More than One Hundred Years of Improvements in Living Standards: the Case of Colombia

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Abstract

This paper examines the long-term trends observed in the standard of living of the Colombian population during the past one hundred years, with special attention on health. We construct a historical index of human development for Colombia (HIHDC) for the 19th and 20th centuries by gender. We find that there were no major advances in living standards during the nineteenth century due to the stagnation of Colombia's GDP per capita as a result of the lack of dynamism in exports. On the contrary, significant advances in all components of the HIHDC were seen in the twentieth century, especially those for women. During the first half of the century, improvements in the quality of life were mainly driven by a higher per capita income, while improvements after the 1950s were driven by greater public investment, for example, in education and health. Next, we analyze health achievements, considering health is one of the components of the HIHDC that has been less studied in the Colombian economic history literature. We construct a new dataset using statistics reported by the Colombian government, which included annual information on the main diseases and causes of mortality during the period of 1916-2014 disaggregated by territorial units. The data show that the percentage of deaths from tuberculosis, pneumonia, and gastrointestinal diseases decreased significantly throughout the century. On the contrary, deaths caused by cancer and heart diseases have increased considerably in recent decades. Results from difference-in-difference models show that the decline in the total mortality rate and in the mortality rate for waterborne diseases was largely related with the expansion in the provision of public goods, namely aqueducts and sewerage services.

Keywords: Human Development, Mortality, Waterborne Diseases, Sewerage, Aqueducts, Public Health, Difference in Difference.

JEL classifications: I00; I15; I18; N36; O10

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Más de cien años de Avances en el nivel de vida:
el caso de Colombia

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Resumen

Este trabajo examina las tendencias a largo plazo observadas en el nivel de vida de la población colombiana durante los últimos cien años, con especial atención en la salud. Construimos un índice histórico de desarrollo humano para Colombia (IHDHC) para los siglos XIX y XX por género. Encontramos que no hubo avances importantes en los niveles de vida durante el siglo XIX debido principalmente al estancamiento del PIB per cápita de Colombia. Por el contrario, se observaron avances significativos en todos los componentes del IHDHC en el siglo XX, especialmente los de las mujeres. Durante la primera mitad del siglo, las mejoras en la calidad de vida se debieron principalmente a un mayor ingreso per cápita, mientras que las mejoras posteriores a la década de 1950 se debieron a una mayor inversión pública, por ejemplo, en educación y salud. A continuación, analizamos los logros de salud, considerando que la salud es uno de los componentes del IHDHC que ha sido menos estudiado en la literatura de historia económica colombiana. Construimos un nuevo conjunto de datos utilizando estadísticas reportadas por el gobierno colombiano, que incluyeron información anual sobre las principales enfermedades y causas de mortalidad durante el período de 1916-2014 desagregadas por departamentos. Los datos muestran que el porcentaje de muertes por tuberculosis, neumonía y enfermedades gastrointestinales disminuyó significativamente a lo largo del siglo. Por el contrario, las muertes causadas por cáncer y enfermedades del corazón han aumentado considerablemente en las últimas décadas. Los resultados de los modelos de diferencia en diferencias muestran que la disminución en la tasa de mortalidad total y en la tasa de mortalidad por enfermedades transmitidas por el agua estuvo relacionada en gran medida con la expansión en la provisión de servicios de acueductos y alcantarillado.

Palabras Clave: Desarrollo Humano, Mortalidad, Enfermedades, Acueducto, Alcantarillado,

Clasificación JEL: I00; I15; I18; N36; O10

I. Introduction

Colombia's nineteenth century demographic regime may be characterized as Malthusian, with low levels of per capita income, low and constant levels of population growth, very high mortality and fertility rates, and very low life expectancy and human capital accumulation. In general, the century was characterized by a very poor economic performance and low standards of living in a mainly rural and agrarian society.

The country entered the twentieth century as one of the poorest countries in the world: Colombian per capita exports were, together with those of Haiti and Honduras, the lowest in Latin America.[2] In addition, sanitary conditions at the beginning of the century were deplorable. For example, in Bogotá, the capital city of the country, the streets were littered with waste and rubbish, and public utilities were almost non-existent. Garbage invaded the streets, and citizens mostly lived in unhygienic conditions causing epidemics and infections in the city (López, 2011). However, throughout the twentieth century, Colombia experienced a very rapid decline in mortality rates, which dropped from roughly 23.4 deaths per thousand inhabitants in 1905 to about 5.5 in 2000. In addition, the infant mortality rate fell from 186 deaths per thousand births at the beginning of the century to 27 by the end of the twentieth century. The percentage of deaths from tuberculosis, pneumonia, and gastrointestinal diseases, which were the main causes of infant deaths during the first decades, decreased significantly throughout the century. On the other hand, the fertility rate declined from about 6.4 children for every woman of reproductive age in 1905 to about 2.5 by the end of the twentieth century. These demographic and epidemiological transformations were accompanied by an important progress in the standard of living of the Colombian population, as a result of improvements in public health and sanitary conditions, better nutrition, and higher per capita income. As a consequence, life expectancy at birth in the country increased from 39.5 years in 1905 to 73 years in 2000.

One of our central hypotheses is that, to a significant degree, the decline in mortality rates was caused by improvements in the provision of public goods, especially regarding sanitary conditions, i.e. sewerage systems and aqueducts. In this sense, this paper provides a comprehensive long-run perspective of well-being in Colombia, covering more than one hundred years, with special attention to the case of health. Particularly, we construct a historical index of human development (HIHDC) for Colombia by gender. We find that there were no major advances in the index during the nineteenth century due to the stagnation of Colombia's GDP per capita resulting from the lack of dynamism of

[2] Bulmer-Thomas, V. (1994), p. 69.

exports per capita. On the contrary, all HIHDC components exhibited significant advances during the twentieth century, especially those for women. Next, we focus on the analysis of health achievements that have taken place in the last one hundred years, since health is one of the components of the HIHDC that has been less studied by the Colombian economic history literature. To this end, we construct a new dataset using statistics reported by the Colombian government, which included annual information on the main diseases and causes of mortality during the period 1916-2014 disaggregated by departments (the main subnational territorial units). We test econometrically whether the provision of public services has an effect on the reduction in mortality rates. Results from difference-in-difference models show that the decline in mortality rates and in the prevalence of some waterborne diseases was highly related with the expansion of aqueducts and sewerage services.

The rest of the paper is organized as follows: first, we discuss related literature, and then we calculate and explain the evolution of the Colombian historical index of human development. Next, we present the data, the empirical strategy, and the results of the estimation of the relation between the advances in sewerage systems and aqueducts and the decline in waterborne diseases and total mortality. Finally, in the last section we present some conclusions.

II. Related Literature

During recent years, economic literature has placed much emphasis in understanding long run trends in economic growth and in the standard of living (Maddison, 2001; Allen, Bengtsson and Dribe, 2005; Deaton, 2013; van Zanden, J.L., *et al.* 2014; Gordon, 2016; Lindert and Williamson, 2016; and Sala i Martin, 2016). One of the most important achievements in human well-being is the unprecedented decline in mortality rates, which led to an exceptional increase in life expectancy during the twentieth century. The reasons for the remarkable decline in mortality that started in Europe in the eighteenth century and continued during the nineteenth century have been studied extensively by the economic history literature.[3] Nevertheless, the decline in mortality in Latin America started later on, around the 1940s, and has been less studied in the literature.

There is a long-standing debate in the literature about the determinants of health achievements (Cutler, Deaton, and Lleras-Muney, 2006). For example, Preston (1975) argues that the reduction of mortality was not related to income increase, but to improvements in technology, such as medical knowledge. More recently, Easterlin (1999) claims that new disease control techniques (based on advancements in

[3] For example, see Cutler, Deaton, and Lleras-Muney (2006).

the knowledge about diseases) were the main source of improved life expectancy, rather than economic growth. In this case, public intervention was crucial for implementing these new methods. On the other hand, McKewon (1976) and Fogel (1986) argue that health improvements were due to economic growth, mainly through access to better nutrition. However, Soares (2007) concludes for a sample of both developed and developing countries that between 1960 and 2000 the gains in life expectancy were largely independent from improvements in income and nutrition.

Recent contributions have highlighted other key factors such as the provision of public goods (e.g. expansion of public water and sewerage provision, and water chlorination) and adoption of health technology. For example, Cutler and Miller (2005) find that there is a causal influence of clean-water technologies on mortality in 13 cities in the United States during the early twentieth century. In particular, they found that in major American cities almost 50% of total mortality reductions, 75% of infant mortality declines, and nearly 66% of child mortality decreases were due to clean water technologies. Similarly, Ferrie and Troesken (2008) estimate that 30%-50% of the reduction in the crude death rate in Chicago between 1850 and 1925 can be attributed to water purification measures. Alsan and Goldin (2015) analyze the decline in child mortality in the Greater Boston area during 1880-1920, period in which the authorities developed a sewerage and water district in the area. They find that the two implementations were complementary and together accounted for nearly 33% of the reduction on child mortality during this period. For the case of Swedish cities, Önnerfors (2015) examines if the implementation of clean-water technologies affected mortality between 1885 and 1925. The author concludes that the decline in mortality in the cities was influenced by many omitted variables besides clean-water technology. Thus, it was not possible to provide a consistent estimate of the magnitude of the effect of clean-water technologies on mortality in Swedish cities during the period under analysis. Finally, Knutsson (2017) analyze how technologies for cleaning and distributing water affected urban mortality in Sweden. The author finds large benefits for the general population of having clean, in-house water, reducing mortality in Stockholm during the 1860s.

The present paper contributes to this literature by examining the factors that explain the reduction of mortality in Colombia, an emerging economy, where studies are scarcer. In particular, we analyze if public health intervention in the form of improvements in the provision of water and sewerage systems has had an effect on mortality in the Colombian departments in the twentieth century. Understanding this relationship in developing countries is crucial from a historical perspective because emerging economies tend to have worse health outcomes and to adapt to—rather than generate—new medical technology. We intend to explain that the improvements in sanitary conditions have led to mortality declines in Colombia, as the literature has found for the advanced economies.

III. Colombian's Historical Index of Human Development (HIHDC)

One of our purposes is to examine how the living standards of the Colombian population have evolved over time. A historical index of human development for Colombia (HIHDC) can provide a comprehensive long-run perspective of the population's well-being.[4] Following Prados de la Escosura (2014 and 2015), we calculate the HIHDC over more than one hundred fifty years. We contribute to the literature by calculating the HIHDC for a long period of time by gender.[5]

The index comprises three main dimensions: education, income, and health.[6] Regarding education, we use data on primary education coverage for men and women during the nineteenth and twentieth centuries.[7] In addition, for the twentieth century we also consider information on higher education by gender.[8] For income, we use GDP per capita Geary–Khamis (GK) international constant dollars,[9] and for health we use data on life expectancy at birth by gender.[10]

Graph 1 depicts the evolution of the HIHDC over more than one hundred fifty years. There were no major advances in the index during the nineteenth century, which was due to very low income growth. According to Kalmanovitz (2008), GDP per capita only grew 0.1% per year during the nineteenth century, and life expectancy was also stagnant: 32 years at the end of that century (Flórez and Romero, 2010). Regarding education, Colombia was one of the most backward countries in the world. For example, at the end of the nineteenth century, Colombia's illiteracy rate (66%) was above that of Argentina (48.7%), Brazil (65%), Chile (56.5%), and Uruguay (40.6%). In addition, education in the country was not only lagging, but also its expansion was very slow: the ratio for children enrolled in

[4] For a historical cross-country comparison of the Human Development Index, see the papers by Crafts (1997, 2002) and Prados de la Escosura (2014, 2015).
[5] Prados de la Escosura (2015) calculates a new historical index of human development for 12 Latin-American countries, including Colombia, by decades, for the period 1870-2007. However, the indices are not discriminated by gender.
[6] Appendix 1 provides details of the HIHDC methodology.
[7] The sources for the data on primary education are Ramírez and Salazar (2010) for the nineteenth century, and Ramírez and Téllez (2007) for the twentieth century.
[8] We constructed a new database for secondary and higher education by gender for the period 1915-2015, assembling information from *Anuario General de Estadistica de Colombia*, several years and DANE.
[9] The main sources for per capita income in Colombia are: Kalmanovitz (2010); Maddison (2014) and Bértola and Ocampo (2012).
[10] For life expectancy at birth we use the data from Flórez (2000), Flórez and Romero (2010), and DANE.

primary education to the total population rose only from 1.5 per cent in 1827 to 2.6 per cent in 1898 (Ramírez and Salazar, 2010).

On the other hand, all components of the HIHDC presented significant advances in the twentieth century (Appendix 2), which led to considerable improvements in the living standards of the Colombian population (Graph 1). In particular, per capita GDP started to grow faster during the first half of the twentieth century, while major improvements in life expectancy and education were seen during the second half of the century. In fact, GDP per capita grew on average 2.7% during the period 1905-50, and 2.0% during 1951-2010.[11] However, during the first three decades of the century, Colombia continued to exhibit a very low life expectancy (40 years) and few educational achievements. Nonetheless, at the beginning of the twentieth century, improvements in well-being were driven mainly by increases in per capita income.

The decline in the mortality rate produced an increase in life expectancy at birth. Mortality rates in Colombia declined from roughly 30 deaths per thousand inhabitants in 1905 to about 13.2 in 1951, and about 5.5 in 2000. Life expectancy at birth improved considerably, from 40.2 years in 1937 to 56 years in 1965, 71 years in 2000, and 73 years in 2010 (Flórez, 2000 and DANE). Regarding education, it was only at the beginning of 1950s that the takeoff began. That change was a consequence of the increase in fiscal revenue allocated to this sector, which was possible due to the favorable economic conditions during those years (Ramírez and Téllez, 2007). In addition, since the mid-1960s, Colombia has experienced significant transformations in its economic structure, which passed from agricultural to industrial, communication, and services activities. This transformation significantly increased rural migration to the cities and contributed to the rise of urbanization. This process implied a labor-force movement from low productivity to higher productivity activities, which increased the demand for more educated workers and induced investment in human capital (Mejía, Ramírez, and Tamayo, 2008). As a consequence, from the late 1950s until the late 1970s, the number of students, teachers and schools grew at an unprecedented rate for both primary and secondary education.

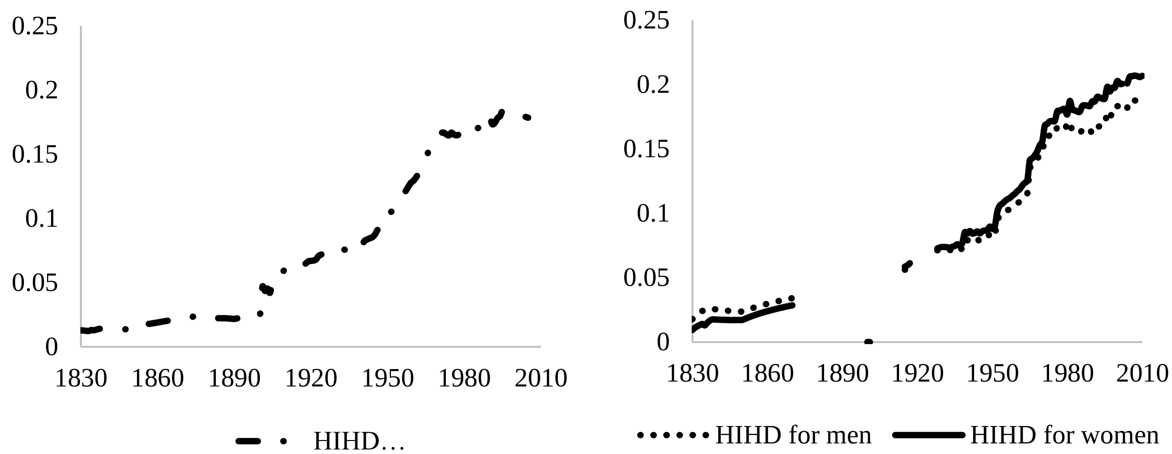
Graph 1 also presents the disaggregated index for men and women in order to observe possible differences in achievements by gender.[12] During the nineteenth century, both indices were similar, with the men's index being slightly higher. This result may be due to the fact that during the nineteenth

[11] See GRECO (2002) for a complete analysis of Colombian economic growth in the twentieth century.

[12] The HIHDC by gender that we calculate can be considered as a proxy, since information of income by gender is not available for such long period of time. Therefore, HIHDC by gender depicts the differences in education and health achievements between women and men throughout the century.

century education showed a high gender disparity: the number of girls attending primary school did not exceed 1% of the population. However, during the twentieth century, women's HIHDC has also improved substantially, especially since the 1950s, when women's index surpasses that of men. This result is interesting when compared to the case of Britain. According to Horrell (2000), women's development index in Britain has improved considerably throughout the twentieth century, but little progress has been made in closing the gap between women's positions relative to men's.[13]

Graph 1
Colombia's HIHDC for 1830-2010: Total and by Gender



Source: Author's calculations. For a detailed explanation, see Appendix 1

In particular, the Colombian women's index improved mainly due to large gains in life expectancy and to large educational achievements. Between 1905 and 2000, women's life expectancy grew over 41 years, from 35 to 76 years, while life expectancy for men grew 36.5 years, from 32.5 years in 1905 to 69 years at the end of the century. Concerning education, when we calculate the HIHDC including higher education instead of primary education as one of its components, we observe that women's HIHDC is greater than the one for men since the 1980s, when the gap between men and women enrolled in higher education began to close. By the end of the century, 52% of total students enrolled in higher education were women (Appendix 3).

IV. The Case of Health: 1915-2015

A. Data and Health Achievements

[13] Horrell (2000) calculated a gendered version of the human development index for the twentieth century in Britain, including indicators for income, leisure, inequality, wealth, health, education, and political rights.

In this section, we analyze achievements in health over the last 100 years in Colombia and the relationship between health outcomes and the provision of public goods (e.g. public water and sewerage provision). We examine health because it is one of the least studied components of the HIHDC by the economic history literature on Colombia.[14] Our hypothesis is that the significant decline in mortality rates, which led to a rise in life expectancy, and to improvements in the HIHDC for both men and women was partly caused by improvements in the provision of public goods, especially regarding sanitary conditions.

For this paper, we construct a database with the annual data on the main diseases, mortality rates, and provision of sewerage and aqueduct services for fourteen Colombian departments (Map 1) for which we were able to collect consistent information for the period 1916-2014.[15] In particular, data by gender on tuberculosis, pneumonia, gastrointestinal illness, cancer, and heart diseases were obtained from statistical yearbooks published by the Colombian government: for 1916-1948, *Anuarios Generales de Estadistica de la Contraloria;* for 1945-1969, *Anuarios Generales de Estadistica;* for 1970-1978, *Registro de Defunciones en Colombia;* and for 1979-2014, DANE database on Vital Statistics of Births and Deaths (*Estadísticas Vitales Nacimientos y Defunciones).*[16] On the other hand, the Colombian censuses provided information on the coverage of aqueduct, sewerage services, and some demographic characteristics.[17]

Graph 2 presents the causes of death in Colombia for some of the main diseases during the period 1916-2014.[18] The data shows profound changes in the causes of mortality for the Colombian population over the last 100 years. There is evidence of an epidemiological transition (the change from deaths caused by infectious diseases to deaths caused by chronic diseases).[19] For instance, the percentage of deaths from tuberculosis, pneumonia, and gastrointestinal diseases decreased significantly throughout the century, especially the latter. On the contrary, deaths due to cancer and heart diseases have increased considerably in recent decades. By gender, some differences are likely to exist in the prevalence of

[14] For a comprehensive analysis on the evolution of education in Colombia, see (among others) Ramírez and Salazar (2010), and Ramírez and Téllez (2007). For a complete analysis of Colombian historical series on income trends and economic growth, see for instance Kalmanovitz (2008), Kalmanovitz and López (2010), and GRECO (2002).
[15] These departments accounted, on average, for 94% of the total population during the period 1916-2014.
[16] The values for the years for which we were not able to find information, were estimated by imputation.
[17] For the years between censuses, we estimated the values by interpolation.
[18] The data on causes of death by type of disease for each Colombian department are not presented here due to space limitations, but are included in our database.
[19] For an analysis on health transitions around the world see Riley (2005).

causes of deaths. For example, there are differences in chronic diseases such as cancer or cardiovascular diseases, where genetics plays a major role in contrast to infectious diseases (Graph 2).

Map 1

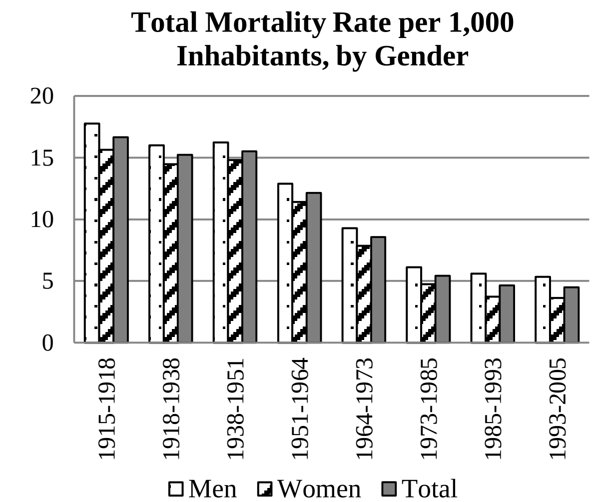
Colombian Sub-national Territorial Units (departments), 1928

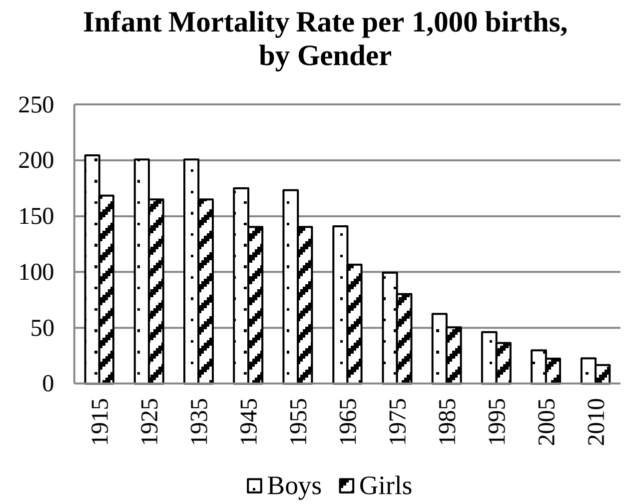
Sources: Authors' elaboration. Note: Shaded departments represent the ones used for the analysis.

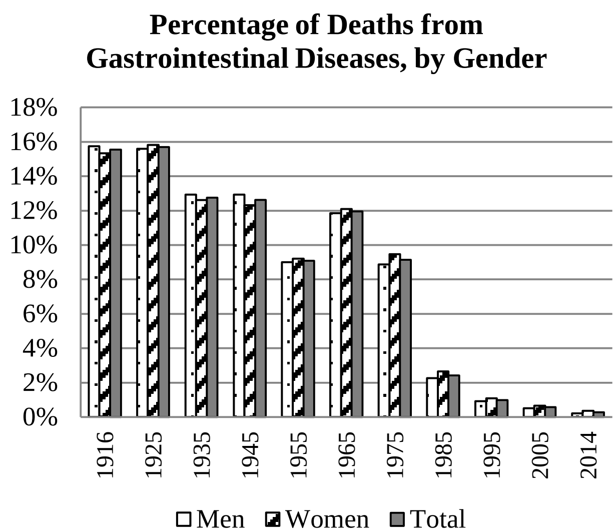
Concerning the provision of aqueducts and sewerage services, Graph 3 presents the coverage rate for the country and by departments. As observed, throughout the century there is a great heterogeneity in the coverage of these services by departments, and for urban and rural areas.

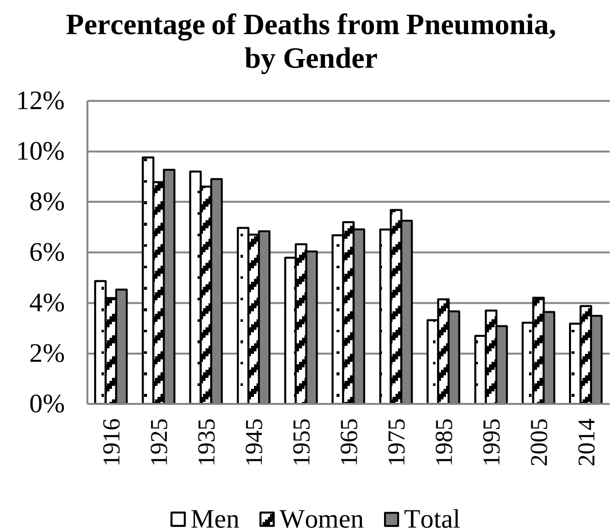
Graph 2

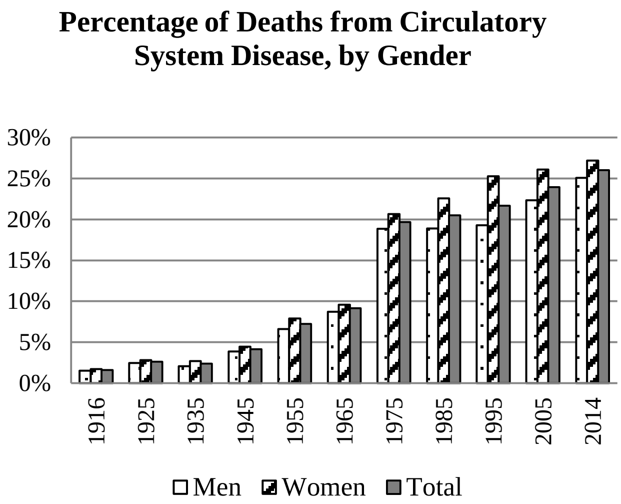
Causes of Death by Type of Disease in Colombia: 1916-2014

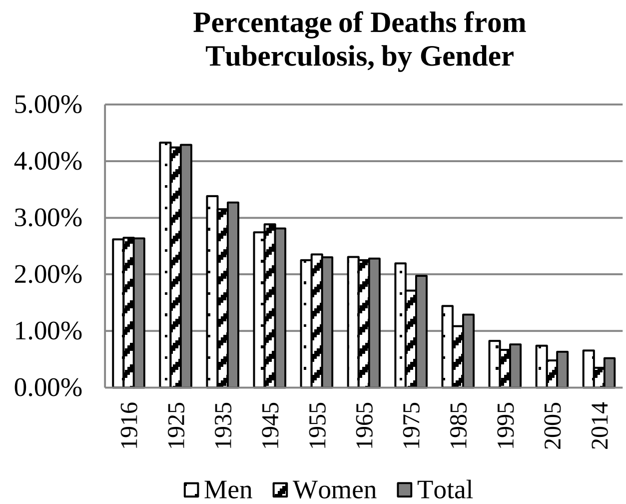


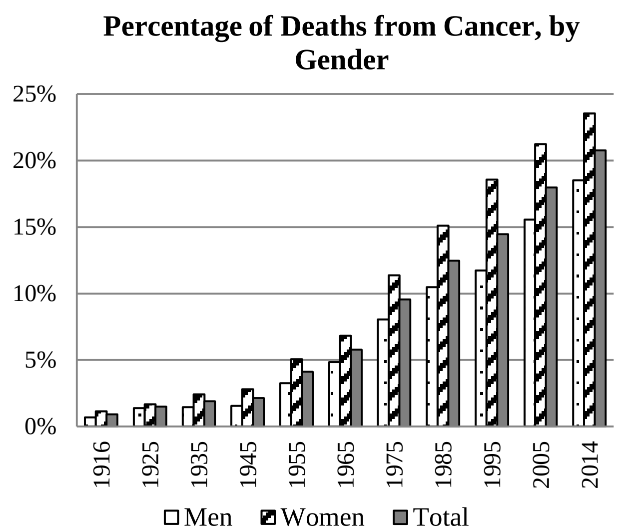


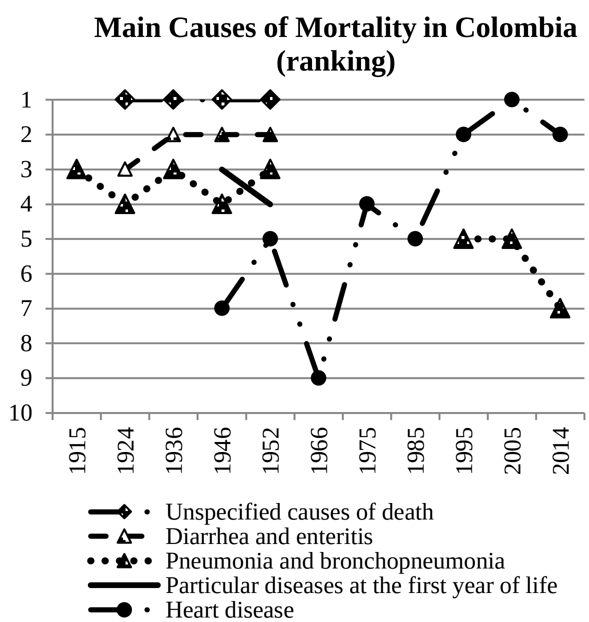








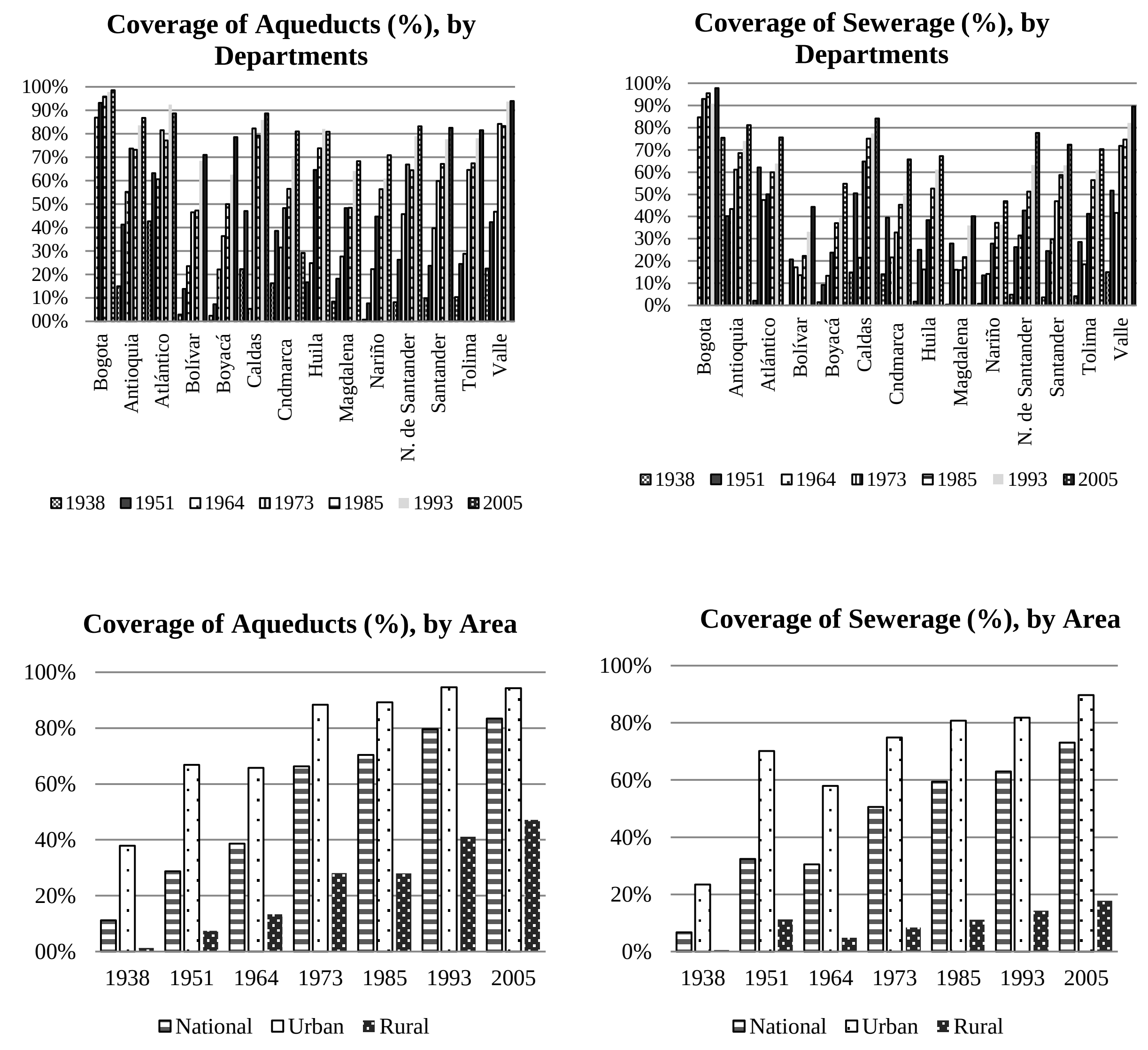




Sources: Database constructed by the authors based on *Anuarios Generales de Estadística de la Contraloría*, *Anuarios Generales de Estadística*, *Estadísticas Vitales Nacimientos y Defunciones* (several years), and Florez (2000).

Graph 3

Aqueducts and Sewerage Coverage by Households (%): National and by Departments



Source: Database constructed by the authors based on the Colombian censuses, several years.

B. Empirical Strategy and Results:

1. Empirical Strategy

Our empirical strategy is to use the exogenous timing and regional variation of sewerage and aqueduct interventions to assess the impact of the provision of these public utilities on mortality rates. We use the time when 40% (or 50%) of the households in a department had access to aqueduct and/or sewerage services.[20] Specifically, we use the differences-in-differences approach to estimate the effect of those interventions on deaths from gastrointestinal infections. We also use other mortality measures such as total mortality rate and deaths from respiratory diseases.[21] We estimate the following equation:

$$log(MRI)_{i,t} = \alpha + \beta_1 W_{i,t} + \beta_2 S_{i,t} + \beta_3 (W_{i,t} * S_{i,t}) + \gamma X_{i,t} + \delta FE_i + \varepsilon_{i,t} \qquad (1)$$

where each observation is a departmental-year cell with *i* indexing the department and t the year. $log(MRI)_{i,t}$ corresponds to the natural logarithm of a mortality rate indicator.[22] We estimate three separate equations using different mortality measures.[23] In the first one, the mortality rate indicator corresponds to deaths from gastrointestinal infections (*GDMR*); the second one, to deaths from respiratory diseases (*RDMR*); and the third one, to the total mortality rate (*TMR*). *W* and *S* are dummy variables indicating whether or not 40% (or 50%) of the households in a department had access to aqueduct (*W*) and/or sewerage (*S*) services at year *t*. That is, the dummy variable is 1 for the years when the coverage of *W* and/or *S* are equal or greater than 40% (or 50%), and 0 otherwise. Also, following Cutler and Miller (2005) and Alsan and Goldin (2015), we include the interaction term between Water (*W*) and Sewerage (*S*) to test if they are substitutes ($\beta_3 > 0$) or complements ($\beta_3 < 0$).[24] β_1, β_2 and β_3 are the difference-in difference estimates of the impact of this infrastructure provision on the difference in mortality measures.

X includes demographic variables such as education.[25] In this paper, we are interested in exploring whether education has had an effect on reducing mortality rates in Colombia throughout the 20th

[20] For robustness, we estimated three more exercises that are presented in Appendix 5, 6 and 7: one when the departments reached 30% of aqueduct and sewerage coverage, another when they reached 60%, and the last one when departments reached 65% of aqueduct and sewerage coverage. The results of these estimations are discussed later in the text.

[21] Despite the fact that Colombia is well-known as a violent county, the mortality rate caused by violent deaths is not as high as other causes of mortality. For example, in 1991, the year with the highest level of violent deaths (79.64 deaths /100,000 inhabitants), the mortality rate from circulatory diseases was (99.71 deaths/ 100,000 inhabitants).

[22] We use logarithms to smooth out the series. All rates are per 1,000 inhabitants.

[23] For a definition of the mortality measures used in this paper, see Appendix 4.

[24] The interaction term between Water (*W*) and Sewerage (*S*) is a dummy variable that equals one in the first years that the provision of *W* and *S* reached a 40% (50%) coverage simultaneously in a department.

[25] Income is another possible variable that could be included in the regressions. However, we do not include it due to the lack of consistent data of departmental income for such a long period of time, and due to the problems of reverse causality between income and health found in the literature (for a complete discussion on this issue see Deaton, 2006). As in the case of education, the economic literature has found an ambiguous relationship between income and some health measures (infant mortality or the decline in the mortality rate). For example, Acemoglu and Johnson (2007) find that that relative growth rate of GDP per capita show some decline in countries

century.[26] *FE* is a department-fixed effect and ε is the error term. We also include lagged dependent variables to account for the noisy nature of year-to-year mortality, as Cutler and Miller (2005) did. All estimations are linear regressions with panel-corrected standard errors, by heteroskedastic and contemporaneous correlation across panels.

2. Results

Table 1 presents the results for the estimations of equation (1), when the dependent variable is the log of the mortality rate for gastrointestinal diseases.[27] Each column corresponds to a different specification. In column 1, we estimate the equation without any controls besides the dummy variables (*W* and *S*), which indicate whether or not a department reached 40% aqueduct (*W*) and/or sewerage (*S*) coverage at year *t;* and an interaction term between aqueduct and sewerage provision. The result indicates that aqueduct and sewerage provisions have a very large significant negative effect on gastrointestinal disease mortality rates. On average, achieving 40% coverage in aqueduct provision reduces the mortality rate for gastrointestinal diseases by 80%, while sewerage provision reduced the mortality rate by 65%. When we considered that households achieved a 50% coverage for aqueduct and sewerage (column 4), the results are quite similar: aqueduct provision and sewerage provision reduce the gastrointestinal mortality rate by 85% and 72%, respectively. The coefficients of the interaction term between aqueduct and sewerage provision are positive and significant, indicating that in this case aqueduct and sewerage provisions were substitute. These results imply that the construction of aqueducts and sewerage affects mortality rates independently, and that both systems contributed to this reduction.[28]

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experiencing large increases in life expectancy. In contrast, Pritchett and Summers (1996) argue that child deaths in developing countries in 1990 could be attributed to the poor economic performance in the 1980s.

[26] The relationship between education and health has been extensively examined in the literature, for example by Lleras-Muney (2005), Cutler and Lleras-Muney (2010) and Cutler, Huang and Lleras-Muney (2015). These authors find that, in general, education is positively associated with health outcomes, but there are important differences across countries. Cutler, Huang and Lleras-Muney (2015), point out that recent studies that estimate the casual effect of education on reducing mortality rates are ambiguous. As these authors mention, some studies have found that for instance education, measured as compulsory schooling, reduces mortality in the United States, but not in England or France (see Cutler, Huang and Lleras-Muney (2015) and references therein). On the other hand, other studies such as Beach, Ferrie, Saavedra and Troesken (2016) examine how the declines of mortality rates due to new water purification technologies affected human capital formation.

[27] We find similar results estimating equation (1) when the dependent variables (mortality measures) were specified by gender. Regressions by gender are available upon request.

[28] A possible explanation for these results can be obtained examining the time when aqueduct and sewerage was provided in Colombia. We note that in most of the departments in which aqueducts were built prior to sewerage, achieved a coverage greater than 40%, which suggests that the construction of both systems was also performed independently.

In columns 2 and 5, we add lagged variables of gastrointestinal disease mortality rates. The coefficients of the first and second lags are positive and significant, which means that the gastrointestinal mortality rate for previous years still has an effect on current mortality. In this model, when we consider coverage of 40%, the results show that, on average, water provision reduced gastrointestinal diseases mortality by 16%, and that sewerage provision has an 8.2% effect on the decline. Considering that households achieved a 50% coverage, the effects are 16% and 11%, respectively. However, the interaction term is no longer significant.

Tables 2 and 3 present regression results using the same specification with the log of total mortality rates and the log of respiratory disease mortality rates as the dependent variables. We expect to find a lesser effect of aqueduct and sewage provision on reducing total mortality and respiratory diseases than on gastrointestinal disease mortality rates. As in Table 1, each column corresponds to a different specification. The results show that the effect of water and sewerage access on total mortality rate and respiratory disease mortality are indeed lower than on gastrointestinal disease mortality rates, especially in the case of sewerage services. For example, when different controls were added to the model (Tables 2 and 3, column 3), the provision of water reduced total mortality rates by 5%, and deaths related to the respiratory system lowered by 9% in the case of aqueduct coverage to 40% of the households. When we considered a coverage of 50%, the effect was no longer significant (Tables 2 and 3, column 6). In addition, the provision of sewerage has no effect on mortality due to respiratory diseases or on the total mortality rate. In these estimations, the interaction term was not statistically significant, suggesting that there are no complementary/substitute effects.

Regarding education, results suggest that this variable plays a role in reducing mortality rates, having a greater effect on total mortality and respiratory diseases mortality rates than on gastrointestinal mortality rates. In the latter case, the provision of aqueducts and sewerage systems has a larger effect reducing mortality rates than education.

Finally, in Appendices 5, 6 and 7, we estimate three more exercises to take into account different levels of coverage in public services.[29] In these cases, we use the time when 30%, 60% and 65% of the

[29] In Appendix 8, we present the results of the estimations using the value of the percentage of coverage of these services obtained from the different census, instead of using dummy variables (the time when households in a department had access to a certain coverage of aqueduct and/or sewerage services). The results are in line with those reported in the text. That is, aqueduct provision had important effects on the decline of the mortality rates for gastrointestinal diseases, total mortality rates, and the mortality rate for respiratory diseases throughout the twentieth century. However, sewerage provision only had important effects on the decline of gastrointestinal diseases' mortality rates.

households in a department had access to aqueduct and/or sewerage services. We find lower effects on reducing mortalities rates when the households in a department reached 60% or 65% aqueduct (*W*) and/or sewerage (*S*) coverage than when they reached coverage of 40% and 50%. However, in the case of 30% sewerage coverage, we find larger effects than in the other cases, suggesting that early expansions on sewerage coverage had larger effects on the decline of mortality rates in Colombia.

Table 1
Effects of the Provision of Water and Sewerage on the Log (Gastrointestinal Diseases Mortality Rate, *GDMR*)

	(1)	(2)	(3)	(4)	(5)	(6)
Aqueduct provision $(W)_{40\%}$	-1.6718***	-0.1743***	-0.1363***			
	(0.108)	(0.042)	(0.033)			
Sewerage provision $(S)_{40\%}$	-1.0582***	-0.0851**	-0.0318			
	(0.111)	(0.043)	(0.031)			
Interaction $(W*S)_{40\%}$	1.3236***	0.1435	0.1221			
	(0.427)	(0.147)	(0.100)			
Aqueduct provision $(W)_{50\%}$				-1.9437***	-0.1752***	-0.1140***
				(0.116)	(0.040)	(0.036)
Sewerage provision $(S)_{50\%}$				-1.2740***	-0.1214***	-0.0853**
				(0.133)	(0.043)	(0.036)
Interaction $(W*S)_{50\%}$				1.3495***	0.1392	0.1521
				(0.350)	(0.140)	(0.125)
Log $(GDMR)_{-1}$		0.6578***	0.698***		0.6657***	0.7048***
		(0.067)	(0.056)		(0.067)	(0.057)
Log $(GDMR)_{-2}$		0.2147**	0.2322***		0.2135**	0.2290***
		(0.084)	(0.072)		(0.084)	(0.072)
Log $(GDMR)_{-3}$		0.0706	0.0309		0.0602	0.0212
		(0.065)	(0.053)		(0.065)	(0.054)
Education			-0.0058			-0.0088**
			(0.004)			(0.004)
Constant	1.4124***	0.0680***	0.0904***	1.0720***	0.0310	0.1043**
	(0.155)	(0.033)	(0.052)	(0.091)	(0.025)	(0.050)
Department Fixed Effects	YES	YES	YES	YES	YES	YES
Number of Observation	1,183	1,141	977	1,183	1,141	977
R^2	0.654	0.950	0.966	0.705	0.949	0.966
Number of Clusters	14	14	12	14	14	12

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. There is a reduction in the number of observation and clusters in columns 4 and 8 due to the availability of information on education at departmental level. Source: Authors' estimations.

Table 2

Effects of the Provision of Water and Sewerage on the Log (Total Mortality Rate, *TMR*)

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Aqueduct provision $(W)_{40\%}$	-0.8222***	-0.0653***	-0.0549***			
	(0.049)	(0.013)	(0.013)			
Sewerage provision $(S)_{40\%}$	-0.2048***	-0.0016	0.0103			
	(0.046)	(0.010)	(0.011)			
Interaction $(W{*}S)_{40\%}$	0.3767***	0.0405	0.0472			
	(0.116)	(0.033)	(0.033)			
Aqueduct provision $(W)_{50\%}$				-0.8915***	-0.0319***	-0.0180
				(0.059)	(0.012)	(0.013)
Sewerage provision $(S)_{50\%}$				-0.1794***	0.0091	0.0134
				(0.051)	(0.010)	(0.010)
Interaction $(W{*}S)_{50\%}$				0.1768*	0.0198	0.0441
				(0.101)	(0.042)	(0.040)
Log $(TMR)_{-1}$		0.7640***	0.6739***		0.7927***	0.6921***
		(0.041)	(0.041)		(0.042)	(0.042)
Log $(TMR)_{-2}$		0.1768***	0.2039***		0.1814***	0.2092***
		(0.050)	(0.048)		(0.051)	(0.049)
Log $(TMR)_{-3}$		0.0044	0.0555		-0.0005	0.0575
		(0.040)	(0.041)		(0.041)	(0.041)
Education			-0.0069***			-0.0073***
			(0.001)			(0.001)
Constant	3.0167***	0.1568***	0.2543***	2.861***	0.0590	0.1735***
	(0.037)	(0.037)	(0.046)	(0.023)	(0.037)	(0.042)
Department Fixed Effects	YES	YES	YES	YES	YES	YES
Number of Observation	1,190	1,148	984	1,190	1,148	984
R^2	0.723	0.976	0.978	0.686	0.975	0.977
Number of Clusters	14	14	12	14	14	12

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. There is a reduction in the number of observation and clusters in columns 3 and 6 due to the availability of information on education at departmental level. Source: Authors' estimations.

Table 3

Effects of the Provision of Water and Sewerage on the Log (Respiratory Diseases Mortality Rate, *RDMR*)

	(1)	(2)	(3)	(4)	(5)	(6)
Aqueduct provision $(W)_{40\%}$	-1.3110***	-0.1082***	-0.1006***			
	(0.069)	(0.021)	(0.022)			
Sewerage provision $(S)_{40\%}$	-0.3200***	-0.0122	0.0144			
	(0.051)	(0.018)	(0.019)			
Interaction $(W*S)_{40\%}$	0.5318***	0.0643	0.0683			
	(0.174)	(0.054)	(0.053)			
Aqueduct provision $(W)_{50\%}$				-1.3390***	-0.0405***	-0.0057
				(0.092)	(0.020)	(0.022)
Sewerage provision $(S)_{50\%}$				-1.3341***	0.0061	0.0119
				(0.076)	(0.019)	(0.018)
Interaction $(W*S)_{50\%}$				0.2074	0.0657	0.1004
				(0.179)	(0.068)	(0.066)
Log $(RDMR)_{-1}$		0.8736***	0.8082***		0.9050***	0.8298***
		(0.040)	(0.044)		(0.042)	(0.044)
Log $(RDMR)_{-2}$		0.1605***	0.1899***		0.1668***	0.1985***
		(0.046)	(0.049)		(0.048)	(0.050)
Log $(RDMR)_{-3}$		-0.1044***	-0.0737*		-0.1043***	-0.0653
		(0.037)	(0.040)		(0.038)	(0.040)
Education			-0.0092***			-0.0111***
			(0.003)			(0.003)
Constant	1.1616***	0.0677***	0.1583***	0.8989***	0.0028	0.1184***
	(0.061)	(0.020)	(0.038)	(0.048)	(0.016)	(0.036)
Department Fixed Effects	YES	YES	YES	YES	YES	YES
Number of Observation	1,175	1,119	984	1,175	1,119	960
R^2	0.745	0.970	0.971	0.676	0.969	0.971
Number of Clusters	14	14	12	14	14	12

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. There is a reduction in the number of observation and clusters in columns 3 and 6 due to the availability of information on education at departmental level. Source: Authors' estimations.

V. Conclusions

This paper shows that Colombia improved the standard of living of its population remarkably during the twentieth century. Progress was made especially on income, education, and health. During the first half of the century, improvements in the quality of life were mainly driven by higher per capita income, while improvements after the 1950s were driven by greater public investments, as in the case of education and health.

The decline in mortality rates, which led to an important increase in life expectancy, was partly triggered by improvements in the provision of public goods, especially regarding sanitary conditions. We find large effects of the provision of aqueducts and sewerage services on mortality rate declines, especially on deaths from waterborne illnesses such as gastrointestinal diseases. However, the effect on mortality rates from water and sewerage access is low compared with the results from other studies such as those by Cutler and Miller (2005). This can be explained in several ways. For example, due to data availability, we use the coverage of water provision instead of a precise measure of water quality. Therefore, our results could be interpreted as a lower bound of the actual effects. Another possible explanation is that the expansion of the aqueduct and sewerage systems in Colombia was gradual, and came late in most of the departments. Also, other factors such as medicines and prevention campaigns may also explain the reduction in mortality rates.

There are some caveats to our paper. First, due to the availability of data, the analysis of the effects of the provision of safe water and sewerage services on some measure of mortality was performed at the departmental level rather than at the municipal level, where the results could be more conclusive. For future research, we intend to analyze some of the major cities of the country, for which we will assemble a consistent database. We also want to extend the estimates to other causes of death such as pneumonia and tuberculosis. In addition to aqueduct and sewerage, there are other factors which are not mutually exclusive that were responsible for the reduction of mortality in the country, and which should be taken into account in future analyses.

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Appendix 1
Human Development Index and Historical Index of Human Development: Methodology

1. **Variables:** The Colombian human index of human development (HIHDC) intends to understand the following dimensions of the standard of living, both at the general level and by gender:

   a. Education: we use the following proxy for coverage in primary education by gender:

$$Coverage = \frac{(Students\ in\ primary\ education)_{t,g}}{(Total\ Population)_{t,g}}$$
$$g = \{male, female, total\}$$

   b. Income: we use the GDP per capita in Geary–Khamis international dollars, at constant prices. A logarithmic transformation of income is necessary because, as Amand and Sen (2000) point out, the function of capabilities is probably concave:

$$LN\_PIB_{pc_t} = \ln\left(PIB_{pc_t}\right)$$

   c. Health: We use the life expectancy at birth by gender.

2. **Construction of a continuous series:** The lack of data availability for several years compelled us to interpolate data for some years. The interpolation uses the nearest points (x_0, y_0) and(x_1, y_1), such that$x_0 < x$ and$x_1 > x$. While y_1 and y_0 are observable, the interpolation of the y value follows this formula:

$$y = \frac{y_1 - y_0}{x_1 - x_0}(x - x_0) + y_0$$

The interpolation is not done for the years 1870-1900, given that the period is too broad, and any interpolation would ignore all of the changes at the end of the century.

3. **HDI:** To calculate the HDI, it is necessary to transform the variables as follows:

$$I_{d,t,g} = \frac{x_{d,t,g} - Min_d}{Max_d - Min_d}$$
$$d = \{income, education, health\}$$
$$g = \{Male, Female, National\}$$

where $x_{d,t,g}$ represents the value of the dimension *d*, in period *t*, and gender, *g*. The maximum and minimum (goalposts) are historical worldwide observations for each dimension. However, no historical information is available on goalpost differentiated by gender, therefore we decide to adopt the same values used by Prados de la Escosura (2015).

Finally:

$$HDI_{t,g} = \sqrt[3]{\prod_{d} I_{d,t,g}}$$

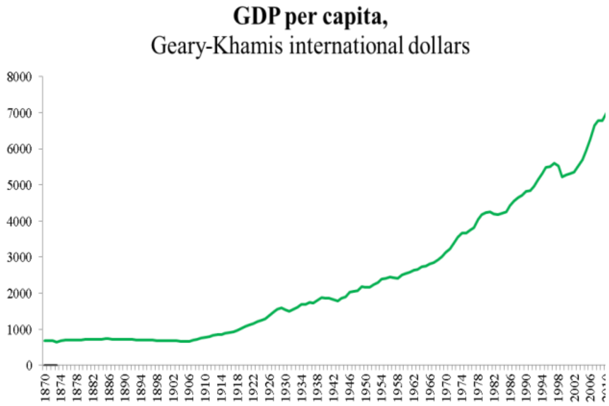
4. **HIHD:** Following Prados de la Escosura's (2015) methodology, the construction of the HIHD results in a logarithmic transformation of $I_{\mathrm{d,t,g}}$ given that as country's development increases, it is more difficult to improve, so this indicator gives more points for growth at advanced levels of development. It is worth mentioning that the income dimension does not require this transformation, since it already has a logarithmic transformation.

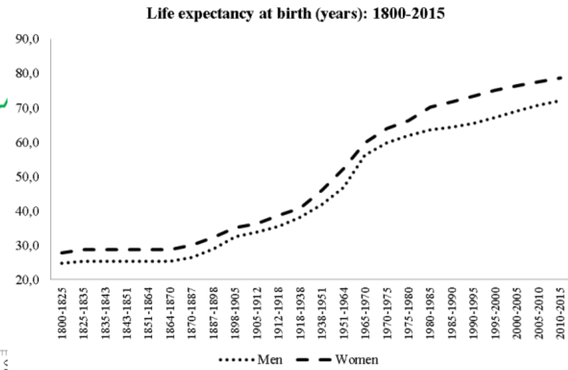
$$HI_{d,t,g} = \frac{\ln(Max_d - Min_d) - \ln\left(Max_d - x_{d,t,g}\right)}{\ln(Max_d - Min_d)}$$

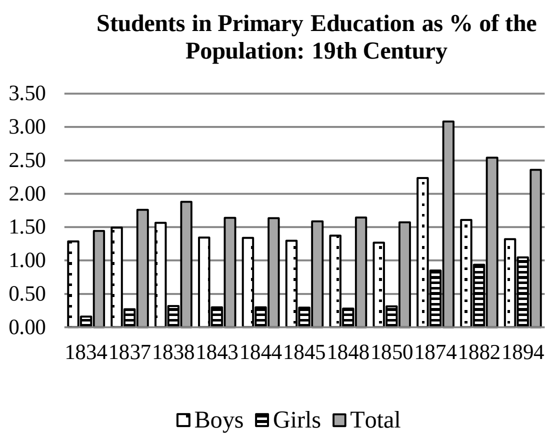
Finally, the calculation of the HIHD is similar to that of the HDI:

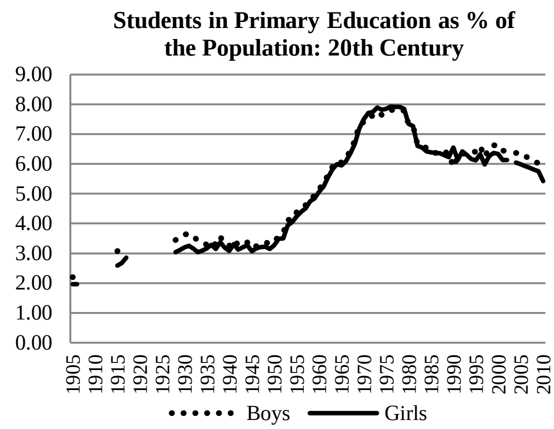
$$HIHD_{t,g} = \sqrt[3]{\prod_{d} HI_{d,t,g}}$$

Appendix 2
Components of the Colombian's HIHD





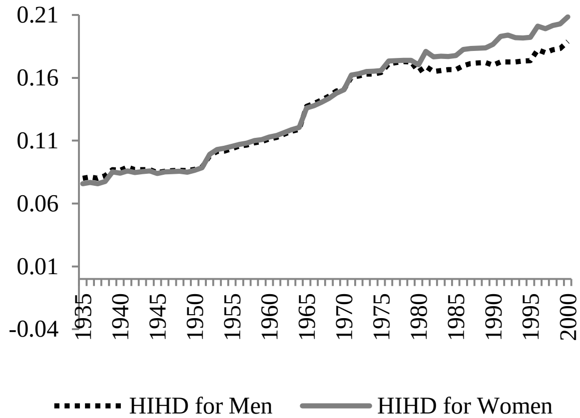




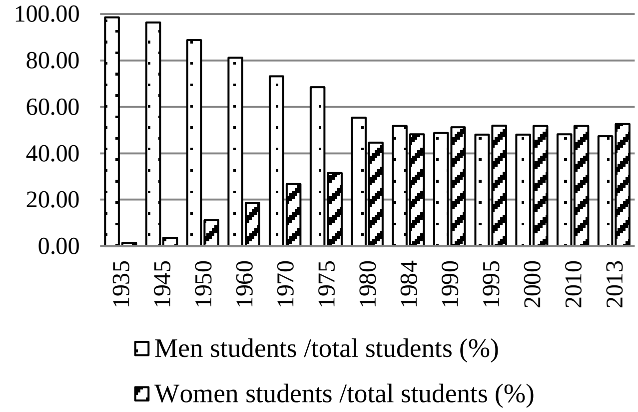
Sources: Calculation by the authors based on GDP data from Kalmanovitz (2010), Maddison (2014) and Bértola and Ocampo (2012); Life Expectancy data from Flórez (2000), Flórez and Romero (2010) and DANE; Education from Ramírez and Salazar (2010), Ramírez and Téllez (2007) and Dane; Population from Flórez and Romero (2010), Flórez (2000) and DANE.

Appendix 3
HIHDC by Gender: 1935-2000

HIHDC by Gender
(Including higher education)



Higher Education in Colombia
(Gap between Men and Women**)**



Sources: Authors' calculations based on data from the Colombian Government statistical yearbooks, *Ministerio de Educación Nacional*, *Anuarios Generales de Estadistica* and *Departamento Nacional de Planeación*.

Appendix 4
Definition of Disease Groups

Gastrointestinal Diseases	Cholera Typhoid and paratyphoid fevers Other infections due to salmonella Shigellosis Other bacterial intestinal infections Other bacterial food poisonings, not classified elsewhere Amoebiasis Other intestinal diseases due to protozoa Intestinal infections due to viruses and other specified organisms Other gastroenteritis and colitis of infectious and unspecified origin
Respiratory Diseases	Pneumonia Chronic diseases of the lower respiratory tract Lung diseases due to external agents All other diseases of the respiratory system
Circulatory System Diseases	Rheumatic fever and chronic rheumatic heart disease Hypertensive diseases Ischemic heart disease Cardiopulmonary disease and diseases of the pulmonary circulation All other forms of heart disease Heart failure Atherosclerosis Aortic aneurysm Diseases of blood vessels and other diseases of the circulatory system.¿

Source: Authors' elaboration.

Appendix 5

Effects of the Provision of Water and Sewerage on the Log (Gastrointestinal Diseases Mortality Rate, *GDMR*)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Aqueduct provision $(W)_{30\%}$	-0.7833***	-0.0760**	-0.0319						
	(0.110)	(0.038)	(0.033)						
Sewerage provision $(S)_{30\%}$	-1.6232***	-0.1279***	-0.1294***						
	(0.123)	(0.038)	(0.033)						
Interaction $(W*S)_{30\%}$	1.3516***	0.0540	0.0699						
	(0.297)	(0.091)	(0.083)						
Aqueduct provision $(W)_{60\%}$				-2.1622***	-0.1334***	-0.0727*			
				(0.148)	(0.036)	(0.037)			
Sewerage provision $(S)_{60\%}$				-1.0139***	-0.0800*	-0.0679*			
				(0.133)	(0.047)	(0.038)			
Interaction $(W*S)_{60\%}$				0.7640***	-0.0468	-0.0551			
				(0.351)	(0.145)	(0.124)			
Aqueduct provision $(W)_{65\%}$							-2.5864***	-0.1597***	-0.1033***
							(0.114)	(0.035)	(0.037)
Sewerage provision $(S)_{65\%}$							-0.7539***	-0.0064	-0.0328
							(0.140)	(0.054)	(0.034)
Interaction $(W*S)_{65\%}$							0.9806**	-0.0450	0.0861
							(0.418)	(0.248)	(0.093)
Log $(GDMR)_{-1}$		0.6657***	0.7001***		0.6799***	0.7127***		0.6821***	0.7105***
		(0.068)	(0.056)		(0.068)	(0.057)		(0.068)	(0.057)
Log $(GDMR)_{-2}$		0.2184***	0.2340***		0.2217***	0.2372***		0.2232***	0.2359***
		(0.084)	(0.072)		(0.085)	(0.072)		(0.085)	(0.072)
Log $(GDMR)_{-3}$		0.0721	0.0315		0.0628	0.0235		0.0692	0.0284
		(0.066)	(0.053)		(0.066)	(0.054)		(0.066)	(0.054)
Education			-0.0037			-0.0101**			-0.0114***
			(0.004)			(0.004)			(0.004)
Constant	1.3159***	0.0456	0.0676	0.8593***	-0.0107	0.0926*	0.8044***	-0.0268	0.1002*
	(0.160)	(0.035)	(0.051)	(0.085)	(0.024)	(0.053)	(0.068)	(0.023)	(0.052)
Department Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Number of Observation	1,183	1,141	977	1,183	1,141	977	1,183	1,141	977
R^2	0.603	0.949	0.966	0.614	0.949	0.965	0.546	0.948	0.965
Number of Clusters	14	14	12	14	14	12	14	14	12

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Source: Authors' estimations.

Appendix 6

Effects of the Provision of Water and Sewerage on the Log (Total Mortality Rate, *TMR*)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Aqueduct provision $(W)_{30\%}$	-0.4859***	-0.0573***	-0.0373***						
	(0.042)	(0.013)	(0.012)						
Sewerage provision $(S)_{30\%}$	-0.5385***	-0.0273**	-0.0282**						
	(0.045)	(0.012)	(0.012)						
Interaction $(W*S)_{30\%}$	0.4541***	0.0304	0.0228						
	(0.097)	(0.028)	(0.029)						
Aqueduct provision $(W)_{60\%}$				-0.9696***	-0.0097	-0.0003			
				(0.071)	(0.013)	(0.012)			
Sewerage provision $(S)_{60\%}$				0.0212	0.0049	-0.0069			
				(0.057)	(0.013)	(0.013)			
Interaction $(W*S)_{60\%}$				0.0082	-0.0458	-0.0293			
				(0.127)	(0.044)	(0.042)			
Aqueduct provision $(W)_{65\%}$							-0.9377***	-0.0044	0.0062
							(0.058)	(0.010)	(0.011)
Sewerage provision $(S)_{65\%}$							0.0676	-0.0001	-0.0050
							(0.055)	(0.019)	(0.022)
Interaction $(W*S)_{65\%}$							0.1365	0.0123	0.0190
							(0.142)	(0.068)	(0.078)
Log $(TMR)_{-1}$		0.7469***	0.677***		0.7989***	0.6948***		0.7996***	0.6941***
		(0.041)	(0.042)		(0.042)	(0.042)		(0.042)	(0.042)
Log $(TMR)_{-2}$		0.1737***	0.2001***		0.1854***	0.2114***		0.1859***	0.2115***
		(0.049)	(0.048)		(0.051)	(0.049)		(0.051)	(0.049)
Log $(TMR)_{-3}$		0.0153	0.0585		0.0013	0.0604		0.0032	0.0619
		(0.040)	(0.041)		(0.041)	(0.041)		(0.041)	(0.041)
Education			-0.0051***			-0.0072***			-0.0073***
			(0.001)			(0.001)			(0.001)
Constant	3.0561***	0.1934***	0.2546***	2.7293***	0.0210	0.1492***	2.7115***	0.0128	0.1483***
	(0.042)	(0.038)	(0.045)	(0.026)	(0.033)	(0.041)	(0.026)	(0.029)	(0.041)
Department Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Number of Observation	1,190	1,148	984	1,190	1,148	984	1,190	1,148	984
R^2	0.733	0.976	0.978	0.605	0.975	0.977	0.498	0.975	0.977
Number of Clusters	14	14	12	14	14	12	14	14	12

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Source: Authors' estimations.

Appendix 7

Effects of the Provision of Water and Sewerage on the Log (Respiratory Diseases Mortality Rate, *RDMR*)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Aqueduct provision $(W)_{30\%}$	-0.7241***	-0.0887***	-0.0635***						
	(0.060)	(0.022)	(0.021)						
Sewerage provision $(S)_{30\%}$	-0.9287***	-0.0715***	-0.0873***						
	(0.062)	(0.018)	(0.020)						
Interaction $(W*S)_{30\%}$	0.8144***	0.0654	0.0682						
	(0.143)	(0.043)	(0.046)						
Aqueduct provision $(W)_{60\%}$				-1.3887***	-0.0263***	-0.0012			
				(0.113)	(0.022)	(0.023)			
Sewerage provision $(S)_{60\%}$				-0.0828	0.0175	0.0145			
				(0.088)	(0.019)	(0.019)			
Interaction $(W*S)_{60\%}$				0.0044	-0.0116	0.0085			
				(0.229)	(0.069)	(0.067)			
Aqueduct provision $(W)_{65\%}$							-1.4274***	-0.0169	0.0067
							(0.089)	(0.017)	(0.018)
Sewerage provision $(S)_{65\%}$							0.0722	0.0227	0.0004
							(0.090)	(0.022)	(0.019)
Interaction $(W*S)_{65\%}$							0.0248	0.0917	0.0712
							(0.262)	(0.084)	(0.079)
Log $(RDMR)_{-1}$		0.8532***	0.7972***		0.8059***	0.8306***		0.9066***	0.8306***
		(0.039)	(0.043)		(0.042)	(0.045)		(0.041)	(0.045)
Log $(RDMR)_{-2}$		0.1542***	0.1837***		0.1656***	0.1938***		0.1661***	0.1941***
		(0.046)	(0.048)		(0.048)	(0.050)		(0.048)	(0.050)
Log $(RDMR)_{-3}$		-0.0936***	-0.0726*		-0.0956**	-0.0605		-0.0930**	-0.0607
		(0.036)	(0.039)		(0.038)	(0.041)		(0.038)	(0.041)
Education			-0.0053**			-0.0109***			-0.0110***
			(0.003)			(0.003)			(0.003)
Constant	1.2380***	0.1018***	0.1600***	0.6931***	-0.0114	0.1142***	0.6648***	-0.0152	0.1165***
	(0.066)	(0.022)	(0.037)	(0.045)	(0.016)	(0.038)	(0.043)	(0.014)	(0.038)
Department Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Number of Observation	1,175	1,119	960	1,175	1,119	960	1,175	1,119	960
R^2	0.768	0.970	0.972	0.571	0.969	0.971	0.488	0.969	0.971
Number of Clusters	14	14	12	14	14	12	14	14	12

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Source: Authors' estimations.

Appendix 8

Effects of the Provision of Water and Sewerage on the *Log of*:

	Gastrointestinal Diseases Mortality Rate, *GDMR*			**Total Mortality Rate, *TMR***			**Respiratory Diseases Mortality Rate, *RDMR***		
	(1)	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
Aqueduct provision (*W*)	-3.8539***	-1.1107***	-1.5525***	-2.4315***	-1.5006***	-0.9393***	-3.550***	-2.4391***	-2.0887***
	(0.737)	(0.426)	(0.796)	(0.313)	(0.239)	(0.428)	(0.478)	(0.471)	(0.951)
Sewerage provision (*S*)	-2.8461***	-2.2891***	-2.3136***	0.3370	0.1954	-0.1081	0.4162	0.1868	0.0040
	(0.722)	(0.411)	(0.530)	(0.346)	(0.283)	(0.291)	(0.485)	(0.428)	(0.666)
Log $(GDMR)_{-1}$		0.6842***	0.6417***						
		(0.054)	(0.096)						
Log $(TMR)_{-1}$					0.4088***	0.5127***			
					(0.062)	(0.079)			
Log $(RDMR)_{-1}$								0.2774***	0.3218***
								(0.053)	(0.067)
Education			0.0333			-0.0164***			-0.0157
			(0.029)			(0.011)			(0.020)
Constant	2.8848***	1.1497***	0.9936***	3.5117***	2.0424***	1.8243***	1.8789***	1.2735***	1.3505***
	(0.151)	(0.164)	(0.189)	(0.089)	(0.204)	(0.218)	(0.140)	(0.177)	(0.195)
Department Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Number of Observation	98	98	85	98	98	85	98	97	84
R^2 (overall)	0.824	0.927	0.937	0.8984	0.913	0.935	0.825	0.844	0.845
Number of Clusters	14	14	13	14	14	13	14	14	13

Note: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Source: Authors' estimations.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