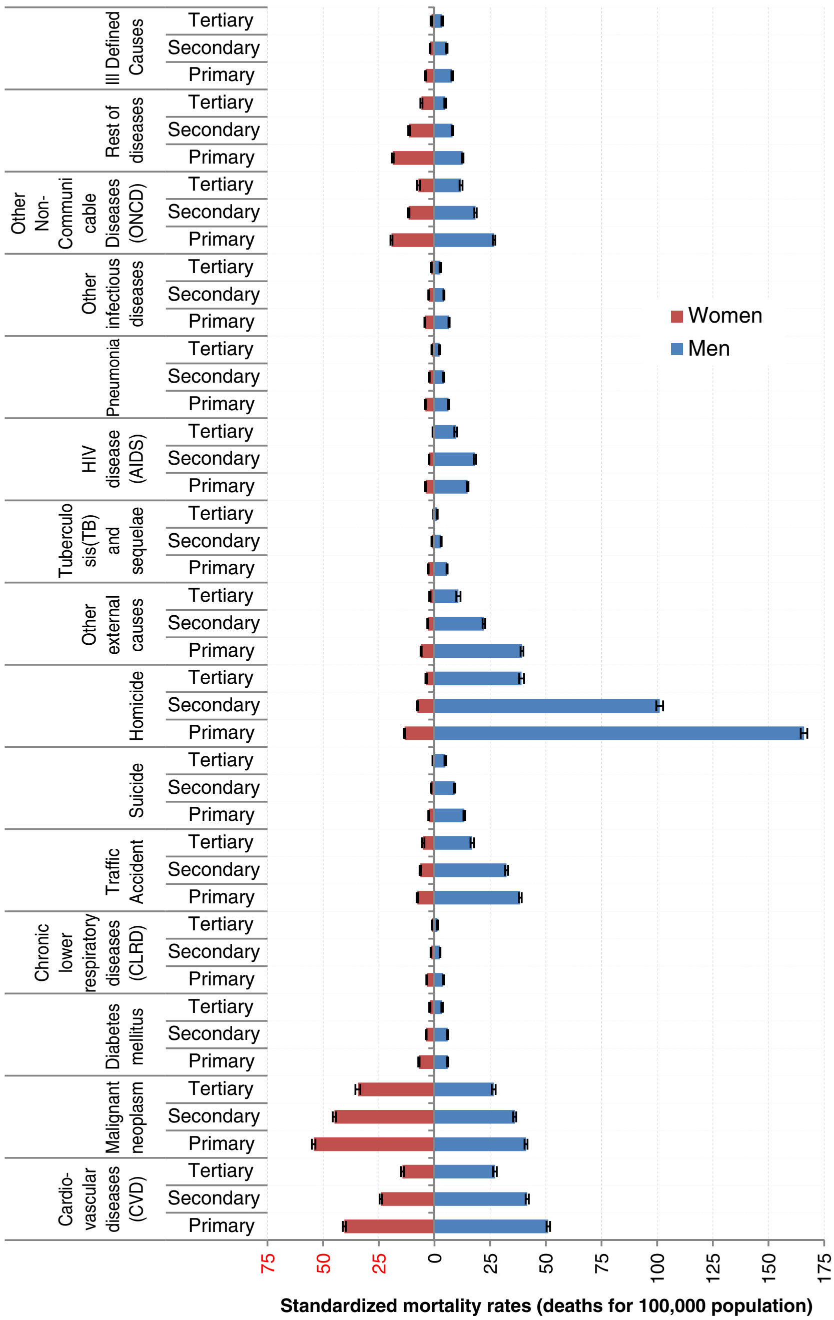

Fig. 1. Age-standardized premature mortality rates per 100,000 populations by educational level, ages 25–64, 1998–2007, Colombia.

men. Homicide rates in Colombia have declined (Acero-Álvarez, 2011; 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; Rodríguez et al., 2003).

Mirroring findings for high-income countries (Fawcett et al., 2005; Huisman et al., 2005; Kunst et al., 1998b; 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).

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	

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; 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; 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; 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 Fig. 4 show age-standardized mortality rates and average years of

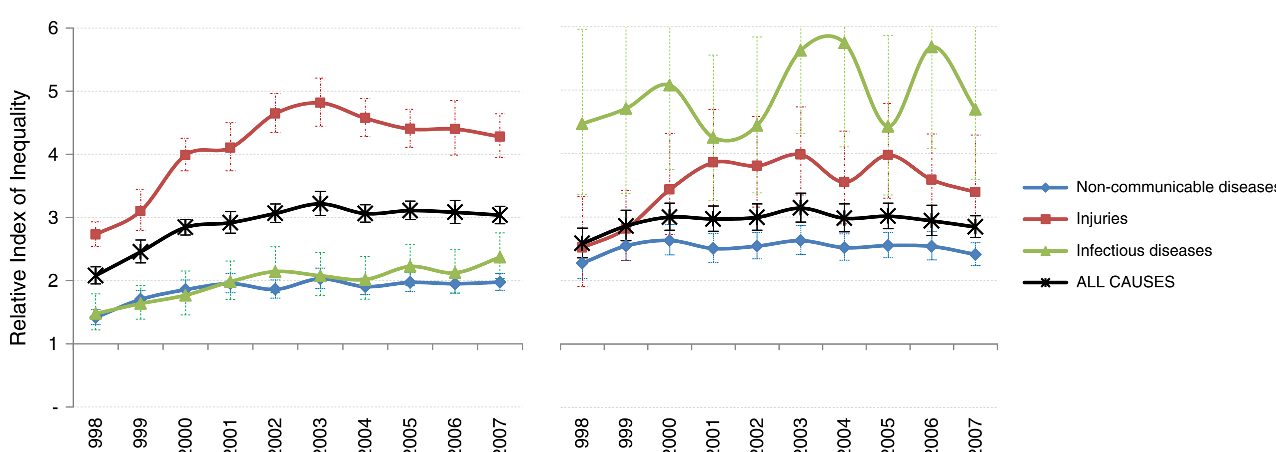

Fig. 2. Trends of the Relative Index of Inequality (RII) of age-standardized premature mortality rates by educational level, ages 25–64, 1998–2007, Colombia.

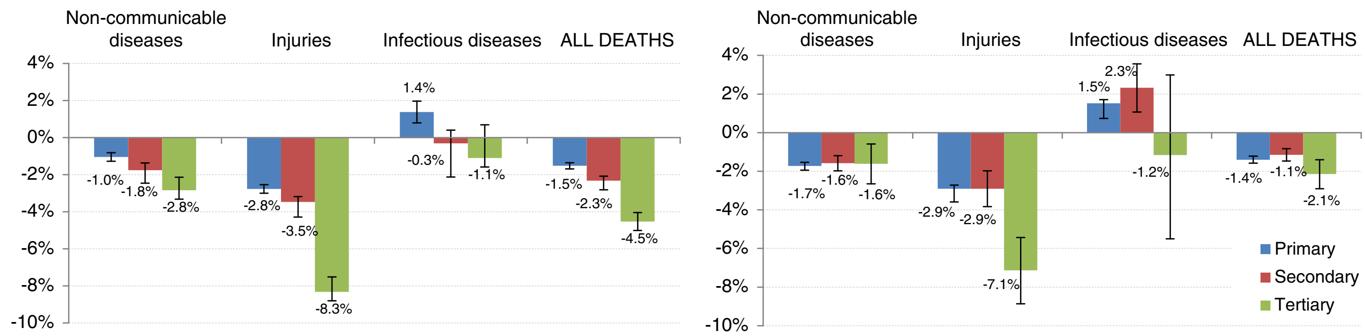

Fig. 3. Annual percentage change (APC) of age-standardized premature mortality rates by educational level, ages 25–64, 1998–2007, Colombia.

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.

Authors' contributions

I. Arroyave was the leading author and developed the article idea, constructed and analyzed the data set, and wrote drafts of the article. A. Burdorf contributed to the 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 analyzed the 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 statement

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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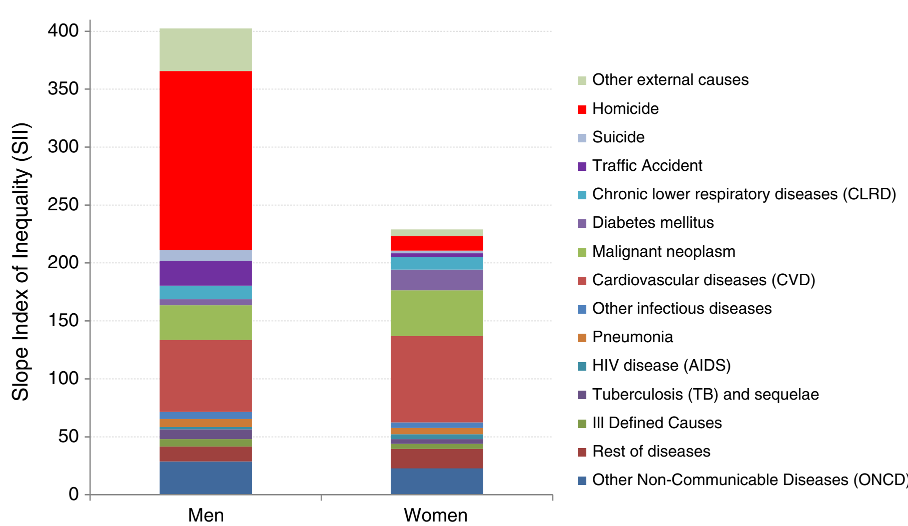

Fig. 4. Slope Index of Inequality (SII) of age-standardized premature mortality rates per 100,000 person-years by educational level, ages 25–64, 1998–2007, Colombia.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ypmed.2014.03.018.

References

Acero-Álvarez, A.D.P., 2011. Descripción del Comportamiento del Homicidio. Colombia, 2010. In: Forensis (Ed.), Datos oficiales sobre la violencia en Colombia en el 2010. Instituto Nacional de Medicina Legal y Ciencias Forenses, Bogota.

Adler, N.E., Newman, K., 2002. Socioeconomic disparities in health: pathways and policies. Health Aff. 21, 60–76.

Ahmad, O.B., Boschi-Pinto, C., Lopez, A.D., Murray, C.J., Lozano, R., Inoue, M., 2001. Age Standardization of Rates: A New WHO Standard, GPE Discussion Paper Series. World Health Organization, Geneva.

Arroyave, I., Cardona, D., Burdorf, A., Avendaño, M., 2013. The impact of increasing health insurance coverage on disparities in mortality: health care reform in Colombia, 1998–2007. Am. J. Public Health e1–e7.

Belon, A.P., Barros, M.B., Marin-Leon, L., 2012. Mortality among adults: gender and socioeconomic differences in a Brazilian city. BMC Public Health 12, 39.

Bonilla Mejía, L., 2010. Demografía, juventud y homicidios en Colombia, 1979–2006. Lect. Econ. 77–102.

Briceño-León, R., Villaveces, A., Concha-Eastman, A., 2008. Understanding the uneven distribution of the incidence of homicide in Latin America. Int. J. Epidemiol. 37, 751–757.

U.S. Census Bureau, 2011. Population Analysis System (PASEX), Population Analysis Spreadsheets, 2.04g ed, Washington DC.

Clegg, L.X., Hankey, B.F., Tiwari, R., Feuer, E.J., Edwards, B.K., 2009. Estimating average annual per cent change in trend analysis. Stat. Med. 28, 3670–3682.

DANE, 2012. Estadisticas Vitales, Informacion DANE. Bases de datos economicas y demograficasDepartamento Administrativo Nacional de Estadistica, Bogota.

Fawcett, J., Blakely, T., Kunst, A., 2005. Are mortality differences and trends by education any better or worse in New Zealand? A comparison study with Norway, Denmark and Finland, 1980–1990s. Eur. J. Epidemiol. 20, 683–691.

Florez, C.E., Méndez, R., 1995. El Nivel del Subregistro de las Defunciones: Colombia 1990. CEDE, Colombia pp. 69–85.

Frenk, J., Frejka, T., Bobadilla, J.L., Stern, C., Lozano, R., Sepúlveda, J., José, M., 1991. La transición epidemiológica en América Latina, Conferencia Internacional de Población. Boletín de la Oficina Sanitaria Panamericana (OSP), Nueva Delhi, pp. 485–496.

Gaviria, A., Medina, C., Mejia, C., 2006. Assessing health reform in Colombia: from theory to practice. J. LACEA Econ. 7, 29–72.

Huisman, M., Kunst, A.E., Bopp, M., Borgan, J.-K., Borrell, C., Costa, G., Deboosere, P., Gadeyne, S., Glickman, M., et al., 2005. Educational inequalities in cause-specific mortality in middle-aged and older men and women in eight western European populations. Lancet 365, 493–500.

IIASA/VID, 2010. IVEP-1.0 (IIASA/VID education database). International Institute of Applied System Analysis (IIASA); Vienna Institute of Demography of the Austrian Academy of Sciences (VID), Viena.

Kunst, A.E., Groenhof, F., Borgan, J., Costa, G., Desplanques, G., Faggiano, F., Hemström, O., Martikainen, P., Vågerö, D., et al., 1998a. Socio-economic inequalities in mortality. Methodological problems illustrated with three examples from Europe. Rev. Epidemiol. Sante Publique 46, 467–479.

Kunst, A.E., Leon, D.A., Groenhof, F., Mackenbach, J.P., 1998b. Occupational class and cause specific mortality in middle aged men in 11 European countries: comparison of population based studies. BMJ 316, 1636–1642.

Mackenbach, J.P., Kunst, A.E., 1997. Measuring the magnitude of socio-economic inequalities in health: an overview of available measures illustrated with two examples from Europe. Soc. Sci. Med. 44, 757–771.

Males, M.A., 2009. Poverty as a determinant of young drivers' fatal crash risks. J. Saf. Res. 40, 443–448.

Mayorga, C., 2004. Tendencia de la mortalidad y sus determinantes como parte de la transición epidemiológica en Colombia. Revista Gerencia y Políticas de Salud.

Murray, C.J.L., Lopez, A.D., 1997. Mortality by cause for eight regions of the world: Global Burden of Disease Study. Lancet 349, 1269–1276.

Patiño-Villada, F.A., Arango-Vélez, E.F., Quintero-Velásquez, M.A., Arenas-Sosa, M.M., 2011. Factores de riesgo cardiovascular en una población urbana de Colombia. Rev. Salud Pública 13, 433–445.

Raghunathan, T., Lepkowski, J., Van Hoewyk, J., Solenberger, P., 2001. A multivariate technique for multiply imputing missing values using a sequence of regression models. Surv. Methodol. 27, 85–95.

Rodríguez, D.Y., Fernández, F.J., Velásquez, H.A., 2003. Road traffic injuries in Colombia. Inj. Control. Saf. Promot. 10, 29–35.

Rodríguez-García, J., 2007. Desigualdades socioeconómicas entre departmentos y su asociación con indicadores de mortalidad en Colombia en 2000. Rev. Panam. Salud Pública 21, 111–124.

SAS Institute, I., 2008. The MIANALYZE Procedure, in: Inc., S.I. (Ed.), User's Guide SAS/STAT® 9.2, Version 8 ed. SAS Institute Inc., Cary, NC, pp. 201-33.

Singh, A.R., Singh, S.A., 2008. Diseases of poverty and lifestyle, well-being and human development. Mens. Sana Monogr. 6, 187–225.

Smith, P., Mossialos, E., Papanicolas, I., Leatherman, S., 2009. Performance Measurement for Health System Improvement: Experiences, Challenges and Prospects. Cambridge University Press, Cambridge.

Storr, C.L., Cheng, H., Posada-Villa, J., Aguilar-Gaxiola, S., Anthony, J.C., 2008. Adult smokers in Colombia: who isn't giving it up? Addict. Behav. 33, 412–421.

UNDP, 2010. Acting on the future: breaking the intergenerational transmission of inequality, Regional Human Development Report for Latin America and the Caribbean1st ed. United Nations Development Programme (UNDP), San José, C.R. p. 208 (pp.).

Wong, M.D., Shapiro, M.F., Boscardin, W.J., Ettner, S.L., 2002. Contribution of major diseases to disparities in mortality. N. Engl. J. Med. 347, 1585–1592.

World Bank, 2011. World Development Indicators (WDI), World Bank Data (WBD). World Bank.

World Health Organization, 2008. Closing the gap in a generation: health equity through action on the social determinants of health. Final Report of the Commission on Social Determinants of Health, Final Report of the Commission on Social Determinants of Health. World Health Organization, Geneve.

World Health Organization, 2012. Disease and Injury Regional Estimates: Cause-specific Mortality: Regional Estimates for 2008. World Health Organization.