The impact of access to clean water on health of the elderly: Evidence from China

Chenxi Liu
Marianapolis Preparatory School, 26 Chase Rd, Thompson, CT, US
Email: cliu20@marianapolis.org

Abstract. Access to clean water is a crucial part for the health of humans. Many present and previous studies have found that drinking water quality affects people’s health. Our study aims to find the association between drinking water and health of the elderly in China. Through regression analysis, the results show significant association between water facility (access to tap water) and old people’s depression level, difficulties to do daily activities and self-assessed health. The harmful chemicals in unsanitary water bring health risks to the old people. We suggest the government that investing more money on drinking water facilities is necessary to improve both physical and mental health of the elderly.

1. Introduction
Over the decades, people’s living condition becomes much better in China, but there are many environmental and health problems needed to be dealt with. As the economy grows, there is an initial phase of environment deterioration followed by a subsequent period of improvement, known as the Environmental Kuznets Curve [1]. At the beginning of industrial development, the developing countries have only the ability to produce pollution-intensive goods. What’s worse, these countries have no previous experiences with industrial development, so they don’t have strict policy associating with the environmental policies. Via an “induced policy response,” “as nations or regions experience greater prosperity, their citizens demand that more attention be paid to the non-economic aspects of their living conditions.” With stringent environmental standards and laws, the developed countries often have cleaner water and better air conditions. The environmental conditions in different countries may not happen exactly as the curve indicates, but some developing countries can learn from the pattern concluded from the developed countries and pay attention to environmental problems at an early stage. Scientists have researched into this field; however, due to the limited availability of data, only a few have taken a look at the problem in China.

With a considerable increase in average income, Chinese people enjoy a better material life but there is no large increase in their life expectancy [2]. As shown in Figure 1, the Gross Domestic Product (abbreviated as GDP) of China increases dramatically during the past 20 years; it is now getting close to the GDP growth rate of America. Accordingly, China is approaching the downward sloping phase of Environmental Kuznets Curve (abbreviated as EKC). Similar to the experience of developed countries, it is policy response that dominates the improvement of environment in China. Moreover, the tight relationship between environmental quality and economic growth shown by the EKC theory along with other research findings indicate that the economic policies are crucial to the making improvements in environment, and only one or two country’s change can help avoid a global disaster [3].
As shown in Figure 2, under the force of newly revised Water Pollution Prevention and Control Law of the People's Republic of China, the public private partnerships (PPP) investment in water and sanitation surged in 2007 and 2017, when the law was enforced and revised, respectively. While the effects of the law and regulations remained to be examined, a number of studies indicate that water pollution imposes significant health risks and improving water quality brings tremendous benefit to people’s health. There is robust evidence suggesting that clean water and advanced sewerage treatments save infants’ and young children’s lives [4]. Drinking water that are not disinfected contains heavy metals and sometimes bacteria, so it increases people’s health risk [5]. These previous works mainly utilize mortality rates and biomarkers as a dependent variable, however, few of them takes mental health and people’s abilities for daily activities into consideration.

In the perspective of government, water pollution is a more difficult problem to tackle compared to air pollution. In contrast to the top-down approach to deal with air pollution issues, water pollution problems require a bottom-up approach - all the people from the bottom to top to pay attention to water resources and water issues so that water conservation can be put into effect and improve
people’s health [6]. As shown by endogenous economic growth theories, improved health may increase human capital, thus, contributes to the engine of economic growth [7].

Given the health benefit in terms of mortality of improving water quality, and the gap in the understanding of how access to clean water affects mental health and abilities for daily activities in the existing literature, it is worthwhile to study the effects of access to water sanitary facilities on mental health. This paper discusses the relationship between access to drinking water quality and people’s mental health status, using data of a nationally-representative survey in China. This paper is organized in the following way. We start with offering the background of China economy growth and environmental degradation in the introduction part. It is followed by explaining the data, method, and model we applied. Then the results are shown with discussion. We end up with conclusion, summarizing the findings.

2. Data and methodological framework

This study utilizes data of China Health and Retirement Longitudinal Study (CHARLS). Collecting data from a nationally representative sample of Chinese residents ages 45 and older around 28 provinces around China, CHARLS is able to serve the needs of scientific research on the elderly. The study is carried out every two years after the baseline national wave in 2011. The Data can be downloaded after requesting from the official site charls.pku.edu.cn. STATA is the software we used to view and analyze the data. We used biomarker, community, and demographic data of the study. There are 20,435 residents who took part in the CHARLS 2015 survey. Table 1 shows the detailed demographic distribution of CHARLS 2015 wave sample.

| Age Group | Percent | Male (%) | Female (%) | Urban (%) | Rural (%) |
|-----------|---------|----------|------------|-----------|-----------|
| <50       | 23.34   | 21.5     | 25.04      | 23.78     | 23.04     |
| 51-55     | 16.73   | 16.65    | 16.8       | 17.26     | 16.37     |
| 56-60     | 15.05   | 15.45    | 14.68      | 14.96     | 15.11     |
| 61-65     | 16.74   | 16.93    | 16.57      | 16.67     | 16.8      |
| 66-70     | 11.74   | 12.58    | 10.98      | 10.88     | 12.34     |
| 71-75     | 7.81    | 8.21     | 7.43       | 7.55      | 7.98      |
| 76-80     | 4.95    | 5.36     | 4.56       | 5.32      | 4.69      |
| >80       | 3.64    | 3.31     | 3.94       | 3.58      | 3.68      |
| Total     | 20435   | 9787     | 10648      | 8343      | 12092     |

Note: Overall, most of the respondents in the sample of CHARLS 2015 age from 45 to 65. The number of female samples are a little bit greater than male samples. There are more people who live in rural areas than those who live in urban areas. Data source: CHARLS 2015.

CHARLS data contains a wide array of information on the demographics, education, health, income, etc. In the individual questionnaire, the respondents are asked how often they feel depressed in the past week with four choices provided i.e. “1 Rarely or none of the time”, “2 Some or a little of the time”, “3 Occasionally or a moderate amount of the time”, “4 Most or all of the time”. We utilize this variable to construct a variable with a four-point-scale to suggest the levels of depression of the respondent. Level of depression equaling to 4 indicates the highest level of depression and level of depression equaling to 1 indicates the lowest level of depression. We use difficulties of activities of daily living (ADL) and difficulties of instrumental activities of daily living (IADL) to show respondents’ abilities for daily activities. ADL includes the abilities of walking, eating, toileting, dressing, bathing and urination and defecation. In our analysis, in our analysis, the variable difficulties of ADL is a dummy variable with 1 indicating that the respondent has difficulty in ADL and 0
otherwise. IADL includes the abilities of shopping, housecleaning, managing money, taking medicine and cooking. Similarly, the variable difficulties of IADL is a dummy variable with 1 indicating that the respondent has difficulty in IADL and 0 otherwise. We further construct an indicator for overall health status of the respondents based on self-evaluation. In the questionnaire, they are asked how they would rate their health with five choices ranging from “1 Excellent” to “5 Poor” provided. In our analysis, we switched the order to “1 Poor” to “5 Excellent”, which fits the common sense that a higher score means the person is more satisfied with his or her health.

Besides the individual survey, CHARLS also collects information on the community or village where the individual respondents live. Among the information, we utilize the one on how many households in your village/community use drinking water from the following sources as the key independent variable. The choices include tap water, well water, pool water, river lakes and books, rain water and snow water, cellar water, spring, and others. Among these water sources, only tap water is pre-processed through water sanitary facilities, thus, is cleaner than the rest on average. To isolate the effects of access to clean water on health, we further construct a dummy variable – water facility – with 1 indicates that the community/village has access to water processed by sanitary facilities i.e. clean water, and with 0 indicates that the community/village does not have access to water processed by sanitary facilities.

In addition, we construct and utilize the following control variables in the regression analysis:

1. years of education: number of years of education.
2. expenditure: expenditure of the household in the last year. This is used as a proxy for income since there are many missing values in the income data.
3. female: dummy variable with 1 indicates that the respondent is female and 0 indicates that the respondent is male.
4. urban: dummy variable with 1 indicates that the respondent lives in urban area and 0 indicates that the respondent lives in rural area.
5. age: age of the respondent.

The empirical methods i.e. the regression model is as below where Y is the health indicator ranging among level of depression, difficulties of ADL, difficulties of IADL, and self-reported health status and water facility is the key dependent variable indicating whether the community/village has access to water sanitary facilities thus clean water.

\[ Y(health\ indicator) = \beta_0 + \beta_1 \text{(water facility)} + \beta_2 \text{(years of education)} + \beta_3 \text{expenditure} + \beta_4 \text{female} + \beta_5 \text{urban} + \beta_6 \text{age} + u_i \]

3. Results and discussion

Figure 3 shows the fraction of communities/villages with access to water sanitary facilities and thus clean water. It suggests that more than a half (66.13%) of the communities have tap water facilities. One third (33.87%) of all the communities in the study do not have access to tap water.

Figure 4 shows the comparison of level of depression between respondents with access to clean water and those do not. It clearly suggests that people who use tap water are less likely to feel depressed.

Figure 5 shows the comparison of self-reported health condition between respondents with access to clean water and those do not. It is evident that people who drink from tap water feel healthier than people who don’t drink from tap water.

Figure 6 shows the comparison of difficulty to do daily activities between respondents with access to clean water and those do not. As the graph shows, people who have access to tap water has much smaller difficulty to carry out daily activities.

Figure 7 shows the comparison of instrumental difficulty to do daily activities between respondents with access to clean water and those do not. People who have access to tap water has much smaller difficulty to carry out instrumental daily activities.
Figure 3. The percent of tap water and non-tap water facilities communities/villages have. The red section represents fraction of communities which do not have access to clean water. The blue section represents fraction of communities which have access to clean water i.e. tap water. Data source: CHARLS 2011 and CHARLS 2013.

Figure 4. Average depressed level of the elderly who drink from tap water and those who do not. The left column represents the average depressed level of people who do not drink from tap water. The right column represents the average depressed level of people who drink from tap water. The higher the bar is, the more people feel depress. Data source: CHARLS 2015.

Figure 5. Self-reported health condition over water facility group. The left column represents the average self-reported health condition of people who do not drink from tap water. The right column represents the average self-reported health condition of people who drink from tap water. The higher the bar is, the healthier people feel. Data source: CHARLS 2015.
Figure 6. Difficulty to do activities of daily living over water facility group. The left column represents the average difficulty to do activities of daily living of people who do not drink from tap water. The right column represents the average difficulty to do activities of daily living of people who drink from tap water. The higher the bar is, the more difficulties people have to do daily activities. Data source: CHARLS 2015.

Figure 7. Difficulty to do instrumental activities of daily living over water facility group. The left column represents the average difficulty to do instrumental activities of daily living of people who do not drink from tap water. The right column represents the average difficulty to do instrumental activities of daily living of people who drink from tap water. The higher the bar is, the more difficulties people have to do daily activities. Data source: CHARLS 2015.

The results above suggest that there is a clear distinction between the respondents with access to clean water and those who do not. To further test whether this distinction is robust to other control variables and to make ceteris paribus comparisons, we performed regression analysis taking into both key independent variables i.e. water facility and control variables into consideration. The results are shown in Table 2.
Table 2. Regression analysis results.

| VARIABLES | (1) ADL_ difficulty_any | (2) IADL_ difficulty_any | (3) self_reported health | (4) Depressed level |
|-----------|------------------------|--------------------------|--------------------------|---------------------|
| water facility | -0.0469*** | -0.0448*** | 0.174*** | -0.115*** |
| edu_years | (0.00956) | (0.00970) | (0.0253) | (0.0263) |
| total_expenditure | -0.00884*** | -0.0141*** | 0.00907*** | -0.0226*** |
| Female | (0.00117) | (0.00119) | (0.00311) | (0.00323) |
| Urban | -0.0375*** | -0.0415*** | 0.0830*** | -0.162*** |
| Age | 0.00684*** | 0.0665*** | -0.135*** | 0.330*** |
| Constant | -0.157*** | -0.0508 | 2.959*** | 1.945*** |
| Observations | 7,956 | 8,089 | 8,075 | 8,004 |

Note: Key X variable water facility and each control variable are put into regression analysis with 4 key Y variables: ADL_difficulty_any (whether the respondent has any ADL difficulty), IADL_difficulty_any (whether the respondent has any IADL difficulty), self-reported health, and Depressed level. ***p < 0.01, **p < 0.05, *p < 0.1. Data source: CHARLS 2015.

For each of the four regressions, according to the F test (F-statistics=89.57, 109.13, 33.74, 72.83), they are all significant, meaning that the models are correctly specified.

According to regression analysis, access to tap water facility has a statistically significant (p<0.01) association with elder people’s level of depression, ADL difficulties, IADL difficulties and self-reported health status. The regressions also suggest that urban, male respondents with longer years of education tend to have fewer difficulties in ADL and IADL, better self-reported health status, and lower level of depression.

These findings consistently indicate the benefit of providing access to clean water. To be more specific, having access to clean water is negatively associated with ADL difficulties and IADL difficulties, which suggests that respondents with access to clean water have fewer difficulties in daily activities such as walking, eating, etc. and fewer difficulties in instrumental daily activities such as shopping, managing money, etc. We also find that having access to clean is negatively associated with level of depression, meaning that respondents with access to clean water have lower level of depression. Moreover, having access to clean water is positively associated with self-reported health status, suggesting that respondents with access to clean water have better self-evaluation of health.

The results fit along with previous findings of drinking water quality and health of the elderly. For example, drinking water turbidity can increase the risk of the elderly to have gastrointestinal illnesses [8]. Moreover, contaminated and unprocessed water might be the source of waterborne diseases [9]. Our finding reflects the health risks that the elderly may have if they don’t have sanitary water sources. Besides problems in physical health status, our results show that the elderly even have more mental issues when they don’t have tap water to drink. It is similar with the negative effect brought by arsenic in drinking water: arsenicosis symptom, which has a strong negative effect on mental health [10]. Even worse, chronic exposure to arsenic through drinking water is associated to an increase in mortality rate [11]. The impacts of a clean water source affect the well-being of the elderly. As a result, it is essential to establish necessary water processing factories and help more people get access to disinfected tap water without harmful chemicals. While chlorination cannot remove arsenic in water, more methods of processing drinking water should be considered to reduce the health risk.
As the climate changes, the quality of surface water, especially rivers and lakes, degrades over time [12]. This degradation can harm people’s health if their drinking water sources are not cleaned thoroughly. For instance, microcystins, a microbial pollutant in water from contaminated water pipes, threatens people’s health and may lead to liver cancer [13]. What’s worse, industrialization and increasing agriculture activities escalate the water scarcity in China [13]. People may not have enough clean water to drink in the future. Economically, taking more care for the elderly is crucial for China because nowadays the population is aging, a problem which many developed countries have. The human capital, involving people’s well-being, determines a country’s economic condition, so the health of the elderly is of vital importance for China, as people retire at an older age. To increase longevity and help people live healthier, the government should fund more money on the sanitary water system and make sure that all the residents can have clean, safe tap water to drink.

There are some limitations in this study that might affect the association between the water facility and the health of the elderly. For instance, we do not include health insurance and water pollution in different regions where the respondents in our live. People with enough insurance and a better environment might have better physical and mental health regardless of the water facility.

4. Conclusions
Through regression analysis, we find that drinking water quality has a statistically significant association with ADL/IADL difficulties, self-reported health status, and level of depression. The results prove previous findings while giving more associations other than water quality’s effect on physical health. According to our findings, having access to clean water significantly lowers people’s difficulties in ADL and IADL, lowers people’s level of depression, and improves people’s self-evaluation of health status, therefore, we propose the government to fund more money in improving the water sanitation facilities. Future studies can focus on the water quality’s effects on people’s mental health to find the theory behind our findings.

References
[1] Grossman G M & Krueger A B 1995 Economic growth and the environment The quarterly journal of economics 110(2) 353-377
[2] Ebenstein A., Fan M, Greenstone M, He G, Yin P & Zhou M 2015 Growth, pollution, and life expectancy: China from 1991-2012 American Economic Review 105(5) 226-31
[3] Acemoglu Daron, et al. 2012 The environment and directed technical change American economic review 102(1) 131-66
[4] Alsan M & Goldin C 2019 Watersheds in Child Mortality: The Role of Effective Water and Sewerage Infrastructure, 1880-1920 Journal of Political Economy 127(2) 586-638
[5] Gul Nida & Shah Mohammad & Khan, Sardar & Khattak N U & Muhammad Said 2015 Arsenic and heavy metals contamination, risk assessment and their source in drinking water of the Mardan District, Khyber Pakhtunkhwa, Pakistan Journal of Water and Health 13. 10.2166/wh.2015.011.
[6] Greenstone M & Hanna R 2011 Environmental regulations, air and water pollution, and infant mortality in India (No. w17210) National Bureau of Economic Research
[7] Jones C I & Romer P M 2010 The new Kaldor facts: ideas, institutions, population, and human capital American Economic Journal: Macroeconomics 2(1) 224-45
[8] Schwartz Joel, Ronnie Levin and Rebecca Goldstein 2000 Drinking water turbidity and gastrointestinal illness in the elderly of Philadelphia Journal of Epidemiology & Community Health 54(1) 45-51
[9] Khan Sardar, et al. 2013 Drinking water quality and human health risk in Charsadda district, Pakistan Journal of cleaner production 60 93-101
[10] Chowdhury S, A Krause and K F Zimmermann 2015 Arsenic contamination of drinking water and mental health IZA Discussion Paper No. 9400
[11] Argos M, T Kalra, P J Rathouz, Y Chen, B Pierce, F Parvez, T Islam, A Ahmed, M Rakibuz-
Zaman, R Hasan, G Sarwar, V Slavkovich, A van Geen, J Graziano, and H Ahsan 2010 Arsenic exposure from drinking water, and all-cause and chronic-disease mortalities in Bangladesh (HEALS): a prospective cohort study *Lancet* 376(9737) 252-258

[12] Delpla I, et al. 2009 Impacts of climate change on surface water quality in relation to drinking water production *Environment international* 35(8) 1225-1233

[13] Zhang Junfeng, et al. 2010 Environmental health in China: progress towards clean air and safe water *The lancet* 375(9720) 1110-1119