

Analyzing the Impact of Mexico’s Clean Water Program, Programa Agua Limpia, on Child Mortality Rates*

Ricky Fung

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This paper analyzes the impact of the clean water program, Programa Agua Limpia, on child mortality rates. It was illustrated that significant decreases in child mortality rates of diarrhea after the introduction of the clean water program. It also illustrated a significant decrease in child mortality within small-medium-sized cities. This demonstrates the importance of improving the water quality in low- and middle-income countries to prevent more child deaths caused by diarrhea.

1 Introduction

Historically, improvements in the quality of municipal drinking water made important contributions to population health in today’s countries (Bhalotra et al. 2021). The late nineteenth and early twentieth centuries witnessed significant advancements in water purification technologies, leading to remarkable reductions in urban mortality across countries such as Japan, France, Sweden, the United States, and the United Kingdom (Bhalotra et al. 2021). Despite these advancements, diarrhea remains a leading cause of child mortality and morbidity, being the fifth leading cause of death in children younger than 5 years old (GBD 2016 Diarrheal Disease Collaborators 2018).

This paper analyses the impact of Mexico’s clean water program, Programa Agua Limpia, on child mortality rates by assessing mortality trends and service coverage. The paper uses replicated data from “Urban Water Disinfection and Mortality Decline in Lower-Income Countries” (Bhalotra et al. 2021) for the analysis.

In 1991, the program, Programa Agua Limpia was involved in disinfecting Mexico’s water supply by chlorinating it in response to a cholera epidemic. Although the main purpose of this

*Code and data are available at: <https://github.com/eatingcorn/urban-water>

program was to prevent the spread of cholera, in **sec-result** it was found that the diarrheal mortality of children under 5 years old with diarrheal infections decreased significantly after 1991. It was also discovered that there was a significant decline in the mortality rate of children with diarrheal infections and all causes, including diarrheal infectious, non-infectious, and respiratory infectious, particularly in small to medium-sized cities. These results demonstrate the importance of improving the water quality in low- and middle-income countries to prevent more child deaths caused by diarrhea.

2 Data

2.1 Data Source and Methodology

The paper used for replication is “Urban Water Disinfection and Mortality Decline in Lower-Income Countries” (Bhalotra et al. 2021). This paper assesses the effectiveness of water disinfection programs in lower-income countries, focusing on the case of Mexico. It examines The History of Programa Agua Limpia in Mexico, Water Disinfection and Diarrheal Disease Mortality Rates, the circumstances where municipal water disinfection is effective, and its cost-effectiveness. The reproduction in this report focuses on the water disinfection and diarrheal disease mortality rates, more specifically the impact of Programa Agua Limpia, on Child Mortality Rates.

The data on Under-5 Mortality Diarrheal Deaths and Under-5 Mortality Rates by Treated and Control Locations or Conditions were constructed from individual-level death certificate data for the period 1979-1997. Individual-level death certificates were publicly available from the Instituto Nacional de Estadística y Geografía (INEGI 2017). The data on Chlorination Coverage under Programa Agua Limpia are obtained from the National Water Commission (CONAGUA 1994) which is responsible for hydrology monitoring and the construction of Mexico’s water conservation facilities.

Using the R programming language (R Core Team 2022) and packages, and tidyverse (Wickham et al. 2019) were used to simulate and test the data set and generate tests. The ggpubr (Kassambara 2023), tidyverse (Wickham et al. 2019), dplyr (Wickham et al. 2023), here (Müller 2020), and haven (Wickham, Miller, and Smith 2023) packages were then used to load, read and write dta files, as well as clean data, test for it, and display the figures.

2.2 Attributes

The Under-5 Mortality Diarrheal Deaths data includes the year of death and mortality patterns among children under 5 years old, covering the causes: of non-respiratory, respiratory, and diarrheal illnesses. It also includes annual death counts, and mortality rates per 1,000 live births for each cause.

The Under-5 Mortality Rates by Treated and Control Locations or Conditions data includes 68 different attributes ranging from the sum of mortalities and the rates of 1-month newborns, 12 months, 4 years, and under 5 years, it also includes treated vs. controlled diseases and living situations. For example, household income, whether individuals lived in small/medium/large cities, etc.

For the Chlorination Coverage under Programa Agua Limpia data, the attributes are month, year, benef, and localities_cv. The month and year represent the date on which the chlorination coverage data was recorded or measured, Benef represents the number of individuals, households, or communities who benefited from chlorination services during the specified month and year, and localities_cv refer to the localities or geographic areas where chlorination services were provided.

3 Results

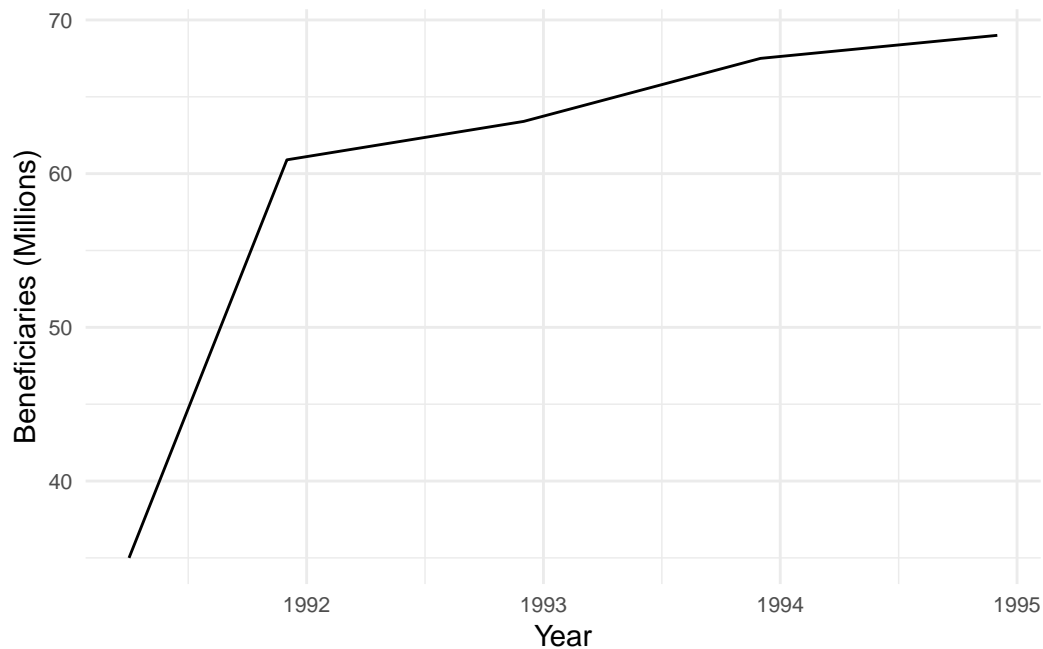


Figure 1: Chlorination Coverage under Programa Agua Limpia

Figure 1 illustrates the the number of beneficiaries (in millions) covered by chlorination services between April 1991 and December 1995. The sharp uptick in coverage between April 1991 and December 1991 was coincident with the introduction of Programa Agua Limpia (PAL). The efforts correspond to an increase in the proportion of the urban population receiving disinfected water.

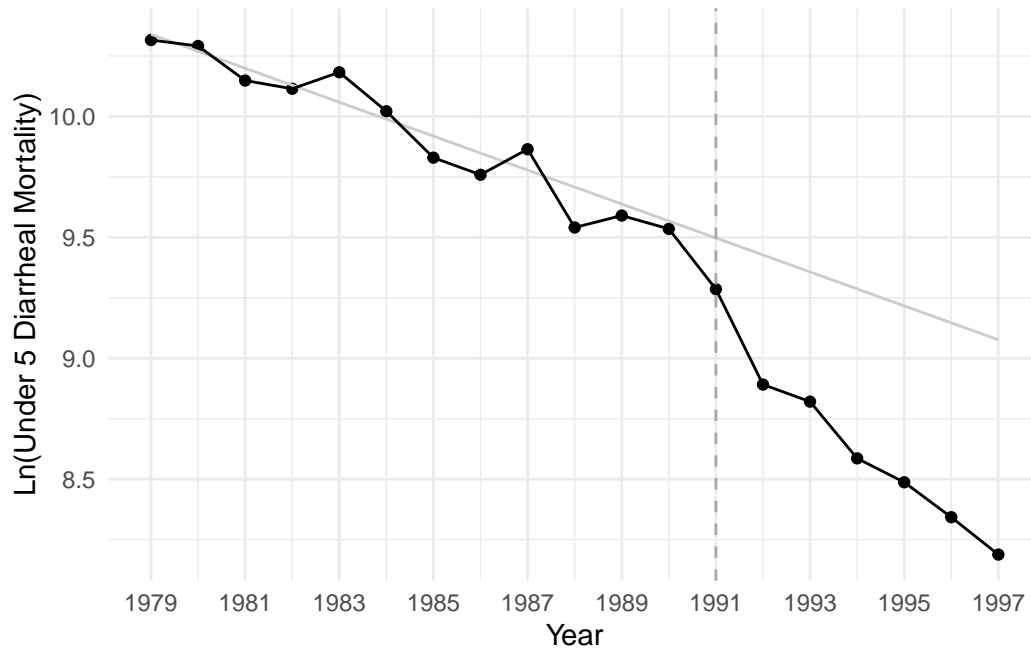


Figure 2: National Trends in Under-5 Mortality Diarrheal Deaths, 1979–1997

Figure 2 illustrates the average trends in mortality rates for diarrheal diseases for nonrural municipalities between 1979–1997. Visually, we note a trend break in the diarrheal mortality series in 1991, coincident with the start of PAL. The gray line is the linear prediction of the pre-PAL trend between 1979 and 1984—notably, actual diarrheal mortality followed this prediction until 1991, when PAL was implemented

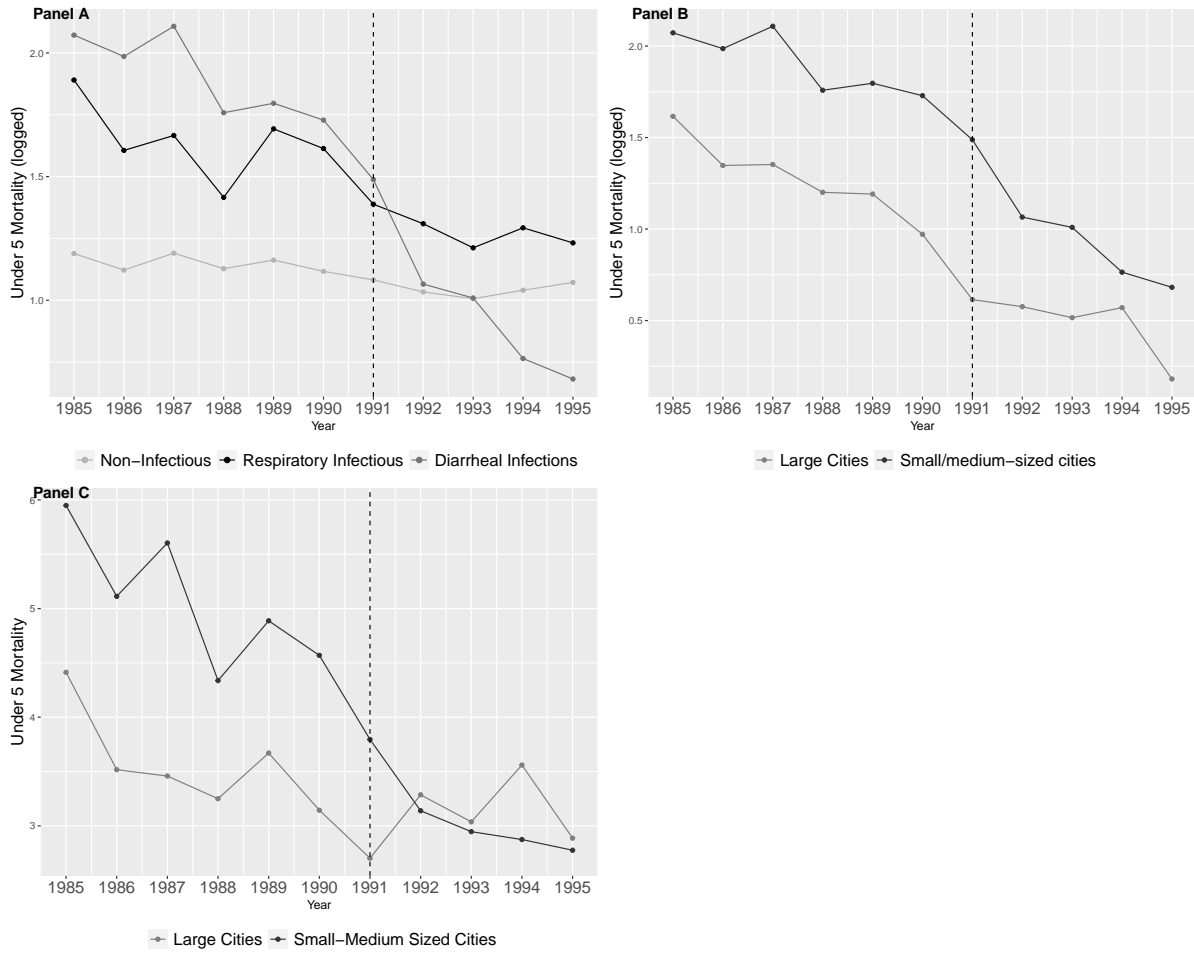


Figure 3: National Trends in Under-5 Mortality Rates by Treated and Control Locations or Conditions, 1985–1995

Figure 3 illustrates the average trends in under-5 mortality rates (per 1,000 live births) for diarrheal diseases alongside respiratory and noninfectious control diseases in municipalities containing small and medium-sized cities (Panel A), diarrheal diseases in municipalities containing small and medium-sized cities versus large (untreated) cities (Panel B), and all-cause under-5 mortality across municipalities containing small and medium-sized cities versus large cities (Panel C).

4 Discussion

4.1 Quality improving water programs decreases child mortality rates

In Section 3, the introduction of Programa Agua Limpia in 1991 demonstrated increased chlorination coverage, resulting in improved water quality, and significant decreases in child mortality rates, especially those related to diarrheal diseases.

In 1991, a cholera epidemic emerged in Chile and Peru and quickly spread through South and Central America (Medina Lois 1991, Ries et al. 1992, Sepúlveda et al. 2006). 1991 was an all time-high for contaminated water diseases due to the spread. With the emergence of the epidemic Programa Agua Limpia was quickly introduced and despite the epidemic significant decreases were still shown in child mortality rates related to diarrheal diseases. After the epidemic the rates remain decreasing showing the effectiveness of water programs.

4.2 Importance of improving water quality in low- and middle-income countries

In Section 3, the introduction of Programa Agua Limpia in 1991 demonstrated increased chlorination coverage, resulting in improved water quality, and significant decreases in child mortality rates for all-causes including diarrheal infectious, non-infectious, and respiratory infectious all around the year 1991.

In the early 1990s Mexico was considered a low-income country who face great socio-hydrological risk (Gutierrez 2019). Emergence of clean water program, Programa Agua Limpia drastically decreased Mexico's child mortality rates after 1991, illustrating the impact water programs has on already struggling countries who face socio-hydrological risks.

4.3 Weaknesses and next steps

This analysis reveals several weaknesses. As stated in Section 2, this paper only focuses on one low-income country, in this case Mexico. The impact of quality improving water programs may differ between other low-income countries and may illustrate no quality changes. Another weakness, is the limited scope as the analysis did not consider other factors that may influence child mortality rates such as healthcare access, sanitation infrastructure, nutrition, etc. For the future the expansion of the scope beyond a single low-income country as well as including multiple countries with varying levels of development and different socio-hydrological risks to understand findings. Additionally, an analysis of factors that may contribute to the effectiveness of water cleaning programs.

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