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The long-run effects of treated water on education: The rural drinking water program in China☆

Jing Zhang [a], Lixin Colin Xu [b,*]

[a] China Financial Policy Research Center, School of Finance, Renmin University of China, 59 Zhongguancun Street, Beijing 100872, China
[b] MC 3-307, Research Group, World Bank, 1818 H Street, NW, Washington, DC 20433, United States

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ABSTRACT

Since little is known about the long-run effect of treated water, we examine the educational benefit to rural youth in China from a major water treatment program started in the 1980s. By employing a data set covering two decades and encompassing more than 4700 individuals between ages 18 and 25, we find that, on average, the program increased the completed grades of education of rural youth by 1.1 years. Moreover, the effect was highly heterogeneous across gender and age of exposure. Rural girls benefited from water treatment more than rural boys such that the water treatment program completely eliminated the gender gap in education in treated villages. Young rural people with access to treated water in early childhood experienced significantly higher gains in schooling attainment (i.e., by more than a year) than those that gained access at later stages of life. Our analysis suggests that this program was cost-effective.

1. Introduction

The poor quality of drinking water has been a serious threat to human health in the underdeveloped areas around the world for centuries. As of 2008, almost 900 million people still rely on unsafe drinking water (World Health Organization, 2011). In particular, with the ongoing industrialization process in developing countries, chemical impurities associated with untreated industrial waste and excessive use of agricultural fertilizers and pesticides have become increasingly important contaminants in drinking water. While the health benefits of treated water have been extensively studied (e.g., Blum and Feachem, 1983; Merrick, 1985; Esrey et al., 1991; Jalan and Ravallion, 2003; Cutler and Miller, 2005; Fewtrell et al., 2005; Galiani et al., 2005; Arnold and Coldford, 2007; Clasen et al., 2007; Maimaitwe and Siebert, 2009; Gamper-Rabindran et al., 2010; Kremer et al., 2011; Bennett, 2012; Devoto et al., 2012), little is known about its possible *long-run* benefits. To fill this void, in this paper we examine the longer-term benefits of treated water on the completed grade of education by youth, following the rollout of a major rural drinking water program that began in China in the early 1980s. In light of the recent literature that emphasize differential impacts of health interventions on gender due to their gender-specific impacts on brawn (Pitt et al., 2012) and the critical importance of early childhood health and nutrition (Cunha et al., 2006; Heckman, 2008; Almond and Currie, 2011), we also explore how the effects of treated water differ by gender and by age of exposure.

One of the world's most ambitious programs for improving water quality for poor people, this rural drinking water program, starting from the early 1980s, had incurred a total cost exceeding 8.8 billion U.S. dollars by 2002, and had covered 300 million people by 2008 (Center for Health Statistics and Information, Ministry of Health of the People's Republic of China, 2009). The program aims to build water plants and pipelines to provide rural residents with safe drinking water. A key component of the new water treatment plants has been to eliminate chemical contaminants and microorganisms by installing clean water technology and equipment. So far, few studies have been

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* Corresponding author at: MC 3-307, World Bank, 1818 H Street, N.W., Washington, DC 20433, United States.
E-mail address: lixin.colin.xu@gmail.com (L.C. Xu).

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conducted to evaluate this important program.[1] In this paper, by employing the longitudinal data of the China Health and Nutrition Survey (CHNS) from 1989 to 2011, we study the long-run educational benefits of the improvements in drinking water *quality* on rural populations.[2]

Our investigations suggest that young people in villages with access to treated water had better education than those without such access: the completed grade of education among youth increased by 1.1 years. The results are obtained after controlling for local educational policies and resources, household characteristics, and village characteristics such as distances to schools. These results remain robust after dealing with the endogeneity of the water treatment program by using topographic features of villages as the instrumental variable; moreover, we do not find villages in the treatment group and those in the control group differed significantly in key observable characteristics before the water program had been launched. We further show that the qualitative results remain robust after we control for village fixed effects, control for water access (i.e., whether a household has on-premise access to water), and estimate heterogeneous effects by gender and by age of exposure.

We find strong support for the brawn theory of gender division of labor in Pitt et al. (2012). In particular, boys gained more body mass than girls from using treated water; girls benefited more from water treatment than boys in terms of schooling attainment, and boys and girls with an older brother benefited more than those with an older sister. The program benefited girls much more than boys so that the gender gap in completed grade of education observed in rural China was completely eliminated by the introduction of this program in treated villages.

Young people that had access to treated water in early childhood (i.e., 0–2 years of age) experienced greater gains in education (by around a year) than those without such access until after early childhood, consistent with the recent literature on the critical importance of early childhood development for human capital investment (Almond, 2006; Cunha et al., 2006; Heckman, 2008; Maccini and Yang, 2009; Cunha et al., 2010; Almond and Currie, 2011). Our estimates also suggest that this program was highly cost-effective.

Our paper contributes to several strands of literature. The *first* is the literature of the effects of health-oriented government programs on youth's final educational achievement. Several studies examine the educational benefits of health programs. For instance, Bleakley (2007) finds that hookworm eradication in the 1910s improved school enrollment of children between ages 8 and 16, but a significant increase was found only in quality of education instead of quantity of education (years of schooling) over the long term. Lucas (2010) shows that the program of malaria eradication had positive effects on female education and literacy rates of ever-married women in Paraguay and Sri Lanka, while Cutler et al. (2010) find that a similar program of malaria eradication had no such positive effects in Indonesia. Our analysis follows this line of research by studying the long-run effects of the rural water treatment program on education in China.

The *second* is the literature on the effects of safe drinking water programs. While the literature on water programs is large, as we listed earlier, few rigorously examine the effect of *water treatment and water quality* on education, especially on final schooling attainment.[3] Drinking water of higher quality improves young people's health, allowing them to improve their educational competency through reduction in absenteeism and improvement in mental focus and energy levels (Alderman et al., 2001). However, while this intervention likely benefits short-term education of the youth, there is no guarantee that it will benefit the final educational attainment. Indeed, since health is also positively correlated with individuals' labor market outcomes such as higher wage rates (Thomas and Strauss, 1997), greater labor supply, enhanced self-employment profits, and agricultural productivities (Strauss, 1986), a healthier youth may choose to participate in the labor market rather than to stay in school. Thus, the program could have resulted in gains in employment and income yet losses in final educational attainment. We add to this literature by focusing on the effect of a comprehensive water treatment program in which improvements in water *quality* is a key component. We also examine the long-run effects on children's final schooling attainment and how the effect differs by gender and by age of exposure. Furthermore, this study evaluates the water treatment program in *rural* areas where residents are usually less privileged throughout the world, as compared to most existing studies that focus on urban residents. Studying water treatment in rural areas is important: their welfare is crucial from the equity perspective; and usually water treatment programs are less cost-effective in rural than in urban areas due to a low population density. We show that this water treatment program in rural areas has significantly improved educational attainment of rural youth and has been highly cost-effective.

The *third* strand is the literature of human capital investment and the gender division of labor (e.g., Becker et al., 2010; Field and Ambrus, 2008; Jensen, 2012; Pitt et al., 2012). We add to this literature by providing a dramatic example in which a health intervention results in improvements in education for rural girls to such a greater extent than for rural boys through the brawn channel that the gender gap in education is completely eliminated in treated villages.

The *fourth* contribution is to the literature on the long-run effects of early childhood conditions (see Maccini and Yang, 2009; Maluccio et al., 2009; Cunha et al., 2010; Almond and Currie, 2011). We show that exposure to treated water at very young age (i.e., 0–2 years of age) had much more pronounced effect on a person's final schooling attainment than exposure at older ages.[4]

Finally, few studies examine the cost effectiveness of fiscal programs in China. Given the magnitude of China's fiscal pie—its fiscal spending is about 14 trillion Yuan (i.e., 2.3 trillion U.S. dollars) in 2013—more evaluations of specific programs are called for, and the current study highlights a program of high cost-effectiveness.

2. The rural drinking water program in China

Before the 1980s, rural residents in China largely relied on untreated water from wells, rivers, and lakes. More than 70% of rural residents in the CHNS dataset drank untreated water in 1989. Sanitation was poor as human and livestock wastes were disposed of freely around dwellings within villages. These unsanitary practices routinely caused endemics of water-related diseases. While microorganisms, the major drinking water contaminants in many other developing countries, have less adverse consequences in China due to the tradition of drinking

[1] An exception is Zhang (2012), which examines the benefits of this program on health. Despite studying the same program, the major differences between ours and Zhang (2012) lie in the following. Zhang (2012) focuses on the health outcomes of adults and children, while our paper studies the long-run effect of this program on youth's completed grade of education. Moreover, we allow the effects to differ by gender and by age of exposure.

[2] Here by a long-run effect we mean the effect on final educational attainment (that is, how many years of education a person chooses to complete in total), which has been shown to exert huge influences on his or her lifetime income and welfare. Long-run effects also imply that the effect can be cumulative over decades (such as from age one to two to the early adulthood). This is in contrast to a short-term effect that shows up within a couple of years of the treatment, as usually measured by school attendance or test scores.

[3] Kosec (2014) uses child-level data from 39 African countries and finds that private sector participation in piped water decreases diarrhea among urban under-five children, and is associated with an 8 percentage point increase in the school attendance of 7–17 year olds. This study does not examine the impact on final educational attainment. Moreover, the water treatment program in Kosec (2014) examines access to piped water, not the change in water quality.

[4] Maccini and Yang (2009) find that Indonesian women experienced long-run gains in education (and other socioeconomic outcomes) when they had favorable weather shocks at their birth years. No such effects are found for Indonesian men. They interpret this as evidence of gender discrimination — parents allocated limited food to boys rather than girls in time of food scarcity.