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ORIGINAL ARTICLE

Implications of Access to Portable Water on Child Health Production in Cameroon

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ABSTRACT
This study attempts to quantify the effects of access to portable water on child health outcome and to investigate potential heterogeneities in the effect of access to portable water on child health by age distribution. Methodologically, we used the 2011/2018 Cameroon demographic and health survey via 2SLS and ivprobit models. Results show that a positive marginal change in access to portable water will result to a corresponding increase in child health, Child health of age 24-36 months is strongly affected by access to portable water. Decision makers should intensify child health – access to portable water campaigns, following the WHO standards.

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Keywords: Implications, Access, Portable Water, Child Health Production, Cameroon

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INTRODUCTION

Contaminated source of water use for bathing, washing, drinking as well as in the preparation of food and poor hygienic environment are a major nuance to human health especially child health. A country's productive capacity is strongly determine by the health quality of the population, it's therefore imperative to examine the intricacies, determinants and issues surrounding this area of study (Tambi and Atemnkeng, 2017). Fundamentally, countries located around the equator are heavily characterize by: high irregular rainfall during the wet season; high rate of sun shine in the dry season; many streams, lakes, rivers, stand-water, springs, swamps; forest and savannah zones as well as irregular hamattan winds. All these may either make or mar human health depending on the nature of the environment. Cameroon located around the equator and in the heart of Africa seems to suffer from these characteristics. She experience irregular rainfall that have provoke swamps and stand waters due to heavy runoff and poor infiltration in the forest zones (Yongsi, 2010). These have created an environment that favours the growth of harmful insects (such as mosquitoes, tsetse fly, midges, scorpions, centipedes) and insect-borne diseases (such as flea, tick, mosquito, and louse borne diseases). These have resulted to illnesses such as malaria, river blindness, filariasis, ross river fever, plague, leishmaniasis, dandy fever and chagas diseases to name a few. All these diseases have ultimately reduces human life especially in the forest and coastal lands of Cameroon.

Due to climate change, the irregular nature of rainfall has resulted to the production of toxic water, hence humans use this water to bath, drink and watch domestic utensils consequently contact the diseases such as cholera, diarrhea, dysentery which all weakens the human system making it vulnerable as well as increasing health expenditure that also weakens the socioeconomic status of Cameroonians. Generally, waterborne diseases are caused by pathogenic microorganisms that most commonly are transmitted in contaminated fresh water. Infection commonly results during bathing, washing, drinking, preparation of food, or the consumption of food. Various forms of waterborne diarrhea diseases probably are the most prominent examples, and affect mainly children in developing countries; according to the WHO (2014) such diseases account for an estimated 4.1 percent of the total daily life years global burden of disease, and cause about 1.8 million human deaths annually. The World Health Organization estimates that 88 percent of that burden is attributable to unsafe water supply; sanitation and hygiene.

In real terms, an unfavorable environment is a dilemma to its inhabitance. The rationale of this issue is that the Cameroon labour market needs men and women that are sound in health and who can rightly contribute to increase productivity, growth and the reduction of poverty. Therefore, from the foregoing, one can clearly observed that water source strongly influences human life, especially child health as they are fragile in nature. Further, Bastian (2009) noted that waterborne diseases can have a significant impact on the economy both locally and internationally. People who are infected by a waterborne disease are usually confronted with related costs and seldom with a huge financial burden. The financial losses are mostly caused by the costs for medical treatment and medication, costs for transport, special food, and by the loss of manpower. Many families must even sell their land to pay for treatment in a proper hospital. On average, a family spends about 10 percent of the monthly households' income per person infected.

As noted in UNICEF (2008) one of the principal millennium development goal (MDGs) states that by 2015, half the people without sustainable access to safe drinking water and basic sanitation should be satisfied. However, until date this objective is still far to be a reality in Cameroon. The quality of water is a major health input, thus achieving this MDG will have a significant impact on achieving many of the other MDGs such as poverty and hunger, universal primary education, gender and equality, reduced child mortality, combating diseases (HIV, malaria) and global partnership. The household water supply is very important for human existence in five reasons: (1) water is vital for health, (2) water leads to social development, (3) water is a good economic investment, (4) water helps the environment and (5) water is achievable.

The United Nation Children's Fund (UNICEF) (2008) revealed that where adequate sanitation is provided coupled with protected water and improved hygiene behaviours one can expect the following improvement: (1) lower morbidity rates in the population, (2) lower mortality rates due to diarrhea, (3) better nutrition among children, (4) cleaner environment, (5) safer food and increased impact of improved water supplies, (6) better learning and retention among school children, (7) more dignity and privacy for everybody especially women and girls and increased awareness of the importance of sanitation and hygiene and the need to develop a more permanent strategy. Hence, water and hygiene are keys to child survival, development and growth, though improved water supply has yet to reach 2.6 billion people in the developing world, almost 980 million of which are children under 18 years old, this means that millions of children are dying each year from preventable diseases (UNICEF, 2008). In rural Cameroon, the stakes are still high, thousands of children are hospitalized each month and many are dying because of water borne diseases and the environmental sanitation.

Thus, the world health organization reported that almost one tenth of the global disease burden could be prevented by improving water supply and management of water resources while in another report they noted that 4 percent of all deaths and 5.7 percent of total disability-adjusted life years can be attributed to water (Prudd-Ustun, 2008). Cheng et al (2012) added that, world wide 1.4 million children die each year from preventable diarrhea diseases and some 88 percent of diarrhea cases are related to unsafe water. Further, water has been described as the most effective public health intervention the international community has at its disposal to reduce child mortality. Hence, because of the great potential to improve child health through targeted interventions in the environment in a context where countries have limited resources to invest in better water, making it important to provide an evidence-based estimate on the benefit of this factor (Bampoky, 2013).

Sambe-Ba (2013) noted that diarrhea diseases remain one of the principal causes of childhood mortality and morbidity in low income countries despite significant progress in our understanding of the pathogenesis of these diseases and in their management. According to the World Health Organization, diarrhea disease is the second leading cause of death in children under five years old worldwide, and is responsible for 1.5 million child deaths every year. Thus, Schiller (2007) indicated that the risk of contacting diarrhea diseases is currently 5-fold higher in Sub-Saharan Africa (SSA) than in industrialized countries. With particular attention to Cameroon, despite the economic growth relative to the region, is facing a familiar string of environmental problems which are tightly connected to socio-economic factors that afflict the population, such as loss of natural habitat, poaching, desertification, overfishing and Diseases. Among these diseases in Cameroon, many children are dying of pneumonia (19 percent), diarrhea (18 percent), malaria (8 percent), neonatal sepsis or pneumonia (10

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percent), preterm delivery (10 percent) and asphyxia at birth (8 percent) and other diarrhea related diseases (GOC, 2011).

Despite the pressing need for appropriate policies, document and disseminate knowledge in this area, it should be noted that research on child health issues vis-a-vis nutrition, mother's employment, fertility, age and education, inequality has been well documented but issues of water source - hygiene and child health outcomes using evidence based estimate has not yet been exploited (Cheng et al, 2012). Most of the studies in this area so far as Cameroon is concern, has instead examine the role of microbial agents in contaminated water that causes diarrhea diseases or the epidemiology of rotavirus diarrhea in children under 5 years, such authors include: Ndze el al (2012), Yongsi (2008, 2010) and Ntouda et al (2013) mean while the issue of water supply and child health are well develop in other countries with the same economic and social strata like Cameroon. Some of the authors include: Bampoke (2013) and Sambe-ba et al (2013) in the case of Senegal, Arval et al (2012) in the case of Nepal, Brainerd and Menon (2012) for India and Roushdy et al (2012) for the case of Egypt to name a few.

This study is therefore bridging this gap in that we attempt to link the household source of water to child health outcomes, the study is also very important because it seems to be the first to use the Cameroon DHS to quantify the relationship between household source of water and child health outcomes in Cameroon. Hence, to do this, we will examine the following objectives: explore the determinants of household source of drinking water in Cameroon, verify the impact of household source of drinking water on child Health outcomes in Cameroon and analyze the heterogeneous effects of child health by child age.

Yongsi (2010) evaluated health risks in the usage of contaminated drinking-water and its relationship with the prevalence of diarrhea diseases in Yaoundé, Cameroon. Using a cross-sectional epidemiological design of 3,034 households with children aged less than five years, revealed a diarrhea prevalence of 14.4 percent in children. Among various risk factors examined, water-supply modes and quality of drinking-water were statistically associated with diarrhea cases while levels of diarrhea attacks varied considerably from one neighbourhood to the other. Further, Yongsi (2008) found that diarrhea illnesses remain one of the principal causes of global childhood mortality and morbidity and concluded that diarrhea diseases and their spatial distribution are important tools for public health management and control strategic planning in Cameroon.

In the same line, Sambe-Ba (2013) examined the epidemiological and microbiological aspects of Community-acquired diarrhea among children and adults in urban, Senegal and realized that viral infection was significantly more frequent in children under five years old during the dry season. Bacteria and parasites were equally noted to be frequent in all age groups. There was equally a seasonal variation of bacterial infections during the study period, with a higher proportion of infections being bacterial and due to *Salmonella* spp. in particular, during the rainy season. This study suggests that in urban settings in Senegal, rotavirus is the principal cause of pediatric diarrhea during the dry season and that the proportion of bacterial infections seems to be higher during the rainy season. Moe et al (1991) evaluated four bacterial indicators of tropical drinking-water quality (faecal coliforms, Escherichia coli, enterococci and faecal streptococci) and their relationship to the prevalence of diarrhea disease in a population of 690 under-2-year-olds in Cebu, Philippines. E. coli and enterococci were better predictors than faecal coliforms of the risk of waterborne diarrhea disease. They noted that little difference was observed between the illness rates of children drinking good quality water (less than 1 E. coli per 100 ml) and those drinking moderately contaminated water (2-100 E. coli per 100 ml). Children drinking water with greater than 1000 E. coli per

100 ml had significantly higher rates of diarrhea disease than those drinking less contaminated water. They concluded that in developing countries where the quality of drinking-water is good or moderate other transmission routes of diarrhea disease may be more important; however, grossly contaminated water is a major source of exposure to faecal contamination and diarrhea pathogens.

Gundry et al (2004) intimated that in developing countries, the microbial contamination of household drinking water is implicated in the prevalence of various diseases, generally diarrhea and cholera, and their relationship with water quality at point-of-use. For cholera, a clear relationship was found with contaminated water. Home water treatment and storage interventions were also found to reduce cholera. For diarrhea, no clear relationship was found with point-of-use water quality, although interventions did significantly reduce diarrhea incidence. Ntouda et al (2013) determines the influence of access to drinking water on the health of populations in SSA, using data from Cameroon, Senegal and Chad DHS. Based on their study, it is clear from their descriptive analysis that 60 percent (Cameroon) and 59 percent (Chad) of the cases of childhood diarrhea are due to the consumption of dirty water. In terms of explanatory analysis, they noted that when a household in Cameroon, Senegal or Chad does not have access to drinking water, children under 5 years old residing there are respectively 1.29, 1.27 and 1.03 times more likely to have diarrhea than those residing in households with easy access to drinking water.

Aryal (2012) observed that the incidence of diarrhea per 1000 population was found to be the highest in spring without toilet with 204.89 followed by Tube well without toilet with 145.30, while it was less in Tap water with toilet with 46.05. With respect to the burden of disease, Aryal also found it to be the highest in spring without toilet and the lowest in Tap water with toilet. Aryal (2012) realized that the households didn't treat water before drinking while hand washing practice was found to be more than 90% regardless of toilet availability. Thus, he argued that, there is greater risk of acquiring diarrhea disease and higher burden of disease in situation of unprotected water source and absence of toilet shows that these are still important contributing factors for diarrhea disease in Nepal. The use of sanitary toilets and protected water source are the important measures for diarrhea disease prevention in Nepal.

METHOD

We adopt a modified version of child health production function model as originally proposed by Rosenzweig and Schultz (1983). In a given production function, child health is a function of factors such as gestational age, the timing, quantity and quality of child health care and health-related behaviour of the mother during pregnancy. In practice, money prices are not observed for many inputs into health production functions, such as use of child health care. If the time cost of using these inputs is large, then measures of distance to a health facility are part of the full price of service and may serve to identify the input, Cebu Study Team (1992) provide examples of this approach for estimating child health production functions.

In some child health literature, it is assumed that the production function is static so that current output is a function of only current inputs. However, many human capital variables we are concerned about are stocks, not flows. For instance, many health variables, such as child height, weight or birth weight are cumulative measures that depend on inputs in past periods and possibly on past health outcomes as well. In fact, Grossman’s (1972a) seminal paper on the demand for health treats health as a capital stock, which depends on past values and current inputs, more so in the Grossman’s model, the demand for health is for investment and consumption purposes (Ajakaiye and Mwabu, 2009). In the spirit of this framework, reproductive health yields direct utility to an individual and also increases labour income through the reduction in sick time so that more time is available for production and through increase work effort.

In this framework, the economic model of the family developed by Becker (1965) and as applied by Frijters et al (2008) forms the analytical framework for our analysis of the consequences of access to portable drinking water (capture as tap water supply (APW)) on child health (capture by child ill/death due to diarrhea diseases (CDD)). This relationship can be described within the framework of a simple household production model of child health for family *i*, as follows:

$$CDD_i = \chi_i \lambda_1 + \delta_1 APW_i + \varepsilon_{1i} \qquad (1)$$

Where CDD_i is a binary variable representing child $i's$ ill/death due to diarrhea as the parent used or gave contaminated water to the child, χ_i is a vector of (1) household characteristics such as place of residence, socioeconomic status and household size; (2) parental characteristics with variables such as: fertility rate, literacy, prenatal care, birth interval and marital status of mother and (3) child characteristic such as age of the child as well as sex of the child. The APW_i is household access to portable water capture in this study as tap water supply in both rural and urban households respectively and ε_i is a random error term. λ_1 is a vector of parameters associated with the exogenous variables in the outcome equation. The coefficient δ_1 is the parameter of primary interest and represents the impact that the household access to portable water has on child health in Cameroon using the demographic and health survey data. Considering this single equation, the Probit estimates may be upward or downward biased depending upon the effect that child health has on household access to portable water and on the correlation between omitted variables and household access to portable water. In rural Cameroon, parents always do their best to give their sick child protected water; however with regards to children in good health, they don't care much on the source of water. Thus, if household access to portable water has a positive impact on child health, then we would expect the Probit estimate of δ_1 to be biased upward.

As observed with the case of rural Cameroon, the prime difficulty of the two-way causality that comes in the effect on household access to portable water and child health may cause the classical endogeneity problem. To avoid the strong likelihood of this endogeneity bias, confounded by the problem of variables that is missing in empirical data, we use a two stage least squares (2SLS) estimation approach. Thus, the first-stage equation in this approach is:

$$APW_i = \chi_i \beta_1 + \alpha_1 RV_i + \pi_{1i} \qquad (2)$$

Whereby RV_i is simply rainfall variation (use as an instrument to solve for the endogeneity problem); it should be noted that the 2SLS model captures the causal effect of household access to portable water for those households whose children's health is affected by rainfall variation. Importantly, though APW_i is ordinal, 2SLS estimates of δ_1 can be interpreted as estimating the average marginal effect of a unit increase in APW_i for children whose health is affected by the variation in rainfall. Before presenting the 2SLS estimates, we present a reduced form analysis of household access to portable water; here we would expect to observe mothers with death children or children suffering from diarrhea diseases to be affected by variation in rainfall. The reason is because children suffering from diarrhea diseases are negatively affected by poor household access to portable water. The 2SLS estimation allows us to scale the probit marginal effects into the effects on an increase in our ordinal household access to portable water measure (Wooldridge, 1997).

As indicated earlier, we use variation in rainfall as an instrument to overcome this endogeneity problem between household access to portable water and child health outcomes which cannot be adequately controlled for by observable characteristics. Assuming that variation in rainfall is a valid instrument, we will use the ivprobit model (probit model controlling for endogeneity) which better respects the binary nature of child health (child death attributed to diarrhea diseases) as represented by the following two equations:

$$CDD^{*}=\lambda_{2}\chi_{i}+\delta_{2}APW_{i}+\varepsilon_{2i} \quad \ldots\ldots (3)$$

$$APW_{i}=\chi_{i}\beta_{2}+\alpha_{2}RV_{i}+\pi_{2i} \quad \ldots\ldots (4)$$

Where CDD_i denotes actual child health and CDD^{*}_{i} represents desired child health, note that $CDD_i = 1$ if $CDD^{*} > 0$ and zero otherwise, and the error terms ε_{2i} and π_{2i} follow a bivariate normal distribution with non-zero correlation.

RESULTS AND DISCUSION

Estimate the result of this study, we will use the pool data of the third and fourth Cameroon demographic and health survey collected in 2011 and 2018 respectively after the 1991, 1998 and 2004 data. The 2018 DHS was aimed at a national representative sample of about 9,733 children while in 2011 there were 11732 children of 0 - 59 months with women of reproductive age, alive and living within the selected zones of sample as well as a sub sample of about 50 percent of households for the men. The results of these surveys were presented for Cameroon, Yaoundé and Douala (two great metropolitan cities), other towns, urban and rural zones and each of the 12 areas of study constituting the 10 regions plus Douala and Yaoundé. The outcome variable of the study is child health capture by child death due to diarrhea diseases; this variable is coded *'h11'* for those children of age 0 to 59 months that had diarrhea at the time of data collection (Tambi and Atemnkeng, 2017). The nature of data is presented in table one of the summary statistics, while household access to portable water is captured as: 1 equal to households using tap water for consumption and 0 otherwise. Principally, annual rainfall variation in milliliters, for 2011/2018 precipitation for the different regions" was collected from the department of statistics of ministry of transport and agriculture and then imported into the data set. The potential instrument use to solve the endogeneity problem is annual rainfall water collected by the household.

The covariates or exogenous demographics used in the study are: fertility rate, literacy, prenatal care, birth interval, marital status of mother, age of child, sex of child, place of residence, socioeconomic status and household size. These variables are already explained in many studies on how they are captured in the DHS (see Awiti, 2014). Oweing to Cheng et al (2012), in this study, under-five mortality/death rate is defined as the probability of a child born in a specific year or period dying before reaching the age of five year per 1000 live births, if subject to age-specific mortality rates of that period. They also noted that the proportion of under-five deaths due to diarrhea is estimated by the WHO based on the causes of death in countries and recorded by the civil (vital) registration system. This variable is already estimated in the Cameroon DHS.

Weighted Sample Descriptive Statistics

Table 1 presents the results of the weighted sample descriptive characteristics. Considering the full sample statistics, we observed that about 18.2 percent of children were ill or death due to diarrhea diseases in Cameroon in the period 2011/2018, this is especially true in rural Cameroon where most of the communities lack basic amenities such as good water supply. The basic water supply for drinking, cooking and washing/bathing include: rain water, collected mostly during the wet season, unprotected springs and wells, flowing streams and rivers as well as few open lakes. These sources of water constitute the most impure sources for human consumption with little or no treatment before consumption. It's often said in these communities that *"if you can't get what you want then manage what you have".* Based on these one can be tempted to say the biological system of the inhabitance of these areas is immune to the water supply especially for the matured rural dwellers. In the period 2008 – 2018, during which the data was collected and most children in the survey were given birth to, precipitation had a maximum variation with the minimum being 216.3562 millimeters and maximum rainfall within this period being 941.0812 millimeters. This precipitation mostly varied according to the height of the altitude and the ecological zone with the highest altitude being 2072 meters.

Table 1. The Sample Statistics

Variable	**Full Sample**		**Female**	**Children**	**Male Children**	
	Mean	**SDV**	**Mean**	**SDV**	**Mean**	**SDV**
Child health (1 = child ill/death due to diarrhea diseases)	0.182	0.386	0.176	0.381	0.187	0.390
Household access to portable water (1= has tap water, 0 otherwise)	0.047	0.211	0.049	0.217	0.044	0.205
Annual Rainfall Variation in millimeters	369.7846	0.289	313.7846	0.217	311.7846	0.205
Mother breast feeding (1= mother breast feed the child, 0 otherwise)	0.547	0.497	0.553	0.497	0.542	0.498
Fertility rate	4.370	2.658	4.353	2.619	4.388	2.697
Participation (1= mother currently working, 0 otherwise)	0.681	0.465	0.682	0.465	0.680	0.466
Marital status (1= mother is married, 0 otherwise)	0.881	0.323	0.884	0.319	0.878	0.326
Prenatal care (1= mother attended prenatal, 0 otherwise)	0.894	0.306	0.891	0.311	0.898	0.301
Birth Interval	29.327	24.110	29.458	24.467	29.192	23.739
Male (1= male headed household, 0 otherwise)	0.859	0.347	0.860	0.346	0.857	0.349
Literacy (1= parent literate, 0 otherwise)	0.428	0.494	0.432	0.495	0.424	0.494
Child age in years (0 – 5 years)	1.827	1.388	1.821	1.389	1.834	1.386
Social status (1= parent non-poor, 0 otherwise)	0.540	0.498	0.537	0.498	0.543	0.498
Household size	10.479	6.201	10.483	6.151	10.476	6.251
Household Size Square	148.276	213.97	147.725	210.233	148.841	217.758
Household residence (1= urban residence, 0 otherwise)	0.401	0. 490	0.396	0.489	0.407	.491
Total Observation	**21465**		**10787**		**10678**	

Source: author; NB: SDV = Standard deviation

About 4.7 percent of households have tap water in their homes, this figure seem right in the sense that only 40 percent of the households lives in urban centers with a total household size of 10.47 headed by male with a total of 86 percent. Among these households, about 54 percent are non-poor and endow with a literacy rate of 42.8 percent with children ranging from 0 to 59 months of age. The birth interval of households in Cameroon following the 2011/2018 DHS is 29.32 giving a fertility rate of 37 percent with about 89.4 mothers engage in antenatal care, 54.7 consciously breast feeding their children. In this, 88 percent of the women are married while 68 percent are currently participating in the job market.

The sample statistics of female children reveal that in a total of 10787 observations, 17.6 percent of the female children were ill or died because of diarrhea or diarrhea related diseases. While in a sample of 10678 observations about 17.7 percent of male children suffered from diarrhea or diarrhea related diseases. The values of the male and female children are fairly the same, depicting the fact that diarrhea is a major problem for all the children and so a cause for concern for all families with children. The percentage for other variables are equally fairly the same, however, many male children seem to be born in the urban centers as compared to the female and with a bigger household size. This can be explain by the higher survival rate of children in urban zones due to either better water supply or medical facilities, the favourable maternal and paternal characteristics such as better education, wealth and prenatal care contribute to reduce or avoid diarrhea disease.

Determinants of Household Access to Portable Water

As seen in Table 2, the results of the reduced form equation which actually portrays the determinants of household access to portable water and particularly the effect of rainfall characteristics. Rainfall generally increases the volume of water supply in households, but unfortunately it reduces the quality in terms of water consumption. This explains why its effect on access to portable water is negative but significantly correlating. When even the volume of water supply increases and in poor quality; households resolve to consuming alternative sources such as mineral water. This is a common phenomenon with urban residential households, especially when the health of their children is as stake. Practically the northern regions of Cameroon are noted on yearly basis to heavily be affected by diarrhea cause by poor supply due to increase in water volumes. This result reveals that parental literacy is a strong determinant of household access to portable water. The idea is that, educated people are well informed so they understand the value of health. Hence the tendency is for more educated people to adopt every precautionary measure to get the best water in to the house. This is also confirmed by mothers currently participating in the job market. Mother's naturally as the primary caretakers of children, will always sacrifice a greater portion of their resources being time or finances to ensure that their children are in good health. In rural Cameroon, it's common to find father's abandoning the burden of children to their mother's this may partially cause by cultural and social reasons especially where both parent are uneducated.

Breast feeding mothers are conscious of the quality of water their children are consuming and so they will prefer to buy refine canned water in the case of Cameroon we have canned water (such as Tangui, Supermont, Volcanic, Seme etc) or water treated with chlorine. Even in the most remote village in Cameroon, mothers with breast feeding children are conscious of the effects of water on children some of them may go as far as to use *Eau de Javel* to treat water they give to their children. The consciousness of women is also explained by the health mass campaign conducted by the ministry of public health concerning diseases such as diarrhea, typhoid and malaria. This is the same case with mothers' fertility rate, birth interval and child age of zero to fifty nine months. From the reduced form result, we observed that access to water correlates with male headed households. Whenever a household is headed by a male, the tendency is for the family income to increase especially when the

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couples are both working. Hence, in such homes the probability is very high for the parent to be aware of the importance of water supply to children. Today, the slogan 'prevention is better than cure' is known by most parents in Cameroon talk less of the educated and working class.

Other factors that negatively correlate with access to portable water are household social status especially non-poor households, household size and urban residence. The result seems to be a reversal of what is expected, however this is not the case; non poor households located in rural community in Cameroon where the water is not good enough for consumption will be bound to consumed impure water and vice -versa. Thus the whole issue of access to portable water strongly relies on the place of habitation. Critically, there are places by nature with good drinking water supply, whereas in others their water is very poor. For instance the Buea community of Cameroon naturally has pure water originating from the impermeable rocks of mount Fako, this water flowing in the form of a spring needs little treatment to meet the WHO standards of good drinking water. This result explains why urban residence is negatively correlating with water source. The problem is not living in an urban milieu or having tap water in the house but the question is; how good is the water for consumption. In towns such as Douala, Kumba, Dschang, Tombel if water is not preserved in the fridge it's difficult to drink it confidently because of the taste and colour the water has. The argument is not that the fridge removes the taste or colour but that the temperature at which this water is store can eliminate every germ or bacterial contained in the water. The household size is also important in determining this phenomenon of access to portable water supply effects and child health in Cameroon.

Concluding on the determinants of access to portable using the Cameroon Demographic and Health survey, we observed that factors such as: parent literacy, working mothers, male household heads, breast feeding children, fertility rate, birth interval, social status, household size, place of residence are important in influencing the probability of access to portable water.

Table 2. Water source effects on child health and determinants of environmental source of water

Variable	Estimation Methods			
	PROBIT (ME)	OLS	2SLS	IVPROBIT (ME)
	HWS	Child ill/death due to diarrhea		
Household Source of Water	n/a	0.001 (0.61)	-0.404*** (3.02)	-0.621** (4.22)
Annual Rainfall Variation in millimeters, for 2004/2011 precipitation for the different regions"	-8.323*** (-20.42)	-0.126** (-2.13)	n/a	n/a
Mother breast feeding (1= mother breast feed the child, 0 otherwise)	0.111*** (2.63)	-0.250*** (-4.61)	-0.480** (-1.99)	-0.212** (-2.06)
Fertility rate	0.605*** (3.59)	-0.004*** (-2.69)	-0.046*** (-4.15)	0.317*** (-5.45)
Participation (1= mother currently working, 0 otherwise)	0.195*** (3.53)	-0.130 (-1.57)	-0.012** (-2.03)	-0.019** (-1.29)
Marital status (1= mother is married, 0 otherwise)	-0.377 (-1.36)	0.018 (0.51)	0.017* (1.94)	0.020 (0.57)
Prenatal care (1= mother attended prenatal, 0 otherwise)	-0.399 (1.39)	-0.221*** (-6.10)	0.069*** (-7.39)	0.213*** (-5.86)
Birth Interval	0.006* (1.69)	-0.000 (-0.46)	0.000 (0.13)	-0.000 (-0.54)
Male (1= male headed household, 0 otherwise)	1.887*** (7.39)	0.066** (2.10)	0.013 (1.48)	0.044 (1.34)

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Variable	PROBIT (ME)	OLS	2SLS	IVPROBIT (ME)
	Estimation Methods			
	HWS	**Child ill/death due to diarrhea**		
Literacy (1= parent literate, 0 otherwise)	0.530*** (2.68)	-0.157*** (-6.21)	-0.055*** (-8.63)	-0.157*** (-6.24)
Child age in years (0 – 5 years)	0.115* (1.78)	-0.101*** (-11.35)	-0.023*** (-11.19)	-0.101*** (-11.28)
Social status (1= parent non-poor, 0 otherwise)	-4.328*** (-18.78)	-0.187*** (-6.24)	-0.024** (-2.34)	-0.116** (-2.55)
Household size	-0.229*** (-5.36)	0.032*** (5.06)	0.011*** (8.14)	-0.035*** (5.48)
Household Size Square	0.007*** (6.40)	-0.001**** (-2.81)	0.000*** (-6.88)	0.001*** (-3.25)
Household residence (1= urban residence, 0 otherwise)	-6.356*** (-28.44)	0.043 (1.42)	-0.038*** (2.91)	-0.144** (2.51)
Constant term	n/a	-0.624*** (-9.01)	0.141*** (2.94)	n/a
R^2/(uncensored R^2/ Pseudo R^2	0.8256	0.0271	0.1916	n/a
Partial R^2 (on excluded instruments)	n/a	n/a	416.96[1, 19842; 0.0000]	n/a
Joint F / χ^2 test for Ho: coefficients on instrument = 0/ Wald/chi2	349.95 [14, 19842; 0.0000]	474.54 [15; 0.0000]	41.88 [14, 19842; 0.0000]	487.85 [4; 0.0000]
Cragg-Donald F-Stat test /rho (ρ)	n/a	n/a	416.961 [16.38]	-0.176 [0.081]
Sargan statistic test / sigma (σ)	n/a	n/a	0.000 [0.000]	11.755 [0.058]
Durbin-Wu-Hausman χ^2 test / Wald test	n/a	n/a	7.455 [0.0003]	4.57 [0.0002]
Observations	21,465			

Source: Computed by author. Notes: ***, ** and * indicate 1%, 5% and 10% levels of significance. N/B: Dependent variable is child ill/death due to diarrhea diseases; absolute value of robust t-statistics in parentheses beneath estimates, ME = marginal effects, n/a = not applicable.

Household Access to Portable Water and Child Health Outcome

Table 2 present the results of marginal effect of probit regression in column 1, ordinary least square in column 2 which can either be bias upward or downward; instrumental variable result in column 3 and probit model controlling for endogeneity in column 4.

Considering equation one above, the result of the OLS regression can either be biased upward or downward depending on the direction of the relationship between water supply and child health effects. Therefore, this OLS result is not appropriate for inference, this explain why the water source is insignificantly revealing that the value of water source is not appropriate for judgment. The 2SLS result solve the problem of endogeneity resulting from the data this can either be from missing variables or omission whereas the IVPROBIT resolve the problem of endogeneity originating from both the data and elsewhere, hence the estimates of IVPROBIT is our preferred result. Further, following the joint F/(p-value) test for Ho: coefficients on instruments = 0/Wald/chi2 of 41.88 [14, 19842; 0.0000] for 2SLS and 487.85 [14; 0.0000] for IVPROBIT reveals that the probit result controlling for endogeneity is preferable.

Considering therefore, the IVPROBIT result, we observed that a marginal change in drinking water supply will result to a corresponding increase in child health of 1.5 percent due to decrease in the number of diarrhea cases among children. This result reveals that the source of drinking water supply is a strong determinant of child health of age 0 to 59 months; this is consistent with the result obtained by the World Health Organization. They reported that almost one tenth of the global disease burden could be prevented by improving water supply and management of water resources while in another report they noted that 4 percent of all deaths and 5.7 percent of total disability-adjusted life years can be attributed to water (Prudd-Ustun, 2008).

As seen above, Cheng et al (2012) added that, worldwide 1.4 million children die each year from preventable diarrhea diseases and some 88 percent of diarrhea cases are related to unsafe water. The other factors positively associated with child health include: household size, urban household residence, while factors negatively associated with child health include; mothers currently employed in the job market, breast feeding children, fertility rate, mother attended prenatal services while pregnant, literacy rate, child age in years, household size square and non -poor parent. Our result reveals that the instrument used is strong and relevance and so valid, following the weak identification test: Cragg-Donald F-Stat [5% maximal IV relative bias] 416.961 [16.38] and the Sargan statistic (overidentification test of all instruments): (Chi-sq(2) P-val): 0.000 [0.000], further, the Durbin-Wu-Hausman test for exogeneity of variables in 7.455[0.0003] and wald test of exogeneity 4.57[0.0002] reveals that the problem of endogeneity is solve. The use of instrumental variable in our study has greatly reduced the effect of any bias that could have existed in our regression and so rendering our result robust.

Effect of access to portable water on child health by age distribution

Table 3 presents the result of household water source effects by child age in years according to the IVPROBIT model as seen from above. We observed that water supply does not affect children of ≤1 year except otherwise. Knowledge of absolute breast feeding is widely vulgarized in Cameroon especially for the first six months of delivery. This means that in the first months of child delivery, mothers absolutely gives their children only breast mild they don't have any contact with water apart from bathing and watching the baby. In most cases the water used to bath the baby is not only boiled but heavily treated to avoid any form of infection.

The rural women in Cameroon have been noted of extending the breast feeding of their children to one year and below. Even those children whose parents attempt to give them water, it's usually treated water. Many hospitals have taken upon themselves to advise the mothers on the importance of water to the health of their children. Factors associated child health at age zero includes: the breast feeding mother, birth interval, male household head, parent social status and the literacy rate of parents. In the other hand the factors associated with child age one include the following: breast feeding mothers, fertility rate, prenatal care, birth interval, household size, social status and mothers currently working.

Table 2. Decomposition of Water Source effects by Child age in Years

Variable	Marginal Effects Estimates of IVPROBIT Model				
	= 0 =	= 1 =	= 2 =	= 3 =	≥ 4
Household Source of Water	0.034	0.722	-0.472***	-0.491***	-0.008
	(1.17)	(0.92)	(12.07)	(6.68)	(-1.44)
Mother breast feeding (1= mother	-0.444***	0.197***	-0.041	-0.132**	-0.031
breast feed the child, 0 otherwise)	(-3.91)	(4.53)	(-0.75)	(-2.37)	(-0.45)
Fertility rate	-0.109	-0.261***	-0.235***	-0.232**	-0.357**
	(-1.53)	(-4.17)	(-2.81)	(-2.01)	(-2.36)
Participation (1= mother currently	0.072	-0.128***	-0.062	-0.119**	0.048
working, 0 otherwise)	(1.18)	(-2.64)	(-1.15)	(-2.06)	(0.65)

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Variable	Marginal Effects Estimates of IVPROBIT Model				
	= 0 =	= 1 =	= 2 =	= 3 =	≥ 4
Marital status (1= mother is married, 0 otherwise)	-0.012 (-0.15)	0.084 (1.35)	0.042 (0.51)	-0.036 (-0.43)	-0.053 (-0.46)
Prenatal care (1= mother attended prenatal, 0 otherwise)	0.015 (1.29)	-0.063*** (-6.96)	-0.003 (-0.29)	-0.000 (-0.03)	0.001 (0.11)
Birth Interval	-0.003*** (-2.74)	0.002** (2.28)	0.000 (0.02)	-0.002** (-2.46)	0.001 (0.43)
Male (1= male headed household, 0 otherwise)	0.188** (2.58)	-0.044 (-0.76)	0.028 (0.38)	-0.043 (-0.57)	0.142 (1.43)
Literacy (1= parent literate, 0 otherwise)	-0.174*** (-3.05)	0.009 (0.21)	-0.199*** (-3.51)	-0.185*** (-2.95)	-0.390*** (-5.28)
Social status (1= parent non-poor, 0 otherwise)	-0.230** (-2.45)	-0.148* (-1.95)	-0.049 (-0.45)	0.076 (0.71)	-0.162 (-1.34)
Household size	0.005 (0.35)	0.0495*** (4.09)	0.041** (2.45)	0.039** (2.47)	0.027 (1.43)
Household Size Square	0.000 (0.32)	-0.001** (-2.42)	-0.001 (-1.55)	-0.001* (-1.84)	-0.000 (-0.48)
Household residence (1= urban residence, 0 otherwise)	0.177 (1.50)	0.165 (1.47)	0.191* (1.71)	0.279** (2.17)	-0.169 (-1.02)
Constant term	-0.551 (-1.14)	-1.105*** (-3.02)	-1.505*** (-4.08)	-1.873** (-5.30)	-0.509 (-0.81)
ρ , Rho of child health residual [Std. Err.]	0.005 [0.178]	-0.138 (0.152)	-0.337 (0.162)	-0.516 [0.159]	0.213 [0.208]
σ (Sigma of child health (s.e)	12.143 [0.136]	11.752 (0.110)	11.598 (0.139)	11.759 [0.141]	11.308 [0.139]
Wald test of exogeneity	0.00 [0.9765]	0.81 [0.3694]	3.67 [0.0053]	6.91 [0.0086]	0.98 [0.3216]
Wald chi2	82.07 [(13; 0.0000]	153.19 [13; 0.0000]	122.92[13; 0.0000]	104.77 [13; 0.0000]	80.47 [13; 0.0000]
Observations	4278	5992	3788	3783	3624

Source: Computed by author using pooled data of 2011/2018 survey and STATA 14. Notes: ***, ** and * indicate 1%, 5% and 10% levels of significance. N/B: Dependent variable is child ill/death due to diarrhea diseases; absolute value of robust t-statistics in parentheses beneath estimates

The health of child age 2 and 3 years old is strongly affected by source of drinking water supply. Children of age two and three years old are difficultly controlled in rural Cameroon due to the nature of the environment and excitement on the part of the children to exercise their leg muscles in walking. It's widely observed that children attempting to walk really create much time to do it, given therefore the dirty and unsecure environment; the children can easily contract diseases roaming the environment either in drinking water or just standing water. Most typical villages in Cameroon have earth floor that are usually characterize by dust, at times muddy in the rainy season, rough food particles, insect infested (termites, ants, house-fly) also water is constantly used to wet the floor to reduce the quantity of dust. All these create a favourable condition for insect growth and so affecting the health of the children 24 to 36 months old.

Other factors positively affecting children's health of age 24 to 36 months are household size and place of residence while factors negatively correlating with child health of age 24 to 36 months are: breast feeding mothers, mother currently working in the job market, prenatal care, birth interval, literacy and social status of the family. Child age 4 years and above is not affected by water supply. This result sound ambiguous, however, the reality in Cameroon holds that child age four is the school going age, most parents at that child's age begins treating the child as themselves or full functioning human being such that what they eat and drink is what the child eats and drink. In such an age children begin to learn even at school the importance and necessity of good drinking water. In most nursery and primary schools in Cameroon, the subject of hygiene especially drinking water is the centre of lectures /class notes being verbal or written, hence as tender the children might be, they begins to exercise some caution in what they drink or eat in both in and out of home. The result of this section is presented in Table 3.

CONCLUSION

Understanding the intricacies underlining the effects of household source of water on child health outcomes as well as other factors determining child health in an era of high infant death rate especially in a developing country like Cameroon is critical for public policy and debate that highlight infant survival rates to be grounded by evidence-based research. These issues are particularly useful in the context of economic growth and poverty reduction in the different regions under public health and increase well-being of households. Such knowledge would help reduced child death rate and inequality, increase household asset endowment, increase maternal labour force participation as time is redeem in going to stay with child in the hospital because of ill health, money is also save which increases standards of living. To bridge this gap we have examined the following objectives: explore the determinants of household source of drinking water in Cameroon, verify the impact of household source of drinking water on child Health outcomes in Cameroon and analyze the heterogeneous effects of child health by child age. We used the IVPROBIT model to estimate our 2011/2018 Cameroon DHS in STATA 14.

We observed that factors such as parent literacy, breast feeding mothers, male household head; household social status, household size and urban residence are strong determinants of household source of water. However, parent literacy, breast feeding mothers, male household head are positively correlating with household water supply while household social status especially non-poor households, household size and urban residence are factors negatively correlating with water source. We also observed that a marginal change in water supply will result to a corresponding increase in child health of 1.5 percent. The other factors positively associated with child health increase due to water effects include: household size, urban household residence, while factors negatively associated with child health are; mothers currently employed in the job market, breast feeding children, fertility rate, mother attended prenatal services while pregnant, literacy rate, child age in years, household size square and non -poor parent. The health of child age 24 and 36 months is strongly affected by source of water supply. Other factors positively affecting children's health of age 24 to 36 months are household size and place of residence while factors negatively correlating with child health of age 24 to 36 months are: breast feeding mothers, mother currently working in the job market, prenatal care, birth interval, literacy and social status of the family.

In terms of policy, we recommend that decision makers in Cameroon through the ministry of public health should intensive child-water hygienic campaigns, while the government strategizing to increase the supply of good drinking water following the WHO standards. This is a major step towards economic growth and poverty reduction in the different regions under public health and increase well-being of households.

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We declared that there is no conflicting interest in this article

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