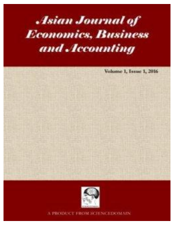

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A Probit Model Version of Water and Sanitation as Predictors of Child Diarrhoea in Ghana

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Authors' contributions

This work was carried out in collaboration among all authors. Authors GE and AP jointly designed the study. Author JAA performed the statistical analysis and wrote the first draft of the manuscript. Author GE handled the analysis of the study while author AP managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Diarrhoea has been recognized as one of the causes of child mortality globally. As in other developing countries, diarrhoea incidence among children is worrisome as 13 percent of children in Ghana do suffer from such according to 2011 Multiple Indicator Cluster Survey report. Despite this knowledge about child diarrhoea, researchers passively discuss issues relating to child diarrhoea in Ghana.

The paper analyzes the effect of water and sanitation on diarrhoea incidence in the Ghanaian context using 2011 Multiple Indicator Cluster Survey data set. The study employed the probit model in estimating the incidence of diarrhoea among Ghanaian children. Even though previous studies in Ghana on this issue showed that drinking improved water source was not associated with child diarrhoea incidence, the econometric analysis of 4925 households in Ghana showed that access to

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improved water and improved toilet facility reduces diarrhoea among children.
Recommendations that were offered included community based urban and rural sanitation and water project as well as educating mothers on the importance of using improved water source.

Keywords: Child diarrhea; Ghana; improved water source; multiple indicator cluster survey; probit model; sanitation.

1. INTRODUCTION

Child health is a vital indicator of economic growth. This is because the initial years of a child's life provide the foundation for future health development and wellbeing. Wellbeing focuses on developing as a person, which has two main elements; psychological wellbeing including feeling and thinking and physical wellbeing. It must be emphasized that physical wellbeing of the child is important for learning and development as this enables the child to explore, to investigate, and to challenge him or herself in the environment. The adult supports a child's psychological and physical well-being by helping them to make healthy choices about nutrition, hygienic practices and exercise.

A progressive start in life helps children to reach their full potentials while a poor start increases the chances of adverse outcomes. In addition to being an economic development indicator, child health is also closely associated with other development indicators such as adult health, educational attainment, productivity, and income of parents and future income prospects of children [1,2,3]. Child health can be measured with several indicators such as mortality which includes diarrhoea mortality and morbidity, acute respiratory infection mortality, incidence of child cancer and other exposure indicators such as excreta disposal facilities; indoor air pollution; safe drinking water as well as other policy indicators that affect the health of the child in terms of safe housing programmes as stated in a research reporting Child Health in Europe [4].

Diarrhoea accounts for 1 in 9 child deaths worldwide, and is now the second leading cause of death among children under the age of five [5]. For children with HIV, diarrhoea is even more deadly; the death rate for these children is 11 times higher than the rate for children without HIV. About 1.5 million children die each year to diarrhoea [5]. It causes death by depleting body fluids resulting in profound dehydration [6]. According to the World Health Organization, diarrhoea kills an estimated 1.9 million children under age five every year, representing almost one in five or 19 percent child deaths globally [7]. In fact, diarrhoea kills more children than AIDS and malaria combined [8].A report in [9] indicates that each child in Sub-Saharan Africa experiences an average of five episodes of diarrhoea per year resulting in about 800, 000 annual deaths. Again, it has been indicated in [10] that 5.9 percent of deaths in developing countries that are attributable to diarrhoea are mainly as a result of using unsafe water, and unhygienic sanitation practices. An account in [11] reveals the fact that diarrhoea accounts for 21 percent of all deaths of children under 5 years of age annually, mostly from developing countries. Rotavirus is the leading cause of acute diarrhoea and causes about 40 percent of hospitalizations for diarrhoea in children under five years. Most diarrhoea germs are spread from the stool of one person to the mouth of another. These germs are usually spread through contaminated water, food, and objects. Diarrhoea can have a detrimental impact on a child's growth and cognitive development. About 88 percent of diarrhoea associated deaths are attributable to unsafe water, inadequate sanitation, and insufficient hygiene [12]. These mechanisms of transmission are therefore preventable through basic water and sanitation infrastructure, notably piped water and appropriate toilet facility through basic hygiene.

In spite of this, a report from [13] indicates that, in 2006, about 2.5 billion people worldwide lacked improved sanitation facilities. Moreover, nearly 1 in 4 people in developing countries practise indiscriminate or open defecation. To further compound the problem, children's faeces are often unsafely disposed off in many developing countries. Children's stools tend to carry a higher pathogen load than adults', and many children play in areas in which stools are found. Addressing child health in terms of access to improved sanitation and water, Millennium Development Goal (MDG) target on sanitation cannot be achieved in Sub-Saharan Africa [14]. By 2050, it is projected that at least one in four people are likely to be affected by recurring water shortages [15]. Universally, sanitation coverage is proposed to fall short of the MDG goal of 75 percent coverage, with a projected global coverage of 68 percent by 2015. In disparity, global water coverage is expected to reach 90 percent, surpassing the MDG goal of 89 percent [16]. There are indications from varied directions that development toward sanitation coverage has dawdled behind water coverage [17]. Benefactors usually put both water and sanitation within a particular program, and sanitation is often treated as a second thought, or deserted completely. This paper represents an attempt to reverse the historic neglect of sanitation and usher in an era of equality between water and sanitation in both focus and funding. As such, while sanitation has yet to gain the attention that it deserves, there has traditionally been no more opportune moment to champion an increase in sanitation aid. While the commitment to fighting AIDS is to be applauded, it is important that issues, such as diarrhoea and sanitation receive the levels of funding that their high death tolls warrant.

The health and well-being of children are of crucial importance not only as reflections of the current health status of individuals and the nation as a whole but also as predictors of the health of the next generation. Even though Ghana has adopted several interventions and programs towards improving child health and welfare and towards the achievement of the MDG4, much has not been achieved. The disturbing statistics on the trend of diarrhoea has challenged and ignited researchers and development practitioners to investigate the likelihood of diarrhoea incidence among children under five and effective measures to combat it. A plethora of studies of water infrastructure have focused on the role of water quality in diarrhoea incidence, while others have examined the importance of the quantity of water utilized, frequently using the distance between household and water source as a proxy. Improved water sources normally have lower pathogen counts, reducing child exposure to the diarrhoea-causing agents than readily infected traditional water sources [12]. Evidence from previous studies have however given uneven results with regards to the relationship between water and child diarrhoea. Most studies found a statistically significant association between improved water quality and reduced diarrhoea incidence [18,19] while some studies showed no such association [12,20]. In Ghana, diarrhoea prevalence is high, while significant gaps linger on access to adequate water and sanitation facilities. Report on Ghana from UNICEF shows that in every year, diarrhoea kills 14,000 Ghanaian children under age five. Diarrhoea is the second leading cause of death of under-five death after malaria [13]. Addressing access to sanitation is key to securing progress on MDG 4 (reducing child mortality by two-thirds). Poor sanitation costs Ghana 420 million Ghana Cedi each year, equivalent to US$290 million, according to a desk study carried out by the Water and Sanitation Program (WSP). This sum is equivalent to US$12 per person in Ghana per year or 1.6 percent of the national output. Even though some studies have been done in Ghana on water, sanitation and child health, two of them concentrated on the northern region of Ghana [21], while the only one nationwide study used 2003 Ghana Demographic Health Survey and only concentrated on piped water. This paper therefore attempts to use WHO classification of improved water source and sanitation of the households as predictors of child diarrhoea.

The general objective of this paper is to determine the effect of water and sanitation on child diarrhoea. The specific objectives are to:

- Investigate the effects of improved water source on child diarrhoea
- Examine the effect of appropriate sanitation facilities on child diarrhoea

To achieve these objectives, the study seeks to test the following hypothesis:

- H_0: Improved water source has no effect on child diarrhoea.
  H_1: Improved water source has a significant effect on child diarrhoea.
- H_0: Improved sanitation facility in the household has no significant effect on child diarrhoea.
  H_1: Improved sanitation facility in the household has a significant effect on child diarrhoea.

The paper will be significant in the sense that the results could improve policymakers understanding of the linkages between water, sanitation and child diarrhoea in the country and serve as an important tool for any possible intervention aimed at improving child health outcomes in Ghana. For example, knowledge about this issue will help increase public-private partnerships, investments by large corporations, and more community-based organizations and non-governmental organizations that will work on improving access to water and sanitation. Also, the outcomes would help to improve other trends such as the consideration of water scarcity in sustainable planning and a move from simple water quality monitoring to the development of a more holistic water safety plan approach by the World Health Organization (WHO). Last but not least, the significance of the paper lies in light of the fact that, understanding the determinants of child diarrhoea and getting the appropriate prescriptions for addressing it could be a further contribution in the cap of achieving the First and Fourth MDGs.

2. MATERIALS AND METHODS

This section is devoted to describe the methods that were employed in conducting the study. The section opens with the research design and theoretical framework, which was followed by the empirical model and the estimation technique. It also captured a brief description of regression diagnostics. The section ended with the sample design and data collection method.

2.1 Research Design

The methodological approach adopted in this study is deeply rooted in the positivist philosophy which postulates that objective knowledge was possible and can be quantified. Positivism also subscribes to the use of natural science methods and practice to study human behaviour in the social sciences [22]. The epistemological assumption that follows from positivism is that, human behaviour can be netted in numerate and hard data seeking to measure and describe social phenomenon by attribution of numbers [23] and this is perfectly in line with the objective of the study. Also according to Harwell [24], research design may reflect the entire research process, from conceptualizing a problem to the literature review, research questions, methods and conclusions, whereas in other studies, research design may refer to the methodology of the study (for example, data collection and analysis). This paper therefore adopts a quantitative cross-sectional study aimed at finding association between water, sanitation and child health outcomes in terms of child diarrhoea. This research design is chosen based on the availability and nature of the data (MICS 2011), the objectives and hypothesis set and finally, provision of consistent and easy provable results. The rationale behind this paper is that, since water and sanitation are directly linked to child diarrhoea there is the need to pay more attention to this issue in order to improve upon the child health in terms of diarrhoea incidence if MDG4 is to be attained.

2.2 Theoretical Model Specification of Household Production of Child Health

The theoretical model for the analysis of child health production derives from household production theory, which originated from the works presented in [25,26] and was adapted as in [27] to analyze the accumulation and depreciation of health capital. The health production model, in which health capital is conceived as the output of a multivariate production process [27-30] provides the basis for the empirical model of this study.

Briefly, in this model it is assumed that the individual inherits an initial stock of health that depreciates over time, but also that the individual may positively influence the stock of health capital via gross investments. Gross investments in health capital can be made via combinations of the individual's own time and market goods such as medical care, diet, housing, exercise and lifestyle. The level of education of the producer also affects how efficiently he or she can produce health and is analogous to the technology of production or stock of knowledge in production theory more generally. Exogenous shocks thus may also affect a consumer's demand for health and the production of gross investments in health.

Jacobson [31] however extended the model in [27] to produce a generalized model by taking the family as the production unit. In this model, every individual in the family is assumed to be both the producer of his or her own health as well as the health of other family members. In this framework, the income of all family members is used in the production of the health capital of each member of the family. Thus, in one of the model [31], a family unit consists of a father, a mother and a child. In this model, the child is considered a passive participant in the production of its own health since he/she cannot invest directly into their own health, therefore the health of the child largely depend on the parents characteristics and resources.

The model further assumes that parents get utility from the good health of their child and can use total time available for market and non-market activities. Therefore, parents use inputs of market goods and their own time and resources to produce child health. This model may be regarded as an extension of Grossman's conception of the determinants of individual demands for health as a consumption argument that enters the utility function directly (since sick days produce disutility), and as a derived demand, since sickness/wellness affects the total time available for market and non-market (production) consumption activities.

The basic theoretical framework that guided this study is therefore derived from the theory of utility maximization and household production of health espoused in [32] and deeply rooted in the generalized Grossman model of demand for health [33] and the extended Grossman model of Jacobson [31] – the parent-child family specification of health demand.

Following [31], child health outcome is determined by the health environment resources, a child-specific health input which does not affect parent utility directly, child health endowment or biological characteristics, parental human capital and household characteristics which include sanitation and water.

The health environment composite good consists of goods which affect both utility and child health status directly. In developing countries this could be, for example smoking, the number of children in the household, household sanitation or the source of water. Child specific health inputs include nutrients intake and individual care practices which include breastfeeding.

Following these theoretical extensions and like previous empirical studies [34-37] on the relationship between environmental variables and child health outcomes and in the vein of those in [31,38-40], the utility function for a family at a time can be written as

$$U_t = U(H_{tc}, H_{tp}, X_t, Y_t, L_t, Z_{ut}, \xi_{ut}) \quad (1)$$

where H_{tc} and H_{tp} represent the health of a child and parents respectively, X_t is a set of goods that affects child health (e.g., food, toys and housing), X_t represents other commodities consumed by the household, L_t is the leisure time, Z_{ut}, and $\xi_{ut}$are exogenous observable and unobservable factors respectively that influence U_t.

Following the specification of the accumulation of health stock introduced in [27], the production of child health is described as

$$H_{tc} = H(H_{tc-1}, X_t, L_{ht}, Z_{ht}, \xi_{ht}) \quad (2)$$

Here, L_{ht} is the amount of time used in the production of child health, H_{tc-1}represents stock of health proxied by birth weight $Z_{ht}$and ξ_{ht} are respectively exogenous observable and unobservable variables affecting H_{tc}.

The budget constraint of the household is

$$I_t = Y_* + w_t T_{wt} = P_{xt} X_t + P_{yt} Y_t \quad (3)$$

I_t is a combination of labour and non-labour family income, T_{wt} is the time spent to earn wage income, w_t, P_{xt} and P_{yt} are respectively the wage rate, prices of X_t and Y_t.

The household also faces a time constraint in the production of household resources given as

$$T = L_{ut} + T_{ht} + T_{wt} \quad (4)$$

Where, T is the total fixed amount of time available (e.g., 24 hours per day), L_{ut} represents the time for household allocate for leisure, T_{ht} is time household allocate the production of health more especially child care and T_{wt} is time for allocate for work hence w_t is wage rate.

From (2), the household utility function can be expressed as an indirect household utility function conditional on the health status of the child given as

$$V_t = U(H(H_{tc-1}, X_t, L_{ht}, Z_{ht}, \xi_{ht}), H_{tp}, X_t, Y_t, L_t, Z_{ut}, \xi_{ut}) \quad (5)$$

Rewriting simply, we have

$$Vt{=}UH,\ C \quad (6)$$

Where, H represents child health and C all other commodities that affect household utility.

Considering (3), (4) and (5), the household utility maximization problem is

Maximize $V_t = U(H, C)$

Subject to the budget and time constraints above, plus the condition of positive initial stock of child health ($H > 0$).

$$\sum_{j=1}^{j} P_{xt} X_t + \sum_{s=j=1}^{s} P_{yt} Y_t + wL_{ut} + wT_{ht} = wT_{wt} + Y_* = I_t \quad (7)$$

Where, Y_* is unearned income. Setting the Lagrange equations presents equation (18) as follows;

$$L = U(H, C) + \lambda[I_t - wL_{ut} + wT_{ht} \sum_{j=1}^{j} P_{xt}X_t - \sum_{k=0}^{n} P_{yt}Y_t] \quad (8)$$

Taking the first derivatives of the Lagrange function with respect to child health and commodities $X \, and \, Y$until the initial conditions are met and solving these first order conditions associated with this optimization problem produces the reduced form of the Marshallian demand function for child health given as;

$$H_t = H(H_0, Y, X, L_u, T_u; \xi) \quad (9)$$

Where, ξ is the combination of $Z_{ht}, \xi_{ht}Z_{ut}, \, and \, \xi_{ut}$ and stands for the non-observable attributes and capture the idiosyncratic errors. As conferred earlier, (9) cannot be estimated directly becauseH_t, the child's quantity and quality of health is not observable. In this however, child diarrhoea prevalence is used as a proxy for child since diarrhoea prevalence is observable. In (9) above also shows that the optimal level of child health is determined by the allocation of parental time between income-generated work, household chores and leisure, the consumption of child-health related goods and other goods and services.

Several modifications of the reduced-form demand and structural functions for child health have emerged in the literature as a result of data constraints and research focus. It has been asserted in [41] that only a few studies are able to use datasets that meet the required criteria.

2.3 Empirical Model Specification

In reference to [42] and the theoretical model adapted for the study, child health status is not determined by food availability alone, but also by access to basic social services and infrastructure such as quality of water and access to improved sanitation, quality of home based care for young children, infant feeding patterns, morbidity and other factors. Therefore following framework adapted [42] for this study and the theoretical expositions in [31] and considering the data available, the empirical model specification for child health measured by child diarrhoea can be represented as:

$$ChildH_{ij} = \left. \begin{matrix} \beta_0 + \beta_1 impWater_{ij} + \beta_2 impSanitation_{ij} + \beta_3 wcbij \\ +\beta_4 ACij + B_5 med + B_6 \, Time + \beta_7 wealth \, indexij \\ +\beta_8 fm + \beta_9 sex + \beta_{10} eco + B_{11} area + \xi_{ij} \end{matrix} \right\} \quad (10)$$

We define $ChildH$ to represent the child health outcome measured by prevalence of diarrhea reported in the period of two weeks preceding the survey. *i and j* represent individual child and specific household/family characteristics respectively. Matrix$X$ includes all control variables and ξ captures the idiosyncratic errors. The main focus of this study is to estimate parameters, $\beta_1, \beta_2 \, and \, \beta_3$ and the expectation is that they should negatively influenced child diarrhoea. Hence, it is expected that improved water source, improved toilet facilities, and child's weight at birth should reduce child diarrhoea.

2.4 Estimation Technique

This study applied a probability model specified as a function of series of explanatory variables such as socioeconomic and demographic characteristics of households. The dependent variable is a binary/dummy variable, which takes a value of zero or one depending on whether or not a child had diarrhoea or not (i.e. Diarrhoea= 1 and No diarrhoea = 0). Thus, a probit model is used to estimate the determinants of child diarrhoea prevalence and to assess the probability of a child suffering from diarrhoea or otherwise.

The probit model also known as the normit model is an estimation technique which allows for estimating the probability that an event occurs or not, by predicting dependent outcome from a set of independent variables. In the child diarrhoea situation the dependent variable is whether a child has diarrhoea or otherwise in relation to the household access to water and sanitation and other household characteristics. The functional form of the linear probability model specified as follows [43].

$$P_i = P(Y = 1|X_i) = F(\beta_i + \beta_2 X_i) = P(Zi \leq (\beta_i + \beta_2 X_i) \quad (11)$$

Here, we define $P_i = P(Y = 1|X_i)$ to denote the probability that an event occurs given the values of the X, or explanatory variables and where Zi is the standard normal variable, which is Z ~ N$(0, \quad ^2)$. F is the standard normal from the cumulative distribution function which can be written explicitly in the present context as

$$F(Y) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{Y} e^{-z^2}\,dz = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{(\beta_1+\beta_2 X_i)} e^{-z^2}\,dz \qquad (12)$$

P_i represents the probability that a child in the household will have diarrhoea or not.

This equation is known as the cumulative logistic distribution function and Z_i ranges from -∞ to +∞; P_i ranges between 0 and 1; P_i is also non-linearly related to Z_i (that is,X_i) thus satisfying the two conditions required for a probability model. In satisfying these requirements, an estimation problem has been created because P_i is nonlinear not only in X but also in the β's. This means that one cannot use ordinary least squares procedure to estimate the parameters [43].

2.5 Regression Diagnostics and Post Estimations Tests

To ensure that estimates from the regression are robust, unbiased and consistent, the data was first observed to deal with influential observations, outliers, missing values and implausible values. The following diagnostics and post estimation tests were also conducted: checking homoscedasticity of residuals [44,45], model specification error test [46], goodness-of-fit test, multicollinearity [47]

2.6 Sample Design and Data Collection

The Multiple Indicator Cluster Survey, 2011 (MICS, 2011) was conducted in 2011 by the Ghana Statistical Service (GSS) [48]. The survey provides valuable information on the situation of children, women and men in Ghana, and was based, in large part, on the need to monitor progress towards goals and targets emanating from recent international agreements: The Millennium Declaration, adopted by all 191 United Nations Member States in September 2000 and the Plan of Action of A World FIT For Children, adopted by 189 Member States at the United Nations Special Session on Children in May 2002. Both of these commitments build upon promises made by the International Community at the 1990 World Summit for Children [48]. The MICS is a household probability sample survey that sets out to cater for a variety of analysis at the various domain of interest. It is an international household survey program developed by UNICEF.

Ghana MICS 2011 is part of the 4th round of MICS survey (MICS4). Its purpose is to collect reliable, disaggregated and internationally comparable statistics on the situation of the Ghanaian people, especially children under the age of 5 and women aged 15-49 and 15-59 men for effective planning, implementation, monitoring and evaluation at national and regional levels. The MICS4 is a random two-stage sample survey. The first stage deals with the selection of Primary sampling units (PSUs) from a sampling frame which is the list of the 2010 Census enumeration area. The second stage dealt with the selection of the secondary sampling units (SSUs).

The sample for the MICS was designed to provide estimates for a large number of indicators on the situation of children and women at the national level, for urban and rural areas, and for ten regions: Western, Central, Greater Accra, Volta, Ashanti, Brong-Ahafo, Northern, Eastern, Upper East and Upper West regions. The urban and rural areas within each region were identified as the main sampling strata and the sample was selected in two stages. Since the sampling frame (the 2000 Ghana Population Census) was up-to-date, a new listing of households was not conducted in all the sample enumeration areas prior to a systematic sample selection of 15 households in each selected cluster. The completely merged file for the study included a total of 7388 children in household that had children with or without diarrhoea. From this sample, type of toilet facility used by the household had 7388 observations of which two were missing. Main source of drinking water for the household also had 7388 observations of which none was missing. On the other hand time taken to and from the water source had a total observation of 4988 with 10 missing observations while the weight of child at birth had a total missing observation of 31. In all, the total number of missing observations stood at 43, reducing the sample to 4925. Hence, the total sample size that was used for the analysis is 4925 as summarized in Fig. 1. The study was started in June 2015 and ended in May 2016.

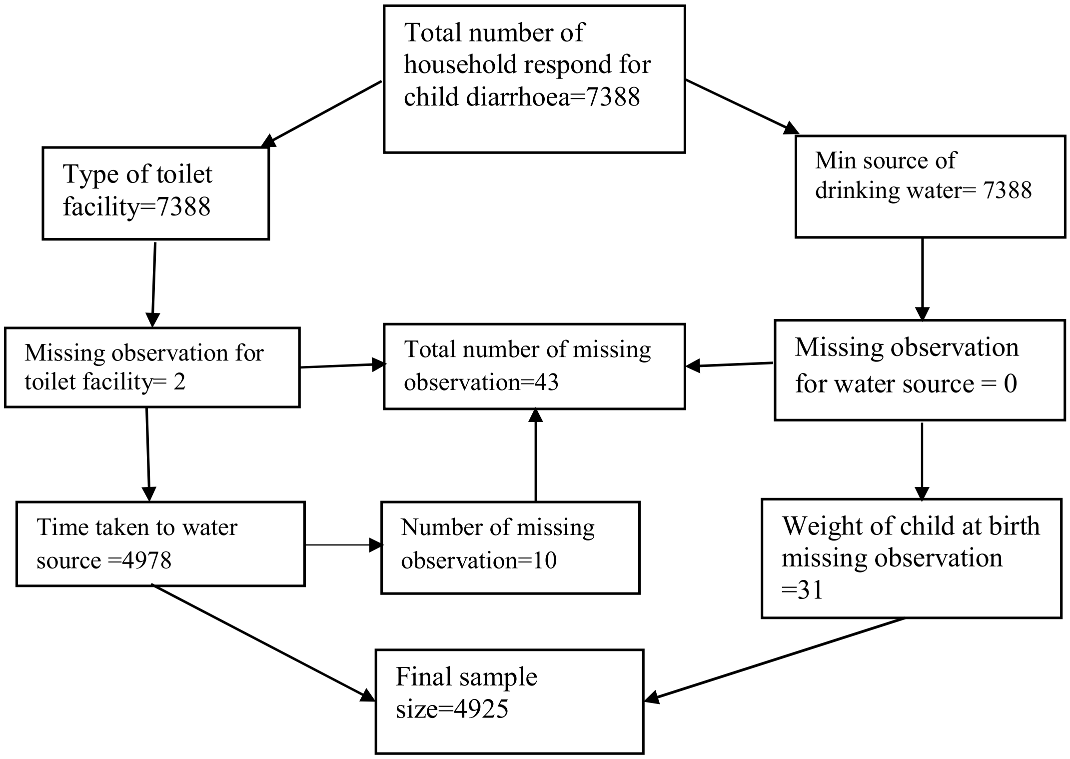

Fig. 1. Data justification
Source: Derived from MICS, 2011

3. RESULTS AND DISCUSSION

This section presents the analysis of the findings of the study based on the results of the probit regression analysis.

The study focuses on two main variables, thus water and sanitation and how they affect child diarrhoea. This segment presents findings from the regression analysis on the core variables and that of other covariates such as wealth of the household, area of residence (urban or rural), educational level of the mother, time taken to the water source and back, age of the child and the weight of the child at birth, type of flooring materials used by the households and the ecological zones within which the respondents can be found. These outcomes have been presented in Table 1 with the standard errors in the brackets. The Pseudo R^2 =0.0352 indicates that 3 percent of the variations in child diarrhoea is explained by the covariates.

The linktest and Hosmer-Lemeshow were conducted to test for model specification and goodness-of-fit respectively. The results for _hat (P>|z|= 0.0038) and _hatsq (P>|z|=0.829) for the linktest shows that the model is correctly specified. This means that we can, only by chance, find other predictors that are statistically momentous. With regards to the goodness-of-fit test, the Hosmer-Lemeshow gave a score of Prob > chi2 = 0.4137 which is greater than 0.05 and shows that the model is of good fit.

In the model, water source was further re-categorized into household that use Piped water, Well water, Rainfall and stream. It can be seen that the probability of a child to contract diarrhoea increase for households that drink from streams at a significant level of 5 percent. Thus, households that use stream as their main source of drinking water are 0.032 more probable to have children suffering from diarrhoea compared to those living in households that use piped water as their main source of drinking water. This is in accordance with studies which revealed that water source has a significant effect on child diarrhoea. For instance, studies undertaken in [12,18,49-53], found that access to piped water leads to a reduction in child diarrhoea. More specifically, it was discovered in Ghana in [51] that a 17 percent reduction in diarrhoea can be induced by improved water supply. A number of studies from other countries for example, in [52,53] have also found such association.

Area of residence has also been revealed as being a significant determinant of child diarrhoea at 5 percent alpha level. Observe that the regression coefficient between urban dwellers and the likelihood of their children to contract diarrhoea is -0.023. Thus one's residential status as an urban dweller reduces the risk of one's child contracting diarrhoea by 0.023. This can help strengthen the positive relationship between unimproved water sources as a study in Ghana [21] has revealed that the consumption same water sources are very common in rural areas.

Time taken to water source and back was not significant in reducing child diarrhoea. This may be due to the fact that the MICS data did not include the use of secondary water sources. This is because, some households may have a particular water source close by, but may choose to travel longer distance in other to get quality water. In this instance, time required to move "to and from" water source would not be an appropriate measure of access to water and quantity of water available to those households for hygienic use. This may explain why time taken "to and from" water source was not significant in explaining child diarrhoea.

Also, it can be discovered that children in households that use pit latrines with cover are 0.23 less probable to contract diarrhoea compared to their counterpart that live in households that practice open defecation, at a 10 percent alpha level, holding all other variables constant. It should be noted that in other to enable comparison, sanitation infrastructure was categorized into households that practice open defecation; Those who share toilet and those that use pit latrine with cover. The coefficient on pit latrine with cover was negative, as expected, indicating that improved toilet infrastructure was more protective against diarrhoea. This results is in consonant with literature that has found improved sanitation facilities to be associated with lower diarrhoea occurrences, both in Ghana [18,49,50] and beyond [19,20,52].

The age of the child in years and its square are found to be highly significant. An additional age of a child under five reduces the probability of contracting diarrhoea by 0.020 at a one percent significance level, holding all other variables constant. Thus as the child advances in age the probability of the child acquiring diarrhoea falls. This is in accordance with the other type of diarrhoea known as toddler's diarrhoea, which subsides as the child advances in age.

Additionally, household economic status which was captured as wealth index in the regression was significant as the wealth of the household improved. The variable was captured as a categorical variable into poorest, second, middle, fourth and richest. It has been uncovered that wealth index is a good indicator of the influence of social class on the health of a mother and the child. Thus the higher the wealth index, the lower the probability that a child in such a household will suffer diarrhoea. This is consolidated by the result from the regression analysis. Thus, children belonging to household that are of better economic standing are 0.063 less probable to contract diarrhoea (at 5 percent significant level) compared to their counterpart who are poor. This shows that wealth has an inverse relationship with child diarrhoea which is consistent with a Pakistani work [54].

Mother's level of education was statistically significant at conventional level of 5 percent. Theory suggests that higher level of education of a mother could alleviate the effect of absent sanitation facility as well as child diarrhoea [49]. Mother's education was included in the regression as a control variable in order to ensure that the effect of wealth was not driven by the higher education level of wealthier women. From our regression output, we found that the probability of child diarrhoea associated with educated women reduces by 0.025, at 5 percent significant level, compared to that of uneducated women. This further confirms results in [18] and [49] on similar study in Ghana even though they did not control for wealth of the households. Also in [35] and [55], it was revealed that household wealth and the education level of the child's mother are significantly and positively correlated with superior child health and/or child survival rates.

An additional weight gained by a child at birth reduces the probability of the child contracting diarrhoea by 0.009 at 1 percent level of significance as shown on Table 1. This confirms a hospital-based case-control study that was conducted at Phanat Nikhom District Hospital, Chon Buri Province, Thailand to determine the association between low birth weight and severe diarrhoea and its magnitude of association among children under two years of age. It was evinced that the crude Odds Ratio between low birth weight and severe diarrhoea was 4.62. However after controlling for confounding variables: age, concurrent infection, duration of diarrhoea attack prior to attending hospital and

ORT usage, the adjusted Odds Ratio was 3.92. The present study confirms that low birth weight is an important determinant of severe diarrhoea and feasible intervention in the case of low birth weight needs to be explored [56].

The ten regions in Ghana were categorized into three ecological zones, namely, the Coastal zone, Forest Zone and the Savannah zone. The Coastal zone comprises Western, Central and Greater Accra regions. The Forest zone is made up Volta region, Eastern region, Asante region and the Brong-Ahafo region while the Savanah zone comprises Northern region, Upper East region as well as the Upper West region. In terms of the zonal distribution, diarrhoea was found to be high among households in the Savanah zone. Thus from the regression, it can be found that households found in the Savanah zone are 0.033 more probable to contract diarrhoea compared to their counterpart in the Coastal zone at a conventional level of 5 percent. This could be attributed to the fact that the Northern belt which is captured here as the savannah zone are the most deprived in terms of living conditions compared to their counterparts in the other zones [57].

Flooring materials used by households was captured as dummy, 1 represents improved material and 0 unimproved flooring material. The result showed that households that use improved flooring material stand a higher chance of reducing child diarrhoea than their counterpart that do not use improved flooring material. Thus, the results evinces that households that use improve flooring materials are 0.036 less probable to have children suffer from diarrhoea at a conventional level of 5 percent. This also supports a study in [58] conducted in Eritrea; which discovered that type of floor material, household economic status and place of residence are significant predictors of diarrhoea.

3.1 Hypothesis Testing for Water, Sanitation and Child Diarrhea

1. H_0: Improved water source does not lead to reduction in child diarrhoea.
2. H_0: Improved sanitation does not negatively influence child diarrhoea.

With regard to the tests performed in the probit model in Table 1, we fail to accept the null hypothesis that improved water source and improved sanitation does not negatively influence child diarrhoea. Thus water and sanitation coefficients are statistically different from zero and as such play significant role in determining child diarrhoea.

Table 1. Probit model on water, sanitation and child diarrhoea

Child diarrhoea	Marginal effects	P>z
Toilet facility		
Shared toilet	0.009 (0.012)	0.459
Pit latrine with cover	-0.023 (0.013)	0.082*
Age of child	0.080 (0.015)	0.00***
Age of child square	-0.020 (0.003)	0.00***
Wealth index		
Second	0.011 (0.015)	0.478
Middle	-0.024 (0.021)	0.255
Fourth	-0.006 (0.023)	0.796
Richest	-0.063 (0.028)	0.027**
Water source		
Well	-.007 (0.013)	0.602
Rainfall	0.003 (0.015)	0.834
Stream	0.032 (0.017)	0.049**
Time taken to water source and back		
Premise	0.002 (0.018)	0.914
30min	0.002 (0.012)	0.842
above 30m	0.004 (0.017)	0.793
Mother's level of education	-0.025 (0.013)	0.053**
Weight of child at birth	-0.009 (0.003)	0.003***
Sex of the child Female	-0.013 (0.010)	0.207
Ecological Zones		
Forest zone	-0.013(0.016)	0.439
Savanna zone	0.033 (0.017)	0.049**
Area of residence		
Urban	-0.023 (0.016)	0.108
Improved flooring material	-.036 (0.015)	0.026**
N=4925 Pseudo R^2 =0.0352 Hosmer-Lemeshaw: Prob>chi2=0.4137		
Linktest _hat: P>|z|= 0.038 _hatsq: P>|z|= 0.829		

**p<0.05 **p<0.01 ***p<0.001*
Source: Computed from MICS 2011

4. CONCLUSION

This section explicitly presents the conclusions based on the above analysis and discussions. Based on the findings, we conclude as follows:

- Child diarrhoea is positively related with unimproved water sources.

- Diarrhoea is very prevalent among children of households located in rural areas as compared to the rate among children of households in the urban areas.
- Time taken to and from water sources is not a determinant of child diarrhoea. This can be explained by the fact that the MICS data did not make use of secondary water sources.
- Children in households that use latrines with cover are less likely to be infected with diarrhoea relative to their counterparts in households that practice open defecation.
- The age (in years) of a child under five is significantly a direct determining factor of child diarrhoea.
- Children whose mothers are of high economic status are less likely to contract diarrhoea compared to their counterparts whose parents are of low economic status.
- Mothers' education and the incident of child diarrhoea are negatively correlated.
- Birth weight and child diarrhoea are inverse correlates.
- Children of households found in the Savanna Zones more probable to contract diarrhoea relative to their counterparts in the Coastal and Forest zones.
- Floor materials, economic status and place of residence are significantly inverse predictors of child diarrhoea.
- In general, water and sanitation are statistically significant in predicting child diarrhoea.

The overall results of this paper suggest that the presence of improved household sanitation infrastructure continues to be significantly associated with reduced diarrhoea in the Ghanaian context. These findings are consistent not only with past research in Ghana, but also with the bulk of studies in other developing countries. In view of these findings, this paper suggest the Ghanaian Government should put in place policies that will give equal attention to both sanitation and water issues. It is recommended that the Government of Ghana create Country Side Sanitation and Municipal Sanitation programs to complements the existing Rural Water and Urban Water programs. While there are a number of policies that the Ghanaian Government could employ in implementing sanitation programs as well as water project, signals suggests that community-led initiatives are very effective compared to other initiatives.

In order to warrant a sustained commitment to sanitation, donors should reconstruct the way in which the issue of sanitation is presented to the public. Also whilst increasing funds for sanitation, donors must be sure to put up with the current level of funding for water. In addition to sustaining global water investments, donors should increase water investment in Africa, where the MDG for water is not on track to be met.

Finally, given the results of this study, health educators should intensify their education on child diarrhoea. The health education approach might also include community mentorship programs between educated mothers and mothers without education.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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