CORVINUS UNIVERSITY OF BUDAPEST

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DO WATER ACCESS INEQUALITIES MATTER FOR CHILD MORTALITY?

A perspective from low-and-middle-income countries

by

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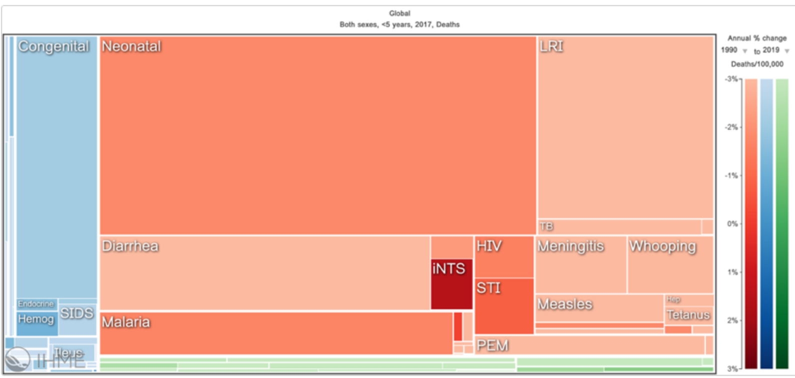
1. Theoretical background and justification of the topic

The primary focus of the dissertation project is to explore the intersection of water and health through an economics perspective. On one hand, water plays a vital role in human health and survival from the public health/epidemiological standpoint. On the other hand, it is a crucial resource for supporting flora and fauna from an environmental viewpoint. However, the significance of water has been neglected in the realm of economics research, resulting in its relative absence in the realm of policies as well. How can we continue to ignore such a critical resource that underpins life and the world? Motivated by this question, my interest was sparked to delve deeper into the role of water. It became evident, particularly during my participation in World Water Week back in 2019, that water stands at the heart of everything, interconnecting environment, ecology, biology, engineering, technology, health, development studies, anthropology, society, business, economics, politics, geopolitics, and international relations. Nonetheless, while traditionally environmental science and more recently interdisciplinary studies have taken on a more active role in this sphere. Consequently, approaches to the study of water are evolving from disciplinary to multidisciplinary, interdisciplinary, and transdisciplinary. This enrichment also reveals the complexity of the research problem - water.

Taking stock of the knowledge in the relevant literature, we recognize the role of health in economic development (Barro, 2013, 1996; Finlay, 2007; Grossman, 1972; Mushkin, 1962; World Bank, 1993) and human development (United Nations, 1990), on the one hand, and the role of water in health from a health economics perspective (Cutler et al., 2006; Cutler and Miller, 2005). On the other hand, we can approach water from a welfare economics perspective, addressing the distribution of water by asking '*Who gets safe water and who does not*?'. This question is particularly relevant in the context of low-and-middle-income countries, given that achieving a full coverage of access to safe water is still at the heart of global development agenda. Then the obvious follow-up question emerges connecting it to health: '*Whether and how this discrepancy affects health status of the people*?'. It then becomes as the central question of the dissertation project. By answering this question, we attempt to contribute this line of research from an economics perspective. In particular, the review of the literature reveals that whether and how the distribution of water access affects child mortality (i) and its economic transmission channel (ii) are unclear (Besnier et al., 2021; Fink et al., 2011; Hoddinott, 1997; Setty et al., 2020, 2019). Moreover, child mortality caused by diarrhea received nearly no attention in the literature, despite only one recent study published (Local Burden of Disease WaSH Collaborators, 2020).

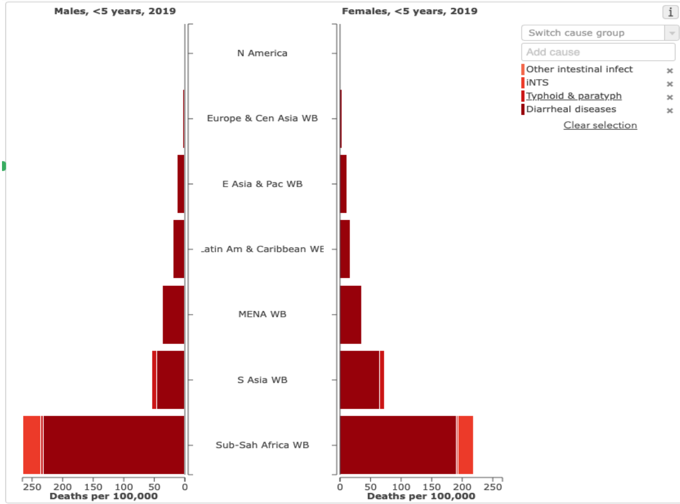
Building on this theoretical background connecting *water access inequality* and *child mortality*, we look at the global health policy sphere to understand the dynamics of the child mortality, especially caused by the infections closely connected to water. The stylized facts yield the following insights. First, diarrhea is the second major killer of children age under 5 globally, after neonatal disorder (Figure 1). Second, diarrhea is the primary concern among the intestinal infections/water borne infections (Figure 2). Third, almost exclusively it is a development concern in low-middle-income-countries. The highest intensity of the disease burden lies in Sub-Saharan Africa, while the lowest burden appears in Europe and Central Asia (Figure 2). Fourth, Infants and children age under 5 are the most vulnerable age groups in mortality caused by diarrheal disease (Figure 3) apart from old age mortality. This demonstrates the relevance of our study.

Figure 1. Diarrhea infection remains as the second major killer among children age under 5 as of 2017



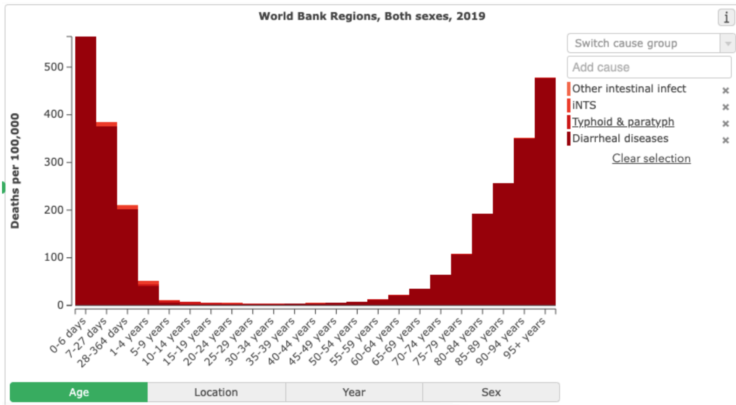
Source: IHME. GBD Compare Data Visualization: http://vizhub.healthdata.org/gbd-compare. (Institute for Health Metrics and Evaluation (IHME), 2020)

Figure 2. Mortality by intestinal infections by World bank regions



Source: IHME. GBD Compare Data Visualization: http://vizhub.healthdata.org/gbd-compare.

Figure 3. Mortality by the causes (intestinal infections) and age groups as of 2019



Source: IHME. GBD Compare Data Visualization: http://vizhub.healthdata.org/gbd-compare.

2. Methodology

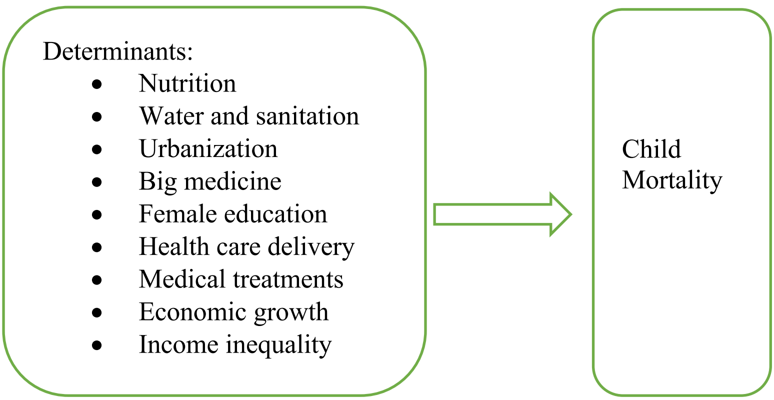
2.1 Scope of the study

Chapter 2 provides a theoretical background of the analysis by clarifying the definition of socioeconomic inequality in water access, approaches to socioeconomic inequality, and economic transmission channel alongside the detailed discussion on the determinants of child mortality. In brief, we define water access inequality as the extent to which inequalities in water access are related to indicators of socioeconomic status such as income/wealth, in line with rank-dependent concentration index approach, building on Wagstaff, Paci, and van Doorslaer (1991). Water access inequality measured by concentration index approach is, therefore, built upon a foundation of welfare economics (Bleichrodt and van Doorslaer, 2006). Concentration index approach to socioeconomic inequality is an alternative to Sen's concept of Equality of Capability (Sen, 1993, 1992) and Human Opportunity Index (Paes de Barros et al., 2009) which is based on Roemer's Equality of Opportunity theory and (Roemer, 1998).

When it comes to an economic transmission channel, it seems water access inequality affects child health through poverty. Intuition is water access tends to be associated with living condition and location of home. Richer people are guaranteed to have home which has access to adequate drinking water and safe sanitation facilities. They tend to be granted access to these facilities at schools and hospitals as well. Whereas poor people tend to lack such access to these facilities, especially in developing world because the universal access to clean water and safe sanitation facilities are realized in most parts of developed world. In similar vein, Deaton highlighted poverty channel through which health effect of income inequality is quite well captured especially in the context of low-and-middle-income countries (Deaton, 2003).

Building on (Anand and Bärnighausen, 2012, 2007, 2004a; Cutler et al., 2006; Gunther and Fink, 2010; Hoddinott, 1997; Novignon and Lawanson, 2017; Nyamuranga and Shin, 2019; Pickett and Wilkinson, 2015; Szreter, 1988; Watson, 2006; Wilkinson and Pickett, 2006; Woods et al., 1989, 1988) we present the determinants of child mortality in Figure 4, which in turn, serves as a conceptual background of the analytical models in Chapter 5.

Figure 4. Determinants of child mortality in LMICs, a health economics perspective



The dissertation project aims to address the gap identified in the literature by clarifying the theoretical/ conceptual background of both child mortality and water access inequality (i) and by generating robust empirical evidence on whether water access inequality is a significant determinant of child diarrhea mortality in the context of low-and-middle-income countries by applying a mixed methods approach (ii). To achieve this goal, we follow 4 mutually exclusive yet sequential set of objectives. First, we aim to provide a theoretical/conceptual background of the project by setting a story for health and economic development through a political economy lens (i), clarifying the determinants of child mortality from a health economics perspective (ii), clarifying the concept of socioeconomic inequalities in water access from a welfare economics perspective (iii), highlighted a plausible economic transmission channel (iv), and selecting a preferred method to quantify water access inequality based on the review of relevant empirical literature (v).

Second, building on this background, we construct water access inequality index in order to reveal its global trend and patterns by assessing 61 countries (objective 2) between 2000 and 2017 (N=61 and t=18).

Third, we assess the likely effects of water access inequality on the two child mortality outcomes by utilizing an extended panel approach with Driscoll-Kraay standard error and the panel data constructed for 47 countries covering the period between 2000 and

2017 (N=47 and t=18). In doing so, we combine the datasets from own estimates of Chapter 4 and other international sources to construct a multi-country, multi-year panel.

Fourth, the last empirical analysis aims to assess how water access inequality affects 'success' and 'failure' of the efforts in reducing child diarrhea mortality in the cases to be selected by applying a comparative case study approach.

Hypotheses:

Theoretical literature yields hypotheses-1, which is tested in Chapters 5, while hypothesis-2 is tested in Chapter 6.

H-1: *Water access inequality* is significantly positively associated with *child diarrhea mortality*

H-2: *Changes in water access inequality (WII)* are significantly associated with *changes in child diarrhea mortality (CDM)*

H-2.1: Decrease WII – Success CDM

H-2.2: Increase WII – Failure CDM

H-2.3: Absence of progress WII - Success CDM, if the absence of change in WII is due to the presence of a high initial coverage of water

H-2.4: Absence of progress WII - Failure CDM, if the absence of progress in WII is due to the absence of improvement towards full coverage of water

2.2 Data, Sources and Variables

The research project exploits publicly available international datasets from the Institute for Health Metrics and Evaluation (IHME), World Development Indicators, WHO/UNICEF – Joint Monitoring Program, UNDP – Human Development Index, and WHO. In doing so, a panel on the key explanatory variable (water access inequality) and a control variable (sanitation access inequality) were estimated by the author building on the WHO/UNICEF –JMP wealth-quintiles datasets for all countries in the sample. In doing so, we utilized data on basic category of water services (as well as sanitation services) as it is the second-best category, where wealth quintile dataset is available. This dataset is built based on the estimates of DHS & MICS household survey (WHO-UNICEF, 2018). Water access expressed by wealth quintiles are produced by applying Principal Component Analysis (PCA), following the method suggested by Filmer & Pritchett (2001).

The most influential academic journals in health economics include Journal of Health Economics, Health Economics, Health Services Research, Pharmacoeconomics, and Journal of Human Resources, while Top 10 most cited scientists globally were David M. Cutler, Jonathan Gruber, Paul Newhouse, Mark V. Pauly, W. Kip Viscusi, Janet M. Currie, Michael Grossman, Frank A. Sloan, Adam Wagstaff, and Eddy van Doorslaer, and the highest ranked institutions were Harvard University, World Bank, MIT, University of California at

Berkeley, Chicago University, Pennsylvania University, Michigan University, and York University (Jakovljevic and Ogura, 2016, p. 2).

Table 3. Variables and Data sources

No	Indicator	Source	Scale
1	U5MRD	IHME	log scale, Per 1000 live births
2	U5MRD, female	IHME	
3	U5MRD, male	IHME	
4	IMD	IHME	
5	IMD, female	IHME	
6	IMD, male	IHME	
7	Water access inequality index (WII)	Own estimates using JMP data	log scale, ranges between -1 and +1
8	Sanitation access inequality index (SII)	Own estimates using JMP data	log scale, ranges between -1 and +1
9	GDP per capita	World Development Indicators	log scale, per capita PPP (current international $)
10	Gini index	World Development Indicators	log scale, 0-100, %
11	Female education	UNDP	log scale, Percentage of population
12	Physicians' density	World Development Indicators	Per 1000 people
13	Health expenditure per capita	World Development Indicators	log scale, per capita PPP (current international $)
14	ORS coverage	IHME	log scale, Percentage
15	Cereal yield	World Development Indicators	log scale, kg per hectare
16	Urbanization	World Development Indicators	log scale, Percentage of population
17	Breastfeeding exclusive	IHME	Percentage

Note: The reasons for inclusion and exclusion of the variables are discussed in Chapter 3.

Justification on the selection of the variables:

Building on the theoretical background (Figure 4), we include the following determinants of child mortality caused by diarrhea in the empirical analyses: GDP per capita, Income inequality, Nutrition, Urbanization, Female education, Healthcare, and Treatment – ORS. These determinants are in line with the synthesis study of David Cutler, Angus Deaton and Lleras-Muney. Since our key interest is accounting the distribution of water access, water access inequality (WII) came to the model as a key explanatory variable, instead of water. For the same reason, we include sanitation access inequality (SII) in the model as a control variable. Moreover, maternal health is suggested as a determinant in child mortality by Cutler and colleagues, yet we consider mother's health is captured by nutrition variable in our macro-analysis, as nutrition is associated with good health (Fogel, 1997). In addition, since we take the nutrition into account as a determinant, we should also control a nutritious status of children. Breastfeeding is known as the most nutritious food for infants and children, and associated with better nutritious status (Roberts et al., 2013). To capture this effect, we included breastfeeding variable in the analytical model.

Immunization variable is excluded from the empirical panel models due to the following reasons. First, our dependent variable is child mortality caused by diarrheal disease. Against diarrheal infection, there is only one vaccination available to date, which first launched in 2006 (World Health Organization, 2021). Despite its availability, Rotavirus vaccine is one of the relatively new and underutilized vaccines, therefore, panel data on coverage of rotavirus vaccine is not sufficiently enough. For this reason, it is excluded. To date, there is no study published that was able to observe the effect of Rotavirus vaccine in a cross-country panel design. All-cause-mortality studies that accounted for the effects of immunization were always included other key vaccines other than Rotavirus vaccine. However, these other routine vaccines are not protective towards diarrheal infection; therefore, these are also excluded from our analytical model. Furthermore, how scarce the data on the coverage of Rota-vaccine is visible in Chapter 6.

2.3 Methods

2.3.1 Concentration index as a preferred approach to socioeconomic inequality

Chapter 4 quantifies water access inequality index by applying Concentration index (CI) approach developed by the prominent health economists of our time (Kakwani et al., 1997; O'Donnell et al., 2007; Wagstaff et al., 1991). It is rooted from a welfare economics foundation (Bleichrodt and van Doorslaer, 2006). As an alternative approach to socioeconomic inequality, CI is a competing approach to egalitarian approaches such as human opportunity index (HOI), which was built upon the concept of equality of opportunity (Paes de Barros et al., 2009; Roemer, 1998) and the concept of Equality of Capability (Sen, 1993, 1992). The key advantage of the CI approach is twofold. First reason is its efficiency and accuracy compared to HOI (Kanbur and Wagstaff, 2014) and other approaches such as The range, Lorenz curve and Gini index, Pseudo Lorenz curves and the index of dissimilarity (Wagstaff et al., 1991). Second, its pragmatic ability to be integrated into existing knowledge and datasets collected through decades of international collaboration compared to both. For example, CI is already integrated to measuring global health efforts such as Health Equity Assessment Toolkit (HEAT) of WHO. This idea is also highlighted by the inequality researchers (Cetrulo et al., 2020) suggesting it can be integrated to measuring water access inequalities under the umbrella of Sustainable Development Goal 6, despite its limitation for being unable to capture multidimensional aspects of inequality.

2.3.2 Panel approach

For Chapter 5, the panel fixed effects regression models are constructed to test the hypothesis – 1. In each model, each outcome variable is specified as a linear function of household water access inequality (Greene, 2003). For the period of 2000 and 2017, the model examines the child mortality effects of water access inequality. We interpolated and standardized by transforming into logarithmic values.

We conducted 7 diagnostic tests to select the appropriate model and their extensions.

2.3.3 Comparative case study approach

Chapter 6 tests the hypothesis – 2 by looking at two country cases by applying comparative case study approach, following a political economy book (Benczes, 2023), in which I contributed Chapter 12 (Bulgamaa, 2023). This study compared two distinct cases through a paired comparison process to assess whether changes in water access inequality is associated with 'success' and 'failure' in the efforts reducing child diarrhea mortality.

2.3.4 Software

The analysis was carried out in STATA 17.0 software. Some visualizations were generated in Tableau, the web-tools of World Bank, IHME, and MS Excel.

3. Findings & Payoffs

3.1 Findings

The key findings of the dissertation as follow:

- Water access inequalities matter for child mortality (**H-1).**

- Decrease in water access inequalities are significantly positively associated with success in child mortality reduction **(H-2.1).**
- Increase in water access inequalities are significantly positively associated with failure in child mortality reduction **(H-2.2).**
- Absence of progress in water access inequalities (WII) is significantly positively associated with *success* in child diarrhea mortality (CDM), if the absence of change in WII is due to the presence of a high initial coverage of water **(H-2.3).**

Conversely,

- When investigating two outliers, we fail to reject the null hypothesis of the H-2.4: Absence of progress in water access inequalities (WII) is associated with failure in child diarrhea mortality (CDM), if the absence of progress in WII is due to the absence of improvement towards full coverage of water **(H-2.4).**
- This suggests that water inequality effect can be camouflaged when testing on the total mortality data. Because we found evidence indicating (WII) inequality increased due to increased coverage for rich and decreased coverage for poor. In this case, the rich gains health, while the poor loses health, given that water and health are directly associated. In this case, health gain of the rich may offset health loss of the poor, which in turn appear as a net health gain for the general population.

It, therefore, does not necessarily contradict the hypothesis on the relationship between water inequality -child mortality.

- It, therefore, suggests that inequality-inequality analysis (inequality in water access – inequality in child mortality).
- All in all, our findings broadly suggest that water access inequalities matter for child diarrhea mortality (i), and water access inequalities may hinder progress in efforts reducing child diarrhea mortality (ii).

3.2 Payoffs

Chapter 2 contributes the existing literature by three ways. First, its attempt to conceptualize water access inequality and highlight an economic pathway is often neglected in the published empirical studies. Second, clarifying a health economics approach to child mortality studies is an added value, given that the study of child mortality is interdisciplinary in nature and it is not often clearly stated. A myriad of existing studies approached from various different perspectives such as epidemiology, public health, social science, development studies, welfare economics, historical and neoclassical economics, make it even more difficult. Third, the conceptualization of this chapter as a whole is unique itself, given that an intersection of water and health research approached from an economics perspective is rare, not to mention its attempt to integrate the notion of distributive justice into the water variable.

The main contribution of Chapter 4 is generating water access inequality index, which allows a further analysis to assess its likely effect on child mortality outcomes. In doing so a new approach to water inequality discourse is applied to build a multi-country panel by borrowing from health inequality research. This approach has important advantages, compared to alternative approaches, such as more effective, more accurate, highly pragmatic and easy to integrate with existing datasets accumulated as a result of decades long international cooperation.

Chapter 5 contributes the literature by bringing a new explanatory variable – water access inequality – into the debate on global child mortality in which we attempt to recognize the role of the distribution of water access for child survival in LMICs, on the one hand, and exploiting a new global dataset on child mortality on the other. It also addressed limitations of the previous studies by focusing on socioeconomic aspect rather than geographic aspect of water inequality (Local Burden of Disease WaSH Collaborators, 2020) and applying a panel design rather than (repeated) cross-sectional design (Cha et al., 2017; Hasan and Alam, 2020). In constructing the panel, we used several techniques to improve its efficiency by interpolating (Anand and Bärnighausen, 2004b; Jamison et al., 2016); extending the panel by including country-time-fixed-effects (Greene, 2003) and Driscoll-and-Kraay standard errors (Hoechle, 2007); and performing robustness check with alternative datasets. In addition, we complement the study by approaching through in-depth comparative analysis in Chapter 6.

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