Economic Costs Analysis of the Avoidable Mortality in Colombia 1998–2011

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Abstract

Objective: To estimate the economic costs of avoidable mortality (AM) in Colombia during the period 1998 to 2011, with the human capital perspective valuing the productivity lost. Methods: The information of cases of avoidable death was identified from the Colombian official general mortality database, and we estimated the potential productivity years of life lost, assuming a productive life span between 18 years and 57 years and 18 years and 62 years in women and men, respectively. Two scenarios were built: lower loss with the minimum wage, and higher loss with the per capita gross domestic product. Total costs for the period were reported by sex and health event. Average cost per 1000 people was also estimated. All costs were adjusted and reported in 2012 US dollars. Results: Sixty-eight percent of the total AM in Colombia during the period 1998 to 2011 occurred during or before the productivity age. The total AM costs were estimated to range between US $80.5 million and US $150.4 million. Higher costs of AM were incurred in men. Events from the injuries group caused the higher productivity lost. Conclusions: All the avoidable deaths in Colombia have a huge economic impact from the productivity lost perspective, equivalent to between 1.6% and 3.0% of the annual gross domestic product. The cost analyses in public health are an additional input for decision making and prioritization of intervention. Keywords: Colombia, cost and cost-analysis, cost of illness, human capital approach, mortality.

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Introduction

Traditional indicators to measure population health changes include general and infant mortality and life expectancy. However, not all deaths occur according to the health expectancy [1]. Premature mortality analysis helps in establishing public health priorities [2] and in evaluating the economic consequences in addition to the burden of disease [3].

The concept of avoidable mortality (AM) was initially introduced by Rutstein et al. [4] in the mid-1970s, referring to events that should not occur in the presence of timely and effective health care. AM has been considered an indicator of the impact of public health interventions [5]. AM not only considers the life expectancy but also includes a judgment over events that potentially should not occur if there is health promotion and prevention and proper treatment, and public policies are implemented [6]. Several lists of preventable or amenable causes of death (CoD) have been published, each of them based on a different conceptualization of AM [4,7,8].

It is possible to economically value the impact of mortality in a population through the potential productivity years of life lost (PPYLL), which evaluate the loss to a society in terms of its individuals’ productive capacity in relation to the working-age population, considering the wages unearned because of the premature death [9]. There are two methods to estimate productivity costs: the human capital approach and the friction costs method [10–13]. The human capital approach is a traditional approach for measuring and valuating production that is lost because of temporary work absences, reduced productivity at work, and permanent work absence from morbidity or premature mortality. It assumes no unemployment and captures all lost productivity due to disease mortality by assuming that individuals who died prematurely would have worked full time until the end of their working lives [12,14]. In contrast, the friction costs method captures the lost productivity only until a worker would likely be replaced by someone [14]. We chose the human capital approach, which is usually used to evaluate costs of illness [12,14–16].

Internationally, there are studies that estimate productivity losses due to premature mortality [14,16–18] but not the cost of AM. In Colombia, some mortality costs analysis had been carried out on a subnational scale [9,19,20]; however, there has been no national analysis estimating the costs of AM. The objective of the present analysis was to estimate using the human capital approach the economic costs of avoidable deaths that occurred in Colombia during the period 1998 to 2011.

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**Methods**

A cost-analysis of AM in Colombia was carried out. For the classification of AM, the list of International Classification of Disease, Tenth Revision causes defined in the report of the Colombian National Health Observatory [6] was used. Concepts and lists of AM published between 1978 and 2010 were taken into account to construct the Colombian list [6], including international [7,8] and Latin American lists [21-23]. To account for the fact that the effectiveness of (primary and secondary) prevention and treatment of illnesses substantially decreases after a particular age, deaths only before a specified age (75 years) [24] were considered avoidable.

The mortality database for the period 1998 to 2011 was provided by the Colombian National Institute of Statistics (Departamento Nacional de Estadísticas). We selected the avoidable death cases according to the International Classification of Disease, Tenth Revision, code for the basic CoD that occurred before the age of retirement (57 years in women and 62 years in men) [25,26]. For each avoidable death, the total PPYLLs were estimated. Deaths that occurred between ages 0 and 17 years were economically valued as equal to those that occurred in age 18 years.

$$PPYLL_i = \begin{cases} a_i - 18, & \text{if } a_d \leq 18, \\ a_i - a_d, & \text{if } a_d > 18 \end{cases}$$

where $PPYLL_i$ is potential productivity years of life lost for individual $i$, $a_i$ is the age of retirement, and $a_d$ is the age of death.

The PPYLLs were multiplied by their cost in 2012 US dollars. Two scenarios were considered: the best-case scenario (lower loss) with a cost per PPYLL equivalent to the 2012 annual minimum wage (US $4326.6) [27] and the worst-case scenario (higher loss) with a cost per PPYLL equivalent to the 2012 per capita gross domestic product (GDP) (US $8080.3) [28], an indicator of the average productivity in Colombia.

$$C_{PPYLLi} = \sum_{j} C_{PPYLLij}$$

where $C_{PPYLLi}$ is the cost of the total PPYLL for individual $i$, $a_d$ is the age of death, $a_i$ is the age of retirement, and $C_{PPYLLij}$ is the cost of the PPYLL for individual $i$ in year $j$.

All costs were reported in 2012 US dollars (US $1 = 1768.23 Colombia pesos [COP]) [29]. The choice of the appropriate discount rate in analyses of productivity costs is controversial and can be varied [14]. An annual discount rate of 3% was used to adjust the costs of all periods. This choice was made considering the fact that in the particular case of economic evaluations of health technologies in Colombia, most studies use a discount rate of 3% [30], similar to the rate in the international literature [31]. We conducted a sensitivity analysis using discount rates of 0% and 5% to include the uncertainty in our estimations. Fig. 1 reports annual salaries applied according to the year of loss. A half-cycle adjustment was implemented to avoid overestimation of the economic loss, assuming that all deaths occur on June 30 each year.

Classification of events in three main groups—communicable, maternal, neonatal, and nutritional disorders; noncommunicable diseases; and injuries—was performed according to the 2010 Global Burden of Disease analysis from the Institute for Health Metrics and Measurement at the University of Washington [32]. The classification also includes 21 groups and 236 individual events. For the present analysis, injuries of undetermined intention were included as an additional subgroup in the injuries group. The results were presented by year, sex, disease, and department (equivalent to states) of residence. Annual cost trends were assessed with a linear regression analysis, reporting the $P$ value of the slope coefficient. All data were managed in Microsoft Excel 2013 (Microsoft) and Stata 12 (Stata Corporation, College Station, TX).

$\text{AMW: annual minimum wage}$

$\text{pcGDP: per capita Gross Domestic Product}$

**Fig. 1** – Low and upper limits for annual salaries according to the year of loss in 2012 US dollars. AMW, annual minimum wage; pcGDP, per capita gross domestic product.
Results

Of the total 1,427,535 avoidable deaths in Colombia during the period 1998 to 2011, 68% (966,113) occurred during or before the working age. Total PPYLLs were 26,276,842, with an annual average of 44.03 PPYLLs per 1000 people (Table 1). Total cost of AM during the period was estimated to be between US $80.5 billion and US $150.4 billion in the best-case and worst-case scenarios, respectively (Table 1), with a trend of annual decrease (P < 0.001). The cost in men was estimated to be US $62.5 billion, with an annual average cost of US $212,240 to US $396,375 per 1000 men. The cost in women was US $18.0 billion (annual average cost US $59,493–111,108 per 1000 women). The ratio of costs between men and women for all years was about threefold (Fig. 2).

Ten departments (Colombian states) with the highest AM costs accounting for 67% of the total costs were Antioquia (US $3.2 billion to US $5.9 billion), Atlántico (US $3.2 billion to US $5.9 billion), Santander (US $3.1 billion to US $5.8 billion), Norte de Santander (US $3.0 billion to US $5.6 billion), Cauca (US $2.5 billion to US $4.6 billion), Tolima (US $2.5 billion to US $4.6 billion), and Bolívar (US $2.5 billion to US $4.6 billion), whereas Guainía, Vaupés, Archipiélago de San Andrés, Providencia y Santa Catalina, Amazonas, and Vichada reported the lowest total costs.

The highest average cost per 1000 population for AM was reported in Caquetá (US $226,036–422,140), Guaviare (US $220,290–411,408), Arauca (US $211,558–395,101), Meta (US $189,117–353,191), and Valle del Cauca (US $185,459–346,359), whereas the lowest average cost was reported in Archipiélago de San Andrés, Providencia y Santa Catalina, Sucre, Bogotá, Bolívar, and Córdoba.

Costs by Event

By group of CoD, the highest costs corresponded to injuries (61% of total costs), communicable, maternal, neonatal, and

<table>
<thead>
<tr>
<th>Year</th>
<th>Avoidable death in working age</th>
<th>Costs best-case scenario (2012 USD)</th>
<th>Costs worst-case scenario (2012 USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>73,122</td>
<td>7,451,538,176</td>
<td>13,916,321,809</td>
</tr>
<tr>
<td>1999</td>
<td>76,604</td>
<td>7,537,820,858</td>
<td>14,077,461,347</td>
</tr>
<tr>
<td>2000</td>
<td>79,541</td>
<td>7,665,117,106</td>
<td>14,315,197,058</td>
</tr>
<tr>
<td>2001</td>
<td>79,844</td>
<td>7,491,099,668</td>
<td>13,990,205,996</td>
</tr>
<tr>
<td>2002</td>
<td>78,853</td>
<td>7,232,923,523</td>
<td>13,508,042,058</td>
</tr>
<tr>
<td>2003</td>
<td>72,261</td>
<td>6,255,904,337</td>
<td>11,683,383,302</td>
</tr>
<tr>
<td>2004</td>
<td>68,988</td>
<td>5,684,022,222</td>
<td>10,615,349,469</td>
</tr>
<tr>
<td>2005</td>
<td>65,020</td>
<td>5,115,898,248</td>
<td>9,554,334,137</td>
</tr>
<tr>
<td>2006</td>
<td>64,625</td>
<td>4,888,275,812</td>
<td>9,129,231,840</td>
</tr>
<tr>
<td>2007</td>
<td>63,421</td>
<td>4,662,786,187</td>
<td>8,708,112,523</td>
</tr>
<tr>
<td>2008</td>
<td>62,203</td>
<td>4,384,487,308</td>
<td>8,188,367,971</td>
</tr>
<tr>
<td>2009</td>
<td>63,203</td>
<td>4,402,191,285</td>
<td>8,221,431,515</td>
</tr>
<tr>
<td>2010</td>
<td>60,834</td>
<td>4,054,683,048</td>
<td>7,572,433,067</td>
</tr>
<tr>
<td>2011</td>
<td>57,594</td>
<td>3,689,704,165</td>
<td>6,890,806,866</td>
</tr>
<tr>
<td>Total</td>
<td>966,113</td>
<td>80,516,451,943</td>
<td>150,370,678,958</td>
</tr>
</tbody>
</table>

Fig. 2 – Avoidable mortality costs in working age by year and sex: Colombia (1998–2011) (in thousands of 2012 USD).
nutritional disorders (20%), and noncommunicable diseases (19%). Trends were similar in the three groups \((P \leq 0.001)\), rising up to 2002 and decreasing thereafter; however, injuries reported a peak in 2009. During the first 10 years, costs of communicable, maternal, neonatal, and nutritional disorders exceeded the costs of noncommunicable diseases, but in the last 4 years the relationship was reversed. Costs of noncommunicable diseases showed a 64% decrease during the period, whereas injuries and communicable, maternal, neonatal, and nutritional disorders showed decrements of 49% and 41%, respectively.

In the second aggregation level for CoD (22 subgroups), costs for intentional injuries (self-harm and interpersonal violence) were highest (43% of the total), followed by transport injuries (9%) and neonatal disorders (8%). Mental and behavioral disorders and neglected tropical diseases and malaria were the groups with a lower loss (<1% of the total). Musculoskeletal disorders and non–Global Burden of Disease groups do not include avoidable events (Figs. 3 and 4). In men, 51% of the AM costs correspond to intentional injuries, followed by transport injuries (10%), whereas in women the main causes of AM costs were intentional injuries (16%), neonatal disorders (11%), and diarrhea, lower respiratory tract infections, meningitis, and other common infection diseases (10%).

In the analysis with the maximum disaggregation (236 CoD), among the four highest cost causes, three were injuries: assault by firearm (US $26.5 billion to US $49.4 billion, 33% of total costs), assault by sharp object (US $3.8 billion to US $7.2 billion, 5%), and self-harm (US $2.8 billion to US $5.3 billion, 4%). Preterm birth complications was the third costly CoD (US $3.2 billion to US $5.9 billion, 4%). In the fifth position appeared other lower respiratory tract infections (US $2.8 billion to US $5.2 billion, 3%), followed by ischemic heart disease (US $2.6 billion to US $4.8 billion, 3%), motorized vehicle with two wheels (US $2.3 billion to US $4.4 billion, 3%), injuries of undetermined intention (US $2.2 billion to US $4.2 billion, 3%), HIV disease resulting in other specified or unspecified diseases (US $2.2 billion to US $4.1 billion, 3%), and pedestrian injury by road vehicle (US $1.8 billion to US $3.3 billion, 2%).

In men, disaggregating the top 10 causes showed that 49% of the costs were concentrated in assault by firearm (40%), assault by sharp object (6%), and self-harm (3%). In women, 30% of the costs were due to assault by firearm (9%), preterm birth complications (7%), other lower respiratory tract infections (6%), congenital heart anomalies (4%), and self-harm (4%). In the later population group, two neoplasms—cervical and breast cancers, each one with 3% of the total costs—were also present.
In the sensitivity analysis, AM costs were US $63.7 billion and US $118.9 billion in the best-case and worst-case scenarios, respectively, using a discount rate of 5% and US $124.9 billion and US $233.2 billion in the best-case and worst-case scenarios, respectively, using no discount rate.

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Discussion

This study describes the economic impact of AM in Colombia and estimates the extent of potential losses due to avoidable death. There are several analyses of mortality costs on the subnational level and for some events [9,19,20,33]; also, there are international studies, but none reports results of AM for Colombia [14]. The present study is the first national analysis of the costs of AM for Colombia. During the period 1998 to 2011, the total productivity losses in the labor market due to AM were approximately between US $80.5 billion and US $150.4 billion (at a 3% discount rate). Annually, the loss was between US $5.8 billion and US $10.7 billion, equivalent to between 1.6% and 3.0% of the GDP. There is a decreasing trend in the costs of AM since 2003. Differences also exist among departments; for example, Caquetá, Guaviare, Arauca, Meta, and Valle del Cauca had an average cost of more than US $185,000 per 1000 in the best-case scenario.

The costs of AM in Colombia were mainly for events from the injuries group (US $49.0 billion to US $91.5 billion), whereas communicable, maternal, neonatal, and nutritional disorders and noncommunicable diseases report similar costs (between US $15 billion and US $30 billion each). During the period 2008 to 2011, costs of noncommunicable diseases started to be more relevant than costs of communicable, maternal, neonatal, and nutritional disorders. This could be explained largely by four behavioral risk factors associated with economic transition, rapid urbanization, and lifestyles: tobacco consumption, unhealthy diets, physical inactivity, and harmful alcohol consumption, especially in lower-and middle-income countries such as Colombia [34].

The annual impact of injuries in the Colombian population corresponds to between 1.0% and 1.8% of the GDP. Other studies have also shown the importance of injuries in the total mortality costs [33]. In our analysis, 33% of the total costs were due to assault by firearm. Costs in men were 3.4 times higher than in women, due to more and early avoidable deaths occurring in men. In this group, the first four CoD were assault by firearm, assault by sharp object, self-harm, and injuries by motorized vehicle with two wheels. Homicide is a complex phenomenon in which behavioral, structural, and cultural elements converge, which does not allow explaining so easily the reasons why it occurs [35]. In women, the first CoD corresponds to assault by firearm, followed by perinatal complications, lower respiratory tract infections, and congenital heart abnormalities, but it should also be noted that cervical and breast cancers were among the top 10 costly CoD in women.

Other analyses in Colombia have shown that in Cartagena city during the period 2000 to 2005, the total cost of avoidable deaths, according to the Taucher [36] list, was estimated to be US$ 310.3 million to US$ 6,323.3 billion in 2005, adjusting for
unemployment rates [33]. For all cases of AIDS/HIV, also in Cartagena, during the period 1995 to 2000, the cost was estimated to be US $15.9 million in 2000 [9]. Other cost analyses of total mortality have been done for two Colombian regions. In the Colombian Amazonia, the total mortality cost for the period 2004 to 2008 was estimated to be COP 2380 billion in 2008 [20], while for the same period in the Caribbean region, the cost was estimated to be US $8.5 billion in 2008 [19]. The cost analysis of premature mortality has also been carried out for other countries [12,14,16,18,37]. Thus, this study is a contribution to the economic impact studies of AM.

In this analysis, we obtained a huge difference in costs by sex using the human capital approach, with higher costs in men, considering the less productive period and early retirement age in women, according to the Colombian labor market. Given this, we conducted an analysis considering the same age in men and women (up to 62 years) and found that the total costs in women changed from US $18.0 billion to US $21.8 billion in the best-case scenario and US $33.6 billion to US $40.6 billion in the worst-case scenario, providing evidence that higher costs in men are not only due to retirement age but also because men die more and younger than women.

This analysis has limitations. First, there is a possibility of misclassification of avoidable deaths that required an in-depth analysis. According to the classification of the Colombian National Health Observatory, an avoidable death corresponds to that death that potentially should not occur in the presence of the corrected intervention of the health system or the availability of public policies in place. Second, the use of the human capital approach for the economic evaluation tends to give more value to loss in population during the working age. In fact, some authors argue that this method generates an inferior limit to the real value of a person’s life [38], but we need an additional approach that does not consider human beings only as production instruments [39]. In this sense, it will be a conservative analysis of the costs of AM in Colombia. However, some authors argue that the human capital approach could overestimate indirect costs because the production loss due to premature death can be replaced by unemployed people [40] and recommend the use of analyses targeted on friction costs or another kind of model [10]. Our analysis considered neither unemployment rates nor friction costs because their use implies evaluating differential costs among departments and sex, valuing less the loss in departments with bigger problems in their labor market (with higher unemployment rates). To produce a comparable estimation among departments and sex, those adjustments were not included, and the same annual wages for the entire population for low and high limits were assumed. The third limitation was related to the possible underreporting of mortality events documented in other studies for Colombia [20]. This aspect could increase the costs reported here in a differential way among departments and because of this underreporting rates also vary among departments. The last limitation is that AM analysis evaluates the final outcome of the problem (i.e., avoidable deaths correspond to avoidable diseases), but it forgets conditions that are not lethal, events that also cause economic costs to the society, and the AM costs exclude the treatment costs during the disease before that condition causes death.

Conclusions

The costs of AM in Colombia, considering only the productivity loss, are very significant, especially the cost due to injuries. Interventions to reduce the occurrence of these events could avoid the productivity loss, in addition to the reduction in treatment and indirect costs before death. Although controversies over the economical valuation of life are present, this approach of analysis presents potentially useful results in the prioritization of public health interventions taking into account the exposed limitations.

The economic analysis in public health is an additional input in the decision-making process, generally presenting a monetary valuing of a health phenomena with many perspectives for the interpretation. In this case, we based our analysis on the fact that premature death interrupts the productive life because of a potentially avoidable cause, where the human capital perspective can be applicable, estimating the wages unearned, to the population level. This analysis could be used in cost-benefit analysis for the selection of potential interventions on the basis of economic criteria.

Differential profiles between men and women require intervention targeted at the most important problem in each group. In men, injuries have more economical impact, whereas in women the group of communicable, maternal, neonatal, and nutritional disorders and noncommunicable diseases including cervical and breast cancers are very important.

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Supplementary Materials

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R E F E R E N C E S


