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Measuring the effect of environmental hygiene on child health outcomes in Cameroon

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Abstract

Aim/purpose – This study attempts to examine the correlates of environmental hygiene and the influence of environmental hygiene on child health outcomes in Cameroon while controlling for other variables.
Design/methodology/approach – The study made the use of Heckman/Control function Model through the 2011 Demographic and Health Survey with a sample size of 11.732 households.
Findings – Result shows that environmental hygienic strongly corroborates with child health outcomes, meaning that improve latrines is associated with increase in child health in Cameroon. Result of determinants shows that education, father's age, father present in the house and urban residence are strongly correlating with environmental hygiene.
Research implications/limitations – Highlights the need for decision-makers to be more intentional with allocating economic resources towards sanitation projects.
Originality/value/contribution – Empirically, this study attempted to quantify the link between environmental hygiene and child health outcomes using the Cameroon DHS while solving for endogeneity, heterogeneity, simultaneity, and selectivity bias.

Keywords: measuring, environmental hygiene, child health, outcomes, Cameroon.
JEL Classification: T11, D12, M13.

1. Introduction

Issues relating environmental hygiene to growth and development in children are at the top of policy making in many countries. The type of toilet facility use by a household (flush to piped sewer system, flush to septic tank, flush to pit latrine, ventilated improved pit latrine, pit latrine with slab, pit latrine without slab/open pit, no facility/bush/field, bucket toilet and hanging toilet/latrine) constitute a major determinant of environmental hazard especially in rural Cameroon. The principal objective of this study is to explore the effect of environmental hygiene on child health endowments; this is very consistent with the Millennium Development Goal number seven. This objective stipulates, to ensure environmental sustainability by reducing by half the proportion of people without sustainable access to safe drinking water and basic sanitation by 2015 (United Nations, 2007), the current sustainable development goals equally lay emphasis on issues related to hygiene. However, this objective is still far to be obtained in Cameroon especially in the area of sanitation and toilet facility.

In 2013, the World Health Organization (WHO) after observing the consequences of the lack of toilet on human health, for instance about 35% of the world or 2.5 billion people, are estimated to not having access to toilets facility. Following the United Nations, 14% or 1 billion people regularly defecate in the open air; this action is noted to produce about 50 communicable diseases, 1 million bacteria, 10 million viruses, 1,000 parasite cysts, and 100 worm eggs (WHO/CDC, 2003), especially diarrhea is something that happens due to lack of toilet access. According to the United States Center for Disease Control (CDC), about 2,200 children die every day from diarrhea more than AIDS, malaria, and measles combined whereas one USA dollar invested in diarrhea prevention yields an average return of $25.50 and about 88% of diarrhea associated deaths are attributable to unsafe water, inadequate sanitation, and insufficient hygiene (WHO/CDC, 2003).

In Cameroon, urban residence without toilets and those living besides lakes, standing and flowing waters always prefer to defecate in water or in the bush rather than an appropriate toilet systems. Further, those that manage to build a toilet because of limited land, ends up digging wells so closed to their toilets these issues have great consequences on the water, environment and health of the people in general. Most of the water borne diseases is transmitted through this media. Rural residence is worst in polluting the environment; most households don't have toilets so they are either defecating in the bush or in the water, others have but open toilets; the wind blows through the feces causing pollution. Children with fragile nature inhale the polluted air and become sick. The polluted air scattered bacteria, viruses, and germs from infected persons to the land surface as well as the water. Children who come in contact with the bacteria are contaminated with diarrhea, typhoid, cholera, etc.

The ministry of public health in Cameroon has attempted on several occasions to carry out mass campaign on the dangers of not having a toilet or environmental pollution, but most of the effort is limited in urban centers especially in the two metropolitan centers of Yaoundé and Douala and some few semi--urban centers. The bulk of the population in other parts of the country is still to be informed while those informed are still to take action. Considering the situation of toilets in Cameroon as illustrated in Table 1, about 27.57 percent households shared toilet facilities, 6.51 percent have flush toilets and 81.54 percent have latrines, while 7.88 percent have no toilets (DHS, 2011).

Table 1. Nature of toilet use system in Cameroon according to households

Description	Percent
Toilet facilities shared with other households	27.57
Flush toilet	6.51
Latrine	81.54
No toilet	7.88
Disposal of youngest child's stools when not using toilet	
Used toilet/latrine	10.75
Put/rinsed in toilet/latrine	61.73
Put/rinsed into drain or ditch	3.16
Throw into garbage	14.71
Buried	0.084
Left in the open	6.66

Source: Computed by author from (DHS, 2011).

In Table 1, we observed that 10.75 percent of households disposed their youngest child's stools when not using toilet, 61.73 percent rinsed and throw in toilet/latrines, 3.5 percent, 3.16 percent of households put/rinsed youngest child's stool into a drain or ditch, 13.71 percent throw into garbage, 8.4 percent buried while 6.66 percent left in the open. These statistics computed from the data base of demographic and health survey 20.111 prove that issues related to toilets especially open toilets is still a major problem in Cameroon hampering the health of families and worsening their social status in terms of family income.

Practically, illness at childhood causes many children around the world to miss significant amounts of schooling. Studies have shown, for instance, that worm infections (result from poor hygiene, such as not washing hands before eating) can cause irregular school attendance and may negatively affect children's cognition and performance when they are at school. From theoretical perspective, providing better toilet and sanitation facilities in households and even schools for children is not enough. Behavioral change is also needed to ensure proper use and maintenance of the facilities and better hygienic behavior. In the fight against diarrhea disease, hygiene education, including hand washing, is the single-most cost-effective health intervention. Hygiene education is not only important for a healthy household, public square or school environment and children performance, it also offers opportunities for communicating with and influencing community/children's families (Cheng, Schuster-Wallace, Watt, Newbold, & Mente, 2012; Downie, Tannahill, & Tieno, 1996).

Cameroon has experienced a number of dramatic successes in health in the decades since independence particularly with respect to child mortality and morbidity and the eradication or reduction of specific diseases. Successes include vaccination programs against measles and other childhood illnesses, the expansion of oral rehydration therapy for treating infant diarrhea diseases and the near-elimination of river blindness and Guinea worm (Ako, Fokoua, Sinou, & Leke, 2008). At least until the 2010 under-five mortality fell sharply in Cameroon and this led to improved economic well-being. However, Cameroon remained behind most of the developing world in child and other health indicators as progress in child health has slowed considerably in the last five years, so far as environmental hygiene effects in child health is concern.

Empirically, some of the studies that have attempted to tackle some aspects of child health are Ako et al. (2008), Baye (2010), Baye & Fambon (2010), Litvack & Bodart (1993). Unfortunately, none of these studies have attempted empirically to quantify the link between environmental hygiene and child health using Cameroon Demographic and Health Survey. Despite the wide awareness of the important role of environmental hygiene as a determinant of child health, there are substantially fewer systematic analyses of which environmental policies and technologies can provide large and equitable improvements in population health. Every year, some two million people die from diarrheal diseases. Much of this disease burden is caused by contaminated drinking water due to poor toilet facility and inadequate sanitation.

To resolve discussed problem, this paper aims at: examining the determinants of favorable environmental hygiene in Cameroon, exploring the effect of environmental hygiene on child health endowments, and to verify the environmental hygiene effects by place of residence as well as suggest economic policies to ameliorate the hygiene-child health effect in Cameroon. In the rest of the study; section two deals with the literature review, section three discusses the research methodology, section four lay emphases on the research findings and discussion, while section five gives the conclusion respectively.

2. Review of literature

Using data for 193 countries abstracted from global databases (World Bank, WHO, and UNICEF) Cheng et al. (2012) attempt to quantify the relationships between water, sanitation and infant, child and maternal mortality. They revealed that under-five mortality rate decreased by 1.17 for every quartile increase in population water access and a similar relationship between quartile increase of sanitation access and under-five mortality rate, with a decrease of 1.66 deaths per 1000 after adjustments for confounders. Their analyses suggested that access to water and sanitation independently contribute to child and maternal mortality outcomes. Hence they concluded that if the world is to seriously address the Millennium Development Goals of reducing child and maternal mortality, then improved water and sanitation accesses are key strategies.

By dividing the world's population into typical exposure scenarios for 14 geographical regions, Trussell & Hammerslough (1983) estimated the disease burden from water, sanitation, and hygiene at the global level taking into account various disease outcomes, principally diarrheal diseases. Considering the diarrheal diseases, schistosomiasis, trachoma, ascariasis, trichuriasis, and hookworm disease, they estimated the disease burden from water, sanitation, and hygiene to be 3.0 percent of all deaths and 5.9 percent of the total disease burden occurring worldwide. Further, a WHO report found that almost one tenth of the global disease burden could be prevented by improving hygiene facilities (WHO/CDC, 2003). Another estimate reports that 4.0 percent of all deaths and 5.7 percent of total disability-adjusted life years can be attributed to water, sanitation, and hygiene (WHO/CDC, 2003). In another estimate providing access to improved drinking-water sources in developing countries would reduce considerably the time spent by women and children in collecting water. Providing access to improved sanitation and good hygiene behaviors would help break the overall cycle of faecal-oral pathogen contamination of water bodies, yielding benefits to health, poverty reduction, well-being and economic development.

In analyzing on this, Bampoky (2013) noted that Fink, Geunther, & Hill (2011) conducted one of the most comprehensive analyses on child health, water, and sanitation. They merged all the demographic and health survey datasets available for seventy countries over the period 1986 to 2007. Even though the estimated effect of improved water and sanitation is smaller than estimations done by other studies, they still found a positive impact in the reduction of mortality, as well as a lower risk of diarrhea, and stunting. However, the authors also find that the positive results of clean water are more subtle and affect only children between 1 and 12 months. Bampoky (2013) further cited many studies in revealing that; in Egypt, having access to municipal water has been associated with a decrease in neonatal and infant mortality. According to her analysis, this study also found that the impact of modern sanitation was considerably larger, decreasing child mortality risk by 68 per (Fink et al., 2011). Trussell & Hammerslough (1983) found that improved latrines decreased child mortality in Sri Lanka, but that the source of water supply was insignificant. In Malaysia, Ridder & Tunali (1999) did not find any impact of access to piped water and toilet facilities on child mortality (Bartlett, 2003; WHO, 2002).

According to WHO (2002), more than three million children below five years die each year from environment-related causes and conditions. This makes the environment one of the most critical contributors to the global toll of more than ten million child deaths annually – as well as a very important factor in the health and well-being of their mothers. Polluted indoor and outdoor air, contaminated water, lack of adequate sanitation, toxic hazards, disease vectors, ultraviolet radiation, and degraded ecosystems are all important environmental risk factors for children and in most cases for their mothers as well. Particularly in developing countries, environmental hazards and pollution is a major contributor to childhood deaths, illnesses and disability from acute respiratory disease, diarrheal diseases, physical injuries, poisonings, insect-borne diseases and prenatal infections. Childhood death and illness from causes such as poverty and malnutrition are also associated with unsustainable patterns of development and degraded urban or rural environments.

3. Research methodology

Practically, illness at childhood causes many children around the world to miss significant amounts of schooling. Studies have shown, for instance, that worm infections (result from poor hygiene, such as not washing hands before eating) can cause irregular school attendance and may negatively affect children's cognition and performance when they are at school.

From theoretical perspective, providing better toilet and sanitation facilities in households and even schools for children is not enough. Behavioral change is also needed to ensure proper use and maintenance of the facilities and better hygienic behavior. In the fight against diarrhea disease, hygiene education, including hand washing, is the single-most cost-effective health intervention. Hygiene education is not only important for a healthy household, public square or school environment and children performance, it also offers opportunities for communicating with and influencing community/children's families. In this line, one can underscore that health, nutrition, sanitation and hygiene education focuses on developing the knowledge, attitudes, values and life skills needed to make appropriate and positive health-related decisions. An active, child-centered and participatory teaching approach is required in the promotion of life skills. Hygiene awareness needs to be linked to practical lessons and involve the classroom, school environment, home and wider community (Cheng et al., 2012).

Methodologically, environmental hygiene (*EH*) can affect Child health endowments (*CHE*) either positively or negatively depending on the nature of the environment. Generally a good *EH* is associated with increase *CHE* and they can be jointly estimated though each has its own interpretation. The causal link of environmental hygiene and child health endowments can be depicted by the following structural equation:

$$CHE = w_1 \pi_b + \sum_j v_j EH_j + \varepsilon_1, j = 1.....3, \quad (1)$$

where *CHE* is child health endowments captured by height for age; *EH* is environmental hygiene; w_1 is a vector of exogenous covariates; v is the parameter of the potentially endogenous explanatory variable (*CHE*) in the child health function, π_b is the vector of parameters to be estimated and ε_1 is the error term that captures both random effects and unobservable variables. The estimation of the parameter v_j would show the effect of *EH* on *CHE*. The (1) is our structural equation of interest where child health is estimated. Following Wooldridge (2002) the reduced form of child health generating child health endowments estimation strategy can take the following form:

$$EH_j = w_2 \pi_{EHj} + w_2 \Omega_{EHj} + \varepsilon_{2j}, \quad (2)$$

where w_2 is a vector of exogenous instrumental variable (IV) (such as tap water and flush to septic tank system) affecting *EH* but have no direct influence on *CHE*, π_{EHj} and Ω_{EHj} are vectors of parameters of exogenous explanatory variables in the reduced form *EH* to be estimated and ε_{2j} is the error term that captures both the random effects and other relevant but unobservable characteristics or complementary inputs. Given that *EH* and *CHE* are jointly estimated, the problem of endogeneity may occur, which can be originating from missing data, the IV helps to solve this endogeneity problem. However, in estimating *CHE* there is further need to deal with potential sample selection bias because some of the children in the 2011 survey were not recorded. The Heckman procedure is used to deal with the sample selection bias (Wooldridge, 2002). The first step in the application of the Heckman procedure is the identification of the probit equation. That is, specification of factors that influence selection of the unit of study into the estimation sample without directly affecting child health. To control for potential sample selection bias, the whole sample, which includes recorded children and none recorded by choice is used. To do this, we introduce equation (3)

$$VS = 1(w_1 \pi_g + w_3 \Omega_g + \varepsilon_3 > 0), \quad (3)$$

where, *VS* (*VS* = Variables Selection) is an indicator function for the selection of the observation in to the sample, it takes the value zero when child health is not recorded and one when child health is recorded, π_g and Ω_g are vectors of parameters of exogenous explanatory variables in the sample selection equation, where w_3 is a vector of exogenous variables instrumenting for the selection of children into the estimation sample and ε_3 is the error term that captures both the random effects and unobservable characteristics of selection. It's worth emphasizing that, since the households without children are excluded from equation (1), equation (3) helps correct any sample selection bias in the estimated parameters. It should also be noted that, the correction factor, derived from equation (3) is the inverse of the Mills ratio (*IMR*).

Considering that the IV (2SLS) model based on equations (1) and (2) will be estimated for the determinants of *CHE* using STATA 11.0, the heterogeneity of child health due to non-linear interaction of *EH* with unobservable and omitted variables could bias the estimated structural coefficients. The control function approach (Garen, 1984) is used to address this issue. Hence, to take care of this potential endogeneity bias, sample selection bias and non-linear interactions of unobservable variables with the observed regressors specified in the child health function regressors simultaneously, equation (1) can be upgraded to equation (4). As follows:

$$CHE_I = w_1 \pi + vEH + \gamma_1 \hat{\varepsilon}_2 + \lambda IMR + \gamma_2(\hat{\varepsilon}_2 * EH) + u \quad (4)$$

Where, $\hat{\varepsilon}_2$ is fitted residual of *EH*, derived from the reduced form linear probability model of *EH* (equation (2)); *IMR* is the inverse of the Mills ratio obtained after estimating the Probit model for selection (equation 3); $\hat{\varepsilon}_2 * EH$ is interaction of the fitted *EH* residual with the actual value of environmental status, u is a composite error term comprising ε_1 and the unpredicted part of ε_2, under the assumption that $E(u) = 0$ and π, v, λ, γ are parameters to be estimated. Exclusion restrictions are imposed on equation (4) because the set of instruments for *EH* is absent from the equation. The terms *IMR*, $\hat{\varepsilon}_2$ and $\hat{\varepsilon}_2 * EH$ in equation (4) are the control function variables because they control for the effects of unobserved factors that would otherwise contaminate the estimates of structural parameters. The reduced form *EH* residual $\hat{\varepsilon}_2$, serves as the control for unobservable variables that correlate with. In particular *EH*, if an unobserved variable is linear in $\hat{\varepsilon}_2$, it is only the constant term that is affected by the unobservable and the instrumental variable (IV) estimates of equation (4) are consistent even without the inclusion of the interaction term.

Considering the advantage of using this method of analysis, the respective assumptions taken into consideration, it can be noted that, the IV estimates are based on the assumptions that: (a) the unobservable variables are uncorrelated with excluded instruments or that the correlation is linear; (b) the estimation sample is randomly selected among children of age 0 to 59 months. The assumptions used for Heckman function are that: (a) the sample on which WAZ is estimated is non-random. Mwabu (2009) noted that the usual generated regressor (IMR) in censored samples is introduced into the WAZ equation through Heckman selectivity procedure to account for sample selection bias. The results of IV and Heckman selection ML approach are presented in Table 4 of the result section.

The Heckman/Control Function approach has some decided advantages over another two step approach, one that appears to mimic the 2SLS estimation of the linear model. This is because the Heckman/Control Function approach makes it much easier to test the null that for endogeneity problem as well as compute for the result. This explains why we choose this method of analysis. However, the Heckman/Control Function approach though likely to be more efficient but it is less robust, secondly, the Heckman/Control Function approaches are more difficult to be apply to nonlinear models, even relatively simple ones.

In terms of data analysis, we used the 2011 Demographic and Health Survey (DHS) (2011)[1] realized by the Ministry of Economic Affairs, Programming and Regional Development and collected by the national institute of statistics. The 2011 DHS was aimed at a national representative sample of about 11.732 children, 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. Considering the case of the child sample characteristics, our unit of observation is the child of age 0-59 months in 2011. The variable environmental hygiene is captured by toilet facility as the principal endogenous variable while child health endowment as the outcome variable is captured by height-for-age z-score. The exogenous demographics are drawn from mother, father, child and environmental characteristics. Specifically; (1) child health is capture by weight-for-age z-score; (2) the potential endogenous variable is environmental hygiene captured by household having a hygienic toilet facility; (3) potential exogenous demographics are: parental education, place of residence, household size and health seeking behavior, parent's social status, source of water and age of parents. The instruments for endogenous variables are: tap water and flush to septic tank system.

[1] For a complete review of the Cameroon 2011 DHS see Tambi (2014).

4. Research findings

The result of this study is presented according to our objectives. Thus, we begin with the summary of the sample descriptive statistics, reduced form estimates of environmental hygiene and selection of children into the estimation sample, child health outcomes and environmental hygiene.

4.1. Sample statistics

Child health in this study is capture at the community level, with about 79 percent of children living in different homes were covered among the 11.732 households sampled and in which 45 percent of households had toilets; 20 percent shared toilet facilities with other households while 37 percent dispose their youngest child's stools when not using toilet either in to ditch, buried or throw in to the open air or water. The descriptive statistics shows that 72 percent of men live in their homes with a maximum family size of 43 persons of which only 39 percent live in urban centers as seen in Table 2.

Table 2. Weighted descriptive statistics

Variable	Mean	Std Dev	Minimum	Maximum
Weight-for-Age Z – Score (waz_mpu)	0.793	0.593	–2.613	2.455
Environmental hygiene (1 = household having hygienic toilet facility, 0 otherwise)	0.451	0.495	0	1
Mother's education in years of schooling	4.593	0.620	0	17
Mother's education square	37.468	0.859	0	289
Mother's age in complete years of living	28.495	10.212	15	49
Mother's age square	860.672	4.405	225	2401
Breast milk (1 = mother breast-fed child, 0 otherwise)	0.399	0.810	0	1
Father's education in years of schooling	5.056	0.766	0	17
Father's age in complete years of living	40.059	5.356	17	98
Father's age square	1733.84	32.059	289	9604
Father present in household	0.724	0.538	0	1
Gender of child (1 = male, 0 otherwise)	0.515	0.210	0	1
Family size/household size	10.212	239.784	1	43
Social status (1 = non poor, 0 otherwise)	0.538	0.494	0	1
Cultural background/ethnicity	4.615	3.693	1	10
Place of residence (1 = urban, 0 otherwise)	0.394	29.095	0	1
Toilet facilities shared with other households	0.198	0.710	0	1
Disposal of youngest child's stools when not using toilet	0.376	0.989	0	1
Predicted Toilet Residual	7.22e-11	11.310	–1.025	0.247
Predicted Toilet * Toilet Residual	0.043	6.544	–0.093	0.247
Inverse of the Mills Ratio (IMR)	0.392	0.675	0.001	0.609
Number of observations				11732

Source: Computed by author from DHS (2011).

A majority of households in Cameroon are non-poor with a percentage of 53.8 percent with a mean age of 17 years for women and 40.5 for men with 59 educated among women as to 5.6 percent educate on the behave of women. Because of the high level education for women only about 40 percent of the women breast fed their children. This may be cause by ethnicity or cultural background, educational level of the parent and other determinant factors. Concerning the control function variables such as predicted value of toilet residual, toilet times toilet residual and the inverse of the mills ratio, the weighted sample descriptive statistics for these control function variables is also very important. These control variables represent unobserved factors that in theory could affect birth weight in complex ways. They are included in the weight-for-age z-score equation to ensure that its parameters are consistently estimated in the Control/Heckman function approach.

4.2. Reduced form estimates of environmental hygiene in Cameroon households

Based on the reduced form estimates, the factors influencing environmental hygiene in Cameroon and its correlates are indicated in Table 3. Here, parental education increases the opportunity cost of spending to have good toilets in particular and environment in general. Education creates hygiene and health consciousness, hence father and mother variables simply revealed that the more an individual is educated, the more he is ready to pay to avoid any form of economic bad environmental pollution. In Cameroon, issues related to environmental protection and/or pollution are gradually being introduced into the primary and secondary education cycles, this is very important in the sense that early awareness can motivate great precautions on the part of the citizens vis-à-vis environmental problems and so far as toilets are concern. This result is consistent with the observation of WHO (2002), who revealed that the more than three million children below five years that die each year from environment--related causes and conditions may be due to parental education/knowledge on environmental issues as presented in column one of Table 3.

Table 3. Reduced-form parameter estimates environmental hygiene and WAZ observed

Variables	OLS	Probit Estimate
	Environmental hygiene	WAZ observed (= 1 if WAZ reported during household survey; 0 if WAZ missing)
Mother's education in years of schooling	0.00086*(1.75)	0.02264**(2.38)
Mother's education square	–0.00013(–1.23)	–0.00152**(–2.36)
Mother's age in complete years of living	–0.00216(–1.01)	0.00198 (0.15)
Mother's age square	0.00004(1.43)	0.00002 (0.12)
Milk (1 = mother breast-fed child, 0 otherwise)	–0.00363(–0.90)	0.09704***(3.89)
Father's education in years of schooling	0.00149***(2.86)	0.01385***(4.35)
Father's age in complete years of living	0.00726***(8.54)	–0.00143(–0.27)
Father's age square	–0.00006*** (–8.44)	3.15e–06 (0.06)
Father present in household	0.07810***(16.60)	0.06031**(2.13)
Gender of child (1 = male, 0 otherwise)	0.00142(0.37)	–0.02615(–0.97)
Family size/household size	–0.00168***(–4.53)	0.00466 (1.58)
Social status (1 = non poor, 0 otherwise)	–0.02301***(–4.88)	–0.00015 (–0.00)
Cultural background/ethnicity	–0.00347***(–3.60)	–0.00326 (–0.56)
Place of residence (1 = urban, 0 otherwise)	0.0362* (1.89)	0.06222*(1.84)
Toilet facilities shared with other households	N/A	0.06515***(12.44)
Disposal of youngest child's stools when not using toilet	N/A	0.00855***(19.59)
Constant	0.77211***(22.67)	–1.39702***(–6.49)
R^2/(Pseudo- R^2)	0.8025	0.7369
Partial R^2 (on excluded instruments)	N/A	154.78[1, 11655; 0.0000]
Joint F / χ (p-value) test for Ho: coefficients on instruments = 0	55.58[14, 11664; 0.0000]	589.24 [14, 11655; 0.0000]
Weak identification test: Cragg–Donald F-Stat (5% maximal IV relative bias)	N/A	10.244 (11.04)
Sargan statistic (over-identification test of all instruments)	N/A	0.755 (0.6854)
Number of observations	11670	11679

Note: OLS = Ordinary Least Square.

Age of parents especially the father, as well as the presents of the male household head at home strongly correlates with environmental hygiene. Experience is the best teachers, meaning with long life many parents have come to the knowledge of the power of environmental hygiene in one's health, talk-less of children. Whenever, the father is at home, he in most cases ensures that sanitation and the general cleaning of the household is ensured. Parents who have been victims of environmental health problems such as diarrhea, dysentery, chickenpox, insects' bites and small pox will always strived to cleaner sanitation environment. The urban place of residence in Cameroon presents a better environment for living as compare to the rural Cameroon. There are many structures such as non-government organizations, urban councils, companies, ministry of urban planning and housing as well as other sanitation structures; that are working on the environment have a greater impact in urban centers than rural communities. The forces of law and order are equally stronger in urban than rural dwelling, in this perspective, the right of neighbors is respected, hence the act of building toilets is strictly under control, meaning that it is to have a better hygienic environment in the cities ceteris paribus, than otherwise.

Toilet facilities shared with other households, family size and non-poor households are negatively correlating with environmental hygiene. Cameroon still has large families, thus when a particular household is sharing its toilet facility with other households, the hygienic condition of that household becomes very terrible. In fact the more number of persons using a particular toilet facility, the higher the probability of having poor hygienic condition. This is exactly the same situation when the family size of a given household is large and they are using the same toilet facility. This result confirms what the WHO (2002) noted that, large household size easily suffer from, polluted indoor and outdoor air, contaminated water, lack of adequate sanitation, toxic hazards and disease vectors. However, it is surprising to find that non-poor household is negatively correlating with environmental hygiene; this might only be possible in rural Cameroon where the hygienic environment is not well coordinated.

4.3. WAZ observed and selection of children into the estimation sample

The selection of children's weight-for-age z-score in to the estimation sample is estimated using the probit model, this is done such that weight-for-age observed is equal to 1 if WAZ is reported during the household survey and is equal to 0 if WAZ is missing. In the Demographic and Health survey, the weight--for-age z-score is observed to be missing with about 0.45 percent, which means that during the collection of the 2011 DHS data some of the children anthropometric measures were collected. Cameroon is still pre-dominated by the rural community where there are still inadequate social amenities such as hospitals and medical centers, hence, children that were not born in the medical center or that were not having health/hospital cards their WAZ could not be collected thus, the missing in the data set. It is therefore necessary to select such children for our analysis. Therefore, the selection of children into the estimation sample is the demand for clinic births or health facilities. The mothers who delivered at the clinics or take their children to the hospital are more likely to report WAZ for their children and these children are the ones used to estimate the child health production function as presented in Table 3.

The reported WAZ sample selection, presents estimation results of a probit model of WAZ reported in DHS. As observed from Table 3, column 2, WAZ is significantly correlating with the treatment variable (disposal of youngest child's stools when not using toilet) at one percent significance level to mean our treatment variable is a strong endogenous instrument of the environment-child health relationship. The other estimates shows that mother's education, mother's age, child took breast milk, father's education, urban place of residence and father's present in the house are strongly associated with child health reporting. The value of these correlating variables shows that mother's education, mother's age, child took breast milk, father's education, urban place of residence and father's present in the house are increasing while those of father and mother's education first increases falls and then rises, suggesting that parents will always prefer to take their kids to the hospital/medical centers where they will medical cards.

4.4. Environmental hygiene and child health outcomes

Considering our assumptions as noted in the methodology section, the results of the IV shows that environmental hygiene is positively associated with child health to about 94.8 percent, while the Heckman/control function also confirms that environmental hygiene is positively associated with child health with about 95.8, 96.4 and −8.8 percent, respectively. The IV estimates tells a similar story as the Heckman/Control Function, however, their results differ in terms of magnitude. The Heckman/Control Function estimate (95.8, 96.4 and –8.8 percent) coefficient on environmental hygiene is larger as compare to the IV estimate, thus Heckman/ /Control Function estimates show stronger correlation between hygiene and WAZ relationship. It should be noted that the generated regressor (IMR) in censored sample is introduced into the child health equation through the Heckman selection procedure to account for sample selection bias as shown in Table 4. Thus, the estimate of maximum Likelihood Heckman/Control Function is obtained controlling for sample selection bias and heterogeneity of the WAZ.

Table 4. Child health production function and environmental hygiene

Variables	2SL	Heckman/Control Function		
		A	B	C
	WAZ_MPU			
1	*2*	*3*	*4*	*5*
Environmental hygiene	0.94882^{***} (4.27)	0.95831^{***} (4.63)	0.96461^{***} (6.61)	-0.0844^{**} (−2.15)
Mother's education in years of schooling	0.08855^{***} (20.24)	0.08884^{***} (21.78)	0.08753^{***} (21.47)	0.08869^{***} (14.64)

Table 4 cont.

1	2	3	4	5
Mother's education square	−0.0033*** (−11.37)	−0.00340*** (−12.27)	−0.0033*** (−12.16)	−0.0031*** (−8.05)
Mother's age in complete years of living	0.00963 (1.63)	0.01024* (1.86)	0.01148** (2.09)	0.02596*** (3.01)
Mother's age square	−0.00016* (−1.71)	−0.00017* (−1.93)	−0.00019** (−2.15)	−0.0003*** (−2.69)
Breast milk (1 = mother breast-fed child, 0 otherwise)	−	0.00201 (0.19)	−0.00201 (−0.19)	0.02906* (1.82)
Father's education in years of schooling	0.00591*** (3.98)	0.00609*** (4.39)	0.00614*** (4.44)	0.00476** (2.26)
Father's age in complete years of living	0.0051* (1.77)	0.00501* (1.89)	0.00441* (1.66)	0.01423*** (4.21)
Father's age square	−0.00004* (−1.83)	−0.00004* (−1.96)	−0.00004* (−1.77)	−0.0001*** (−3.99)
Father present in household	−0.1280*** (−5.81)	−0.12766*** (−6.22)	−0.1293*** (−6.31)	−0.0597*** (−3.24)
Gender of child (1 = male, 0 otherwise)	−0.00103 (−0.10)	−0.00116 (−0.12)	0.00043 (0.04)	−0.00316 (−0.21)
Family size	0.00227*** (1.93)	0.00233** (2.13)	0.00258** (2.37)	−0.0097*** (−5.11)
Social status (1 = non poor, 0 otherwise)	0.37701*** (28.49)	0.37712*** (30.61)	0.38181*** (31.00)	0.39529*** (22.28)
Cultural background/ethnicity	0.06266*** (23.16)	0.06253*** (24.81)	0.06219*** (24.72)	0.04997*** (13.77)
Place of residence (1 = urban, 0 otherwise)	0.00143 (0.13)	−	−	−
Environmental residual	N/A	−1.0901*** (−4.90)	−0.9021*** (−4.33)	0.24084 (0.72)
Interaction of environment * residual	N/A	N/A	−0.0072*** (−6.69)	−0.00439 (−1.15)
Inverse of the Mills Ratio (IMR)	N/A	−0.10865 (−1.46)	−0.08795* (−1.68)	5.99241*** (4.17)
Constant	−2.6776*** (−13.65)	−2.63402*** (−14.19)	−3.1307*** (−15.69)	−2.1029*** (−14.01)
R^2/(Pseudo- R^2)/ uncensored obs	0.3686	0.4537	0.4558	5030
Joint F / χ (p-value) test for Ho: coefficients on instruments = 0 / Wald chi^2	597.59 [14, 11655; 0.0000]	604.88[16, 11653; 0.0000]	574.07[17, 11652; 0.0000]	3594.48 [14; 0.0000]
Anderson canon. corr. LM statistic / Under-identification test	152.947 [0.0000]	N/A	N/A	N/A
Durbin−Wu−Hausman χ test for exogeneity of variables	23.756 [0.0000]	N/A	N/A	N/A
ρ (Correlation of waz Residual with Sample Selection Residual), [Std. Err.]	N/A	N/A	0.8029 (0.0021)	N/A
σ (Sigma of waz) (s.e)	N/A	N/A	0.53092 (0.006)	N/A
Number of observations	11670			

Note: 2SLS = Two stage least square, N/A = Not Applicable.

Estimates of IV in the tests of joint significance of coefficient on χ^2/F statistics (p-values) are the same as the estimate of maximum Likelihood Heckman/Control Function except in the strength of their magnitude. However, as expected, the Durbin–Wu–Hausman chi-square test rejects exogeneity of all child health inputs (environmental hygiene, parent education shown in Hechman selection) indicating that least square is not a valid estimation method. Through the Control function results, we observed that, the problem of selectivity bias is check. The results from the parsimonious specification of Control function estimates are therefore preferred to IV which can be understated and Heckman estimate of column (A) and (C) (low environmental hygiene magnitude), this confirms the drop of our hypothesis that, there is no heterogeneity in WAZ. As noted in Heckman (1979) and consistent with the formula for the IMR (Wooldridge, 2002); the estimated coefficient on this ratio is simply the estimated value of sigma (σ) times the estimated value of rho (ρ) as indicated in Table 4.

The results of Heckman/Control function in column (b) suggest that there is no problem of selection bias in this sample. Specifically, it is assumed that there are no unobservable variables interacting with the regressors in the child health equation or if in case they do exist, then the interaction is linear. Since the magnitude of the coefficient of environmental hygiene of the Heckman estimate of column (A) and (C) is lower than that of the control function of (B) and also given that the Wald χ^2 test for $p = 0$ (p-value) is 0.8029[0.0021] of Table 4, makes the Control function estimates of column (B) preferred to (A) and (C).

Focusing on the result of column (B), we observed that whenever the environmental hygienic condition is favorable the children have 96 percent chances of being in good health. This means that improve latrines is associated with increase child health in Cameroon. This observation is consistent with the ideas of Bampoky (2013) who found out that the impact of modern sanitation was considerably larger in decreasing child mortality risk by 68 percent and Trussell & Hammerslough (1983) who also realized that improved latrines decreased child mortality in Sri Lanka. Just as noted in Tambi (2014), the estimates of the control function based on the inverse of the mills ratio, show some correlation between rho and sigma, that has statistically significance coefficient on inverse of the Mills ratio, so it is evident that the unobservable variables that are associated with selection of children into estimation sample are not separable from unobservable that are correlated with WAZ as noted in Table 4.

The negative coefficient on the inverse of the Mills ratio suggests that some of the children of households living and using poor toilets / unfavorable environment had better health than some of the children living in favorable environment or using good toilets. This finding justifies the choice of the control function approach in Table 4 because it corrects for sample selectivity bias. The WAZ of an infant randomly selected from the population is the average of child health of 0 to 5 years children using a favorable toilet and an unfavorable toilet. The exogenous variables associated with WAZ in Cameroon are: mother's education, mother's age, father's education, father's age, family size, non poor households and cultural ground. While variables such as mother's education square, mothers' age square, father's education square, father's age square and father present in the house are negatively correlating with child health as presented in Table 4.

4.5. Test of assumptions, robustness of result and instruments validity

Considering the Cragg–Donald F-statistics (5% maximal IV relative bias), Sargan Statistics (over-identification test of all instruments), Durbin–Wu–Hausmanχ^2 test for exogeneity of variables and the joint F and χ^2 tests, we realized that the instruments used in this work is valid both for the input equations and for the selection equation. As seen in Table 4, the first-stage F statistic on excluded instruments increases up to 154.48 (p-value = 0.0000), while the χ^2 statistic for the selection equation is 589.24 (p-value = 0.0000). This high χ^2 statistics indicate that the instruments strongly identify the sample selection equation as presented in Table 3.

The Sargan statistic (0.755, p-value = 0.6854) suggests that the instruments are valid and however, looking at the Cragg–Donald F-statistic we realized that though the instruments are relevant, they are marginally weak (10.244 [11.040]). This is necessary in the sense that, since there is one endogenous regressor (including the sample selection variable) and two instruments, there is need to check whether over-identification restrictions hold in Table 3. On this basis, it becomes relevant to verify the assumption that the extra instrument is uncorrelated with the structural error term. Diagnostic tests indicate that the inputs into WAZ production function are endogenous, since the Durbin–Wu–Hausmanχ^2 test for exogeneity of variables (23.756 [0.0000]), which indicates that the OLS estimates are not reliable for inference.

The F-statistics on excluded instruments for the input equation is low, suggesting that the excluded instruments are weak in this case; hence, we say the instruments are weak but relevant. Stock, Wright, & Yogo (2002) already argued that instruments are relevant but weak if their joint effect is statistically significant but at a low F statistic, typically less than 10. When the instruments are relevant but weak, the 2SLS estimator is biased toward the OLS estimator, which is known to be inconsistent (Bound, Schoenbaum, Stinebrickner, & Waidmann, 1995). However, if the bias of the 2SLS estimator, relative to the inconsistency of the OLS estimator is small (at most 10%) weak instruments are still reliable for inference (Tambi, 2014; Stock et al., 2002).

5. Conclusions

From the foregoing, this study has attempted to measure the effect of environmental hygiene on child health outcomes in Cameroon using 2011 demographic and health survey collected by the national institute of statistics. The research questions were: what are the determinants of environmental hygiene in Cameroon? How does environmental hygiene affect child health endowments? What are the environmental hygiene effects by place of residence? And what economic policies can be proposed to ameliorate the environmental hygiene--child health effect?

In terms of variables and methodology: (1) child health was captured by weight-for-age z-score; (2) the potential endogenous variable was environmental hygiene captured by toilet facility; (3) potential exogenous demographics were: parental education, place of residence, household size, parents social status, sex of child, child took breast milk and age of parents. The instruments for endogenous variables are: toilet facilities shared with other households and disposal of youngest child's stools when not using toilet. We used the 2SLS and Control Function models in STATA 11.0 to estimate our result. The Control function estimate helps to purge parameter estimates of simultaneity bias, sample selection bias and heterogeneity concurrently.

The result showed that whenever the environmental hygienic condition is favorable the children have 96 percent chances of being in good health, this means that improve latrines is associated with increase child health in Cameroon. While result by determinants of environmental hygiene showed that: parental (mother and father) education, father's age, father present in the house and urban household resident are strongly correlating with environmental hygiene. These results highlight the need for decision-makers to be more intentional with allocating economic resources towards sanitation projects.

The limiting factor of this type of study is the use of a single cross section data, single child health measure as well as the use of many assumptions. We stipulated that the IV estimates are based on the assumptions that: (a) the unobservable variables are uncorrelated with excluded instruments or that the correlation is linear; (b) the estimation sample is randomly selected among children of age 0 to 59 months. The assumptions used for Heckman function are that: (a) the sample on which WAZ is estimated is non-random. With regards to future research, researchers in this domain should use more than one child health measure among the host of child anthropometrics and other sources of data to carry out their analysis.

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