Health and Economic Effects of Piped Water

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1 Introduction

According to a 2006 study by the Asian Development Bank over 100 million of the 250 million Indonesians do not have access to safe drinking water and an additional 75 million rely on potentially contaminated sources. These numbers have declined however since the Indonesian economic crisis of 1998 the expansion and maintenance of water services have faltered. Estimates are that only 2 US dollars per person is being invested annually on water and sanitation in Indonesia, far less than other low and middle-income countries. (The Water Dialogues 2009). Currently, the only evidences of piped water's impact on health and economic outcomes published in peer reviewed journals is a decrease in infant mortality (see Gamper-Rabindran et al 2007 and Galiani et al 2005), one paper which shows increase in years of school attended for young girls (see Gould et al 2009) and another paper showing a significant negative externality of piped water operating through sanitation and resulting in an overall negative effect of piped water on health (see Bennett 2011). Previous studies have been unable to determine piped water's impact on an individual's health and economic prosperity because of data limitations. My research explores these individual level impacts as well as gender differential effects by exploiting the quasi-experimental variation created by the gradual expansion of piped water services in Indonesia over the past decades.

I will analyze the effects of piped water on infant mortality, the long term effects on later life health and economic outcomes and how those effects differ by gender. Clean water is critical to maintaining proper hygiene during childbirth and therefore readily available safe water could result in decreased maternal and infant mortality. Furthermore, water's influence on infant mortality is extended through diarrhea, the second leading cause of death for children under five in Indonesia and caused, mainly, by contaminated drinking water (Asian Development Bank 2006). Furthermore, health is a stock that is constantly evolving beginning in utero and early life inputs such as water can have potentially large effects on later-life economic outcomes. This is known as the fetal origins hypothesis from the seminal work by Barker (1992). Therefore, piped water is likely to affect the health of adults and consequentially their economic outcomes. And the effect of piped water on the health of adults is likely to differ by gender because of the disproportionate burden carried by women in developing countries to provide water to their home. In Indonesia, as in many other developing nations, the task of carrying water to and from its source belongs to women (World Bank Group 1994). This exhausting and physically demanding task is costly and many case studies show its negative effect on female health (see Ray (2007) for a review).

The data and the quasi-experimental variation created by the gradual introduction of piped water in Indonesia allow my research to fill at least three voids in the current literature. First, the Indonesian Family Life Survey (IFLS) contains individual level data whereas the current literature uses mostly community level data without measures of individual health or economic status. Second, with individual data I am able to disentangle the differential effects of piped water on men and women. Third, because of the panel structure of IFLS I am able to exploit the quasi-experimental variation and control for household fixed effects to attain a plausibly exogenous identification strategy.

2 Data

2.1 Water Infrastructure in Indonesia

In Indonesia, a corporation owned by the local government known as a Perusahaan Daerah Air Minum, or PDAM, operates all water services provided by the government. Importantly, the Ministry of Finance is in charge of allocating funds for the development and expansion of infrastructure and these funds originate from taxes and the domestic capital market. Prior to the later 1960s very few cities in Indonesia had public water utilities (PDAM). By the mid 1990s the number of PDAMs had grown to over 300. 39% of the population in the early 1980s was estimated to have access to safe drinking water. By 2004 62% of the population was estimated to have access to safe drinking water and 77% had access to an improved water source. These numbers are still well below the Millennium Development Goal that at least 73% of the population has access to safe drinking water. The expansion of the water infrastructure in Indonesia beginning in the late 1960s was relatively constant until 1998 when the entire country suffered an economic crisis. Infrastructure investment dropped from 14 billion US dollars in 1994 to 5 billion in 2002.

2.2 Indonesian Family Life Survey

I use the Indonesian Family Life Survey (IFLS) that allows me to control for unobservable family-specific influences on health and economic outcomes. IFLS is an ongoing longitudinal survey that has been conducted in four waves, the first occurring in 1993, the second in 1997, then in 2000 and 2007. Additionally, there was a subsample survey conducted in 1998 designed to collect information on the impacts of the economic crisis that hit Indonesia during that year. The study is representative of 83% of the Indonesian population with over 30,000 individuals surveyed in 13 of the 27 provinces. IFLS collects many indicators of health, such as chronic conditions and general symptoms, self-reported health and other anthropometric measures recorded by trained interviewers. Included amongst these anthropometric measures are height, weight, blood pressure, cholesterol levels and lung capacity. Of particular interest to this study is height because of it's well-documented relationship to early life health inputs. However, I also investigate how piped water's effects on weight-for-age and weight-for-height as well as how these effects differ by age and by gender. IFLS also collects detailed pregnancy histories for each adult woman in the sample and it includes miscarriages. This allows for a detailed examination of infant mortality, more detailed than previous studies that used community level rates that are potentially biased from misreporting. Also, the data includes information on attained education, wages, income, assets and other measures of wealth. This information allows for the investigation of the fetal origins hypothesis that early life inputs such as water and nutrition impact later life economic outcomes. As with the previously mentioned anthropometric measures of health, I also investigate how these effects differ by age and by gender.

3 Model

I will employ multiple empirical models to ascertain the effects of piped water, beginning with a household fixed effects model:

$$Y_{ijt} = \beta_0 + \beta_1 Treat_i + \beta_2 X_{ijt} + \alpha_j + \epsilon_{ijt} \tag{1}$$

The variable $Treat_i$ indicates whether or not the individual was under the age of 5 when the community received piped water. In past research current and long term height has been shown to be malleable to health inputs up to the age of 5. Investigating the differential impacts of piped water on males and females is very simple requiring the addition of one interaction term:

$$Y_{ijt} = \beta_0 + \beta_1 Treat_i + \beta_2 Treat_i \times Female_i + \beta_3 X_{ijt} + \alpha_j + \epsilon_{ijt} \tag{2}$$

Additionally, to investigate piped water's impact on infant mortality I will employ a the following latent variable model that controls for the genotype with a household fixed effect, α_m. The treatment variable, $Treat_i$ will be examined at various stages of the child's life, trying to identify critical periods of health inputs.

$$Y_{imt} = \beta_0 Treat_i + \beta_1 X_{mt} + \alpha_m + \epsilon_{imt} \tag{3}$$

$$Y_{imt} = \begin{cases} 0 \text{ if } Y^*_{imt} < 0 \\ 1 \text{ if } Y^*_{imt} \geq 0 \end{cases} \tag{4}$$

4 Results

The preliminary results demonstrate significant beneficial effects of piped water on height. The distributions of height for treated and untreated groups appear distinct and the distributions of placebo groups, as well as tests of the same, do not appear different from those of untreated groups.[1]

Table 1 is divided into 4 panels, panel A describes the effect of having access to piped water when younger than 5 on various anthropometric measures, panel B describes the effect of having access and mainly using piped water, panel C reports the estimates for the 5 to 8 placebo group and panel D reports the estimates for the 9 to 12 placebo group. The three anthropometric measures used are height for age z-score, weight for age z-score and weight for height z-score, with height being the measure for which the biological evidence is most clear. The first three columns display the estimated impacts on these three health outcomes using household fixed effects, and the last three use community fixed effects. In panels A and B we see that the effect of piped water is both positive and significant on height, while it's effect on both measures of weight is inconclusive. Furthermore, panels C and D show significantly negative effects of piped water on height for the placebo groups. All this evidence tells the coherent story that piped water significantly benefits health in Indonesia.

5 Future Work

Preliminary results show significant differences between both the distributions and means of the height of individuals with access to piped water at a young age and those without. Additionally, test of placebo groups show that the impact of piped water on health is operating as predicted by the biological evidence and that there does not appear to be other unobserved changes occurring simultaneous to the introduction of piped water throughout Indonesia. Current work is being done to clean the indicators of exposure to piped water, particularly for those households and individuals that move. The next steps are to differentiate the gender effects and incorporate both pregnancy histories and measures of economic outcomes such as education and wages to determine piped water's impact. The greater understanding of the value of clean water that this research achieves will provide a foundation for future research involving the optimality and sustainability of water markets.

6 Tables

The above described Table 1 is included on the following page.

[1] Because this research is at an early stage the results are constantly evolving and I will undoubtedly have different results when I present at the PAA conference in May. However, additional results are currently available but not included due to space considerations.

Table 1: Preliminary Estimation Results

	Dependent Variables					
	Height for Age Z-Score	**Weight for Age Z-Score**	**Weight for Height Z-Score**	**Height for Age Z-Score**	**Weight for Age Z-Score**	**Weight for Height Z-Score**
Panel A						
Less than 5 when pipes introduced	0.12 ***	0.04	-0.82 ***	0.05 *	-0.06	-0.26
	(0.02)	(0.03)	0.25	(0.03)	(0.05)	(0.95)
Spline of Age 1	-0.14	-0.09	-0.22	-0.14	-0.09	-0.22
	(0.01)	(0.01)	0.05	(0.01)	(0.01)	(0.04)
Spine of Age 2	-0.01	-0.01		-0.01	-0.01	1.09
	(0.00)	(0.00)		(0.00)	(0.00)	(0.04)
Spline of Age 3	-0.01	0.05		-0.01	-0.05	-1.34
	(0.00)	(0.00)		(0.00)	(0.00)	(0.10)
Spine of Age 4	-0.02	-0.03		-0.02	-0.03	
	(0.00)	(0.01)		(0.00)	(0.00)	
Parentage Controls	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects	Household	Household	Household	Community	Community	Community
Robust Standard Errors	Yes	Yes	Yes	Yes	Yes	Yes
Panel B						
Less than 5 and household uses piped water	0.08 ***	-0.05	0.08	0.07 **	-0.03	0.12
	(0.02)	(0.03)	(0.17)	(0.03)	(0.04)	(0.08)
Spline of Age 1	-0.14	-0.09	-0.02	-0.14	-0.09	-0.22
	(0.01)	(0.01)	(0.05)	(0.01)	(0.01)	(0.04)
Spine of Age 2	-0.01	-0.01		-0.01	-0.01	1.09
	(0.00)	(0.00)		(0.00)	(0.00)	(0.05)
Spline of Age 3	-0.01	0.05		-0.01	0.05	-1.32
	(0.00)	(0.00)		(0.00)	(0.00)	(0.05)
Spine of Age 4	-0.02	-0.03		-0.02	-0.03	
	(0.00)	(0.00)		(0.00)	(0.00)	
Parentage Controls	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects	Household	Household	Household	Community	Community	Community
Robust Standard Errors	Yes	Yes	Yes	Yes	Yes	Yes
Panel C						
False Treated: Age 5-8 when pipes introduced	-0.11 ***	-0.06	0.51 ***	-0.05 **	-0.03	0.03
	(0.03)	(0.04)	(0.15)	(0.03)	(0.04)	(0.11)
Spline of Age 1	-0.14	-0.09	-0.22	-0.14	-0.09	-0.22
	(0.01)	(0.01)	(0.05)	(0.01)	(0.01)	(0.04)
Spine of Age 2	-0.01	-0.01		-0.01	-0.01	1.09
	(0.00)	(0.00)		(0.00)	(0.00)	(0.04)
Spline of Age 3	-0.01	0.05		-0.01	0.05	-1.32
	(0.00)	(0.00)		(0.00)	(0.00)	(0.05)
Spine of Age 4	-0.02	-0.03		-0.02	-0.03	
	(0.00)	(0.00)		(0.00)	(0.00)	
Parentage Controls	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects	Household	Household	Household	Community	Community	Community
Robust Standard Errors	Yes	Yes	Yes	Yes	Yes	Yes

7 References

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