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Interaction Effects of Maternal Education and Household Facilities on Childhood Diarrhea in sub-Saharan Africa: The Case of Ghana

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Abstract

Diarrhea is a leading cause of mortality and morbidity among children in sub-Saharan Africa. While a good living environment, comprising safe water and toilet facilities, is essential in reducing the risk, it is unclear if the disadvantages associated with untreated water and lack of toilet facilities are the same for all children. Since diarrhea is transmitted through a variety of agents, we argue that other parentally provided inputs combine with water and toilet facilities in determining a child's vulnerability. Using population-based data from the 1998 Ghana Demographic and Health Survey, this paper assesses whether toilet and drinking water facilities provide different protection to children of literate mothers compared with those of illiterate mothers. The results suggest that children whose mothers were less educated were the most vulnerable to diarrhea in the absence of water and toilet facilities. The policy implications of the findings are discussed.

Key words: Childhood diarrhea, water and toilet facilities, maternal education, sub-Saharan Africa, Ghana.

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Introduction

Despite the advances in health and sanitation, sub-Saharan Africa continues to show a pattern of high childhood mortality mainly due to infectious and parasitic diseases, with diarrhea as one of the leading causes (Kirkwood, 1991; WHO, 1995). According to the World Health Organization, each child in the region experiences an average of five episodes of diarrhea per year resulting in about 800,000 annual deaths (WHO, 1996). In Ghana, diarrhea has been identified as the second most common health problem treated in outpatient clinics (Agyei *et al.,* 1988). While actual mortality rates from diarrhea are difficult to pin down due high under registration of infant deaths, it has been identified as one of the most common causes of infant deaths (Ampofo, 1988).

Diarrheal diseases thus pose a major threat to child health and survival in sub-Saharan Africa and not surprisingly, there have been considerable policy and research interests in understanding the etiology and preventive measures. It is, for instance, widely recognized that exposure to the diarrheal pathogen is conditioned by a variety of household environmental factors, particularly water and toilet facilities (Ahiadeke, 2000; Esrey, 1996; Esrey *et al.,* 1991; Habicht *et al.,* 1988; Johannes *et al.,* 1992; Root, 2001; Ryland & Raggers,1998; Tagoe, 1995; Woldemicael, 2001). In 2000, for instance, about 1.3 million children in developing countries were estimated to have died from diarrheal diseases as a result of unsafe water, sanitation and hygiene (WHO, 2002).

Although treated water and adequate sanitary facilities are essential in reducing the risk of childhood diarrhea, a significant number of people in sub-Saharan Africa lack access to such facilities (see, World Bank, 2002). While the long- term solution might involve the provision of such facilities, there is the need to understand how existing household facilities could be best optimized to reduce the risk in the short run. Previous research, for instance, has not explored if the disadvantages associated with untreated water and lack of toilet facilities are the same for all children. If there is evidence that some children are less vulnerable in the absence of treated water and sanitary facilities, specific intervention programs could then be made.

In this paper, we investigate the effects of drinking water and toilet facilities on the risk of childhood diarrhea and assess whether they vary by maternal education using population-based data from Ghana. The major research questions to be addressed are: first, are children in households without piped water and toilet facilities more vulnerable to diarrheal morbidity? Second, do the disadvantages associated with such facilities vary by maternal education?

Since diarrhea is transmitted through a variety of agents (Cutting, 1991; van Ginneken and Teunissen, 1992), we argue that other parentally provided inputs combine with household facilities in determining a child's vulnerability. Good home management practices such as boiling and filtering of untreated water could potentially reduce the risk of childhood diarrhea even in households with poorer sanitary facilities. A priori, we expect the variation in household facilities on the risk of childhood diarrhea to be less pronounced and quantitatively negligible among children of educated mothers than their counterparts with less educated mothers. Thus, while children in households without access to treated water and toilet facilities

may be exposed to a higher risk of diarrhea, those whose mothers are highly educated are expected to be less vulnerable.

The premise derives from previous research that associates high levels of maternal education with better understanding and appreciation for hygiene and health related matters (Caldwell, 1979; Cochrane *et al.,* 1980; Meegama, 1980; Ware, 1984). Given this, educated mothers without adequate facilities could be expected to take steps to ensure a healthy environment. This could, for instance, be done by decontaminating untreated water and disposing of feces in a sanitary manner than their less educated counterparts and by so doing, reduce the vulnerability of their children.

Data and Methods

Data on morbidity in sub-Saharan Africa are scarce and the situation in Ghana is no exception. The limited information reported on patients' records greatly restricts the type of analysis that can be done on morbidity patterns. Against this backdrop and following previous research, this study uses population-based morbidity data obtained from the 1998 Ghana Demographic and Health Survey (GDHS). The 1998 GDHS is the third in a series of surveys undertaken by Macro International in collaboration with the Ghana Statistical Service that started in the late 1980s. The survey is a nationally representative, stratified, self-weighting probability sample of women in the reproductive ages of 15 to 49 years and consisted of household and individual questionnaires. The total sample included 4843 women from whom birth history, household and health information was collected. The quality of DHS data has been extensively discussed in the literature (Rustein and Bicego, 1990) and will therefore not be highlighted here.

This study is confined to children born to the sample of women in the five years preceding the survey, yielding a sample size of 3026 children. The restriction of the study to recent births serves to ensure that the background maternal and household characteristics relate to current conditions. The outcome measure, diarrheal morbidity, is based on mothers' response (yes or no) to a question on whether a particular child had experienced diarrhea[1] during the two weeks before the survey. Given the binary nature of the dependent variable, a binary logistic regression was used. For meaningful interpretation, the coefficients from the regression have been transformed by exponentiation (exp b) and can be interpreted as incidence ratios. For a categorical variable, a risk ratio significantly greater than one indicates that children with this attribute have a higher risk of diarrhea than those in the reference category while the reverse is true if the ratio is less than one.

Since children of the same mother share similar characteristics and are therefore exposed to the same physical and social environments at the household level, the assumption of independence of observations inherent in conventional regression models is hard to justify. To account for possible clustering within households and model misspecification, the Huber-White

[1]Defined as passing three or more watery stools per day.

sandwich estimator was applied to produce robust variance estimates (StataCorp, 2003; Williams, 2000; White, 1980).

The main independent variables are the household's toilet and drinking water facilities with maternal education[2] as a stratifying variable. The toilet facilities are categorized as no facility and toilet facility[3] while drinking water is classified as piped, well, borehole and stream/river/dam. Given the association between household facilities and child health in general and diarrheal morbidity in particular (Dikassa *et al.,* 1993; Johannes *et al.,* 1992; Mock *et al.,* 1995; Root, 2001; Tagoe, 1995; Woldemicael, 2001), we expect the risk of childhood diarrhea to be lowest in households with piped water and toilet facilities. However, on account of the health, nutrition and hygiene related knowledge among highly educated mothers and the fact that such mothers are likely to engage in good home management practices, their children are expected to be less vulnerable to diarrhea than those of uneducated mothers in the absence of water and toilet facilities.

Besides household environmental facilities, there is a unique combination of theoretically relevant demographic, socio-economic and socio-cultural factors that affect the risk of childhood diarrhea (see Mock *et al.,* 1995; Tagoe, 1995; Woldemicael, 2001). The demographic factors include the age and parity of the child, and maternal age at birth. Very young children are less vulnerable to diarrhea because of the protective effects of breastfeeding and the less exposure to contaminated agents, but the risk increases for those aged six months up to 24 months and decreases thereafter. Maternal age at birth also has an association with diarrhea. Although there is no consistency in the literature on its effects, since very young mothers do not have much parental experience on issues relating to infant feeding and child care, their children could be expected to be more vulnerable to diarrhea. Conversely, while old mothers may have much parental experience, they are likely to hold more tenaciously to certain traditional childcare and feeding practices that could potentially increase the risk of diarrhea among their children. The effect of maternal age is therefore open to empirical assessment.

[2]Maternal education was categorized into high and low. Low education is used to refer to mothers with less than secondary education while high education refers to those with at least secondary education. This distinction derives from previous research that suggests a minimum threshold of secondary education as necessary to realize the reproductive related benefits of maternal education.

[3]Although there are significant differences in the risk of childhood diarrhea by type of toilet facility (flush, pit/pan), we decided against creating a separate category for flush toilets given the small number people with access to it.

The birth order of the child is also expected to associate with the risk of diarrhea. Children of higher birth orders could be expected to be more vulnerable mainly because the quality of care and attention reduces as the number of children a woman has increases. These children may receive poorer quality care hence they are more likely to come into contact with diarrheal pathogens. Higher order births may also signal a higher number of children in the household which increases the risk of contamination of the diarrhea pathogen.

Further, studies elsewhere have found that children in rural areas are more vulnerable to diarrhea than their urban counterparts. In Eritrea, for example, the risk is about 38 percent higher in rural children compared with their urban counterparts (Woldemicael, 2001). The general presumption is that rural or urban residence clearly distinguishes between poor and good conditions of health and sanitation. In the context of Ghana, however, it needs to be recognized that the urban locality also poses a potential risk because of overcrowding and other environmental threats (see Benneh *et al*., 1993; Maxwell *et al.,* 2000; Songsore, 1992). Additionally, although breastfeeding is universal in Ghana, urban residents are more likely to wean[4] and introduce food supplements to their children early which may in turn increase the vulnerability of such children to diarrheal diseases. Thus, the effect of rural-urban residence on diarrhea in Ghana is open to empirical verification.

Finally, a number of socio-cultural factors such as ethnicity and type of marital union of the mother could also influence the risk of childhood diarrhea. In Ghana, each ethnic group has its own corpus of knowledge and practices in the sphere of child health and nutrition (Gyimah, 2002). We argue that adherence to, and the performance of ethnic rituals and beliefs may strengthen or weaken a child's defense against diarrheal diseases. Customs and rituals such as dietary taboos and food avoidances placed on lactating women can negatively impinge on the health, welfare and nutritional status of mothers and children. Among the *Mole-Dagbani*, for instance, women are denied eggs and other protein food during pregnancy (Ghana and UNICEF, 1990). This customary practice could potentially affect the nutritional status of the expectant mother leading to the birth of a child with a low birth weight which in turn increases the risk of diarrhea for that particular child. Ethnic differences in weaning practices and feeding patterns could also predispose a child to the risk of diarrhea. *Akan* mothers, for example, are discouraged from giving eggs to their young children because of the belief that it predisposes the child to become a thief while *Ewe* mothers are known to offer specially prepared nutritious food for their young children (Cantrelle and Locoh, 1990; Ghana and UNICEF, 1990).

[4]The median duration of breastfeeding is 22.1 months for rural children compared with19 months for their urban counterparts (GSS and MI, 1999:117).

Table 1: Distribution of the sample by selected covariates

	Total		MATERNAL EDUCATION			
			Low Education		High Education	
	Number	Percent	Number	Percent	Number	Percent
DRINKING WATER						
Piped	804	26.57	336	17.33	468	43.05
Well	451	14.90	320	16.50	131	12.05
Borehole	794	26.24	578	29.81	216	19.87
Stream/Dam/Lake/other	977	32.29	705	36.36	272	25.02
TOILET FACILITY						
Have a toilet	1815	59.98	927	47.81	888	81.69
Have no toilet	1211	40.02	1012	52.19	199	18.31
RESIDENCE						
Urban	672	22.21	289	14.90	383	35.23
Rural	2354	77.79	1650	85.10	704	64.77
EDUCATION						
Below	1939	64.08	-	-	-	-
Secondary and above	1087	35.92	-	-	-	-
MOTHER'S AGE AT BIRTH						
under 20	349	11.53	190	9.80	159	14.63
20-29	1549	51.19	961	49.56	588	54.09
30-34	543	17.94	351	18.10	192	17.66
35 years aand above	585	19.33	437	22.54	148	13.62
BIRTH ORDER OF CHILD						
1	661	21.84	330	17.02	331	30.45
2-3	1062	35.10	655	33.78	407	37.44
4-5	672	22.21	458	23.62	214	19.69
6 and above	631	20.85	496	25.58	135	12.42
CURRENT AGE OF CHILD						
0-5 months	307	10.15	202	10.42	105	9.66
6-11 months	324	10.71	208	10.73	116	10.67
12-24 months	700	23.13	437	22.54	263	24.20
Over 24 months	1695	56.01	1092	56.32	603	55.47
MARITAL UNION						
Monogamy	2036	67.28	1225	63.18	811	74.61
Polygamy	693	22.90	532	27.44	161	14.81
Not currently married	297	9.81	182	9.39	115	10.58
ETHNICITY						
Akan	1332	44.02	567	29.24	765	70.38
Ga-Adangbe	189	6.25	109	5.62	80	7.36
Ewe	348	11.50	188	9.70	160	14.72
Mole-Dagbani	1033	34.14	970	50.03	63	5.80
Others	124	4.10	105	5.42	19	1.75
TOTAL	3026	100.00	1939	100.00	1087	100.00

Children whose mothers are in polygynous unions are also expected to have a higher risk because of the relative size of such households combined with their low socio-economic status. Children in such households may receive less attention than their monogamous counterparts, and it is possible that their general wellbeing and nutritional status may be poorer, and thus increasing their vulnerability. Polygynous marriages have also been associated with traditional childbearing practices (Kuate Defo, 1996) which could potentially predispose a child to the risk of diarrhea.

Table 1 shows the distribution of the sample by the selected covariates. Only 26.5 percent of the sample has access to piped water facilities which also varies by maternal education. For example, only 17.3 percent of children whose mothers are less educated live in households with piped water compared with 43.0 percent of their counterparts whose mothers are highly educated. Also, about 40 percent of the children live in households without a toilet facility which also varies remarkably by maternal education. To test the hypothesis outlined earlier, the analysis is presented in three parts. Part one presents the prevalence rates and the unadjusted effects that highlight the associations between the covariates and the risk of diarrhea. To examine the net effect of each covariate, part two presents a multivariate model while the final part stratifies the analysis by maternal education to examine if the effects of toilet and water facilities differ across educational groups.

Findings

Table 2 presents the prevalence rates and the unadjusted risk ratios associated with the household, demographic, socio-economic and socio-cultural factors. The overall prevalence rate of 19.1 percent is consistent with recent World Bank estimates but varies remarkably across groups. Overall, the directions of the unadjusted effects are congruent with theoretical expectations. Starting with drinking water, there are significant differences on the basis of quality. Not surprisingly, children in households with piped water are the least vulnerable to diarrhea compared with those with drinking water from other sources. This is an expected finding because piped water tends to be less contaminated than other sources and substantiates several recent findings in sub-Saharan Africa notably, Ethiopia (Johannes *et al.,* 1992), Congo (Mock *et al.,* 1995), Eritrea (Woldemicael, 2001), Nigeria (Ahiadeke, 2000), and Zimbabwe (Root, 2001). The highest risk is among children in households with water from the stream or lake or dam which tends to be more contaminated due to a variety of factors including fetching and storage (Stephens, 1984).

Table 2: Prevalence rates and unadjusted risk ratios of childhood diarrhea

	Prevalence rate	Unadjusted odds ratio
DRINKING WATER		
Piped (reference)	14.70	1.00
Well	20.50	1.48**
Borehole	19.90	1.44***
Stream/Dam/Lake	21.40	1.58***
TOILET FACILITY		
Have toilet (reference)	17.00	1.00
None	23.00	1.48***
RESIDENCE		
Urban	17.60	0.88!
Rural (reference)	19.40	1.00
EDUCATION		
Secondary and above	14.53	0.62***
Below (reference)	21.66	1.00
MOTHER'S AGE AT BIRTH		
under 20 years	22.22	1.30!
30-34	19.02	1.07
35 years and above	20.45	1.17
20-29 years (reference)	18.00	1.00
BIRTH ORDER OF CHILD		
1	19.15	1.22
4-5	20.06	1.29*
6 and above	22.88	1.53***
2-3 (reference)	16.23	1
CURRENT AGE OF CHILD		
0-5 months	14.42	0.94
6-11 months	25.92	1.96***
12-24 months	27.32	2.11***
Over 24 months (reference)	15.13	1.00
MARITAL UNION		
Polygamy	28.86	1.47***
Not currently married	18.84	1.09
Monogamy (reference)	17.54	1.00
ETHNICITY		
Ga-Adangbe	16.93	1.00
Ewe	14.66	0.85
Mole-Dagbani	23.42	1.51***
Others	22.76	1.45!
Akan (reference)	16.88	1.00
Total	19.10	

Statistical significance: ***<0.00; **<0.01; *<.05; !<0.10.

Also, there appears to be a remarkable difference in the likelihood of diarrhea by the presence of a toilet facility. A toilet facility provides some notion of a household's sanitary conditions and as such an indication of the possibility of transmission of the diarrheal pathogens through feacal contamination. The gross effect suggests that, the absence of a toilet facility increases the risk of childhood diarrhea by 48 percent. This high risk could perhaps be due to contamination caused by open air defecation as well as the use *chamber-pots* as toilet bowls by children in such households which are not often properly disposed of.

The effects of the other covariates are also consistent with theoretical suppositions. Maternal education shows a strong association with diarrhea. Children of educated mothers are 38 percent less likely to get diarrhea compared to those whose mothers are less educated. This validates the hypothesis about the positive impact of high levels of maternal education on child health. The age of the child also shows a curvilinear effect on the risk of diarrhea, the risk being highest at age segments 6-11 months and 12-24 months and least at 0-5 months and above 24 months. As discussed earlier, the higher risk at these age segments could be attributed to weaning practices during which infant food can easily become contaminated. At these ages also, infants are either crawling or walking and, as such, can easily pick dirt or other contaminated objects if considerable care and attention are not given.

Maternal age at birth also shows a significant association with the risk of diarrhea. While children of both very young and old mothers are most vulnerable as hypothesized, the effects are not significant in the case of the latter. There is also evidence of a curvilinear effect of birth order, the risk being highest among first and higher order births. Having more children in a household means contact between potential infectives and susceptibles will be higher than in households with fewer children. In addition, large families may have less time to look after individual children hence these children may receive poorer quality of care.

There is also evidence of socio-cultural effects on diarrhea. Children whose mothers are in polygynous marriages have a significantly higher risk (1.47) than their monogamous counterparts perhaps validating the hypothesis on differences in child care practices and socio-economic status. On ethnicity, the results show that the risk is significantly higher among *Mole-Dagbani* children. This could probably be attributed to the cultural practice of denying pregnant women egg and other protein foods which potentially affects the nutritional status of the expectant mother and birth weight of the new child. Some recent studies in Ghana, however, suggest that ethnic differences in reproductive related behaviors and infant mortality are mainly the result of socio-economic disparities rather than intrinsic cultural norms (Addai, 1999; Takyi and Addai, 2002; Gyimah, 2002). The extent to which ethnic differences in diarrhea are due to socio-economic disparities will be assessed in the multivariate models.

The unadjusted results thus reveal significant differences in the effects of household facilities as well as varying degrees of the control variables on the risk of childhood diarrhea. However, because no controls are introduced at this level, we are unable to assess the independent effects of the covariates. Against this background, the multivariate results presented in Table 3 explore if the benefits of treated water and toilet facilities persist after controlling for other factors. Four nested logistic models are estimated: Model 1 examines the

joint effects of water and toilet facilities; Model 2 adds the socio-economic factors of education and residence; Model 3 builds on Model 2 by including the demographic factors, while Model 4 assesses all the theoretically relevant covariates.

The results confirm the robustness of the household factors and corroborate the hypothesis that children in homes with piped water and toilet facilities are less vulnerable to diarrhea morbidity. In Model 4, for example, the likelihood of childhood diarrhea is 61 percent higher in households with water from streams and lakes compared with those with piped water. Additionally, the absence of a toilet facility increases the risk by 24 percent. The directions of the other covariates are also consistent with the unadjusted effects (Table 2) expect for place of residence.

The findings on place of residence suggests that children in urban areas have a significantly higher risk than their rural counterparts consistent with findings in Congo (Mock *et al.,* 1995) but contradicting those reported in Eritrea (Woldemicael, 2001). Although this is an unexpected finding, it could perhaps be traced to other hazards in the urban environment, notably, the unhygienic disposal of solid and liquid waste, overcrowding (see Benneh *et al.,* 1993; Songsore, 1992) and street food[5] which collectively increase the vulnerability of the children in urban areas to diarrhea. Also noteworthy from Table 3 is the disappearance of the ethnic differences once the socio-economic factors are controlled. This suggests that ethnic differences in Ghana are mainly due to socio-economic disparities.

The central question in this paper, however, is whether the effects of water and toilet facilities vary by maternal education. The results, shown in Table 4, reveal substantially lower risks among children of the highly educated for comparable household facilities. As expected, the variance in water and toilet facilities is smallest among children of educated mothers. Thus, while children in households without toilets and piped water are the most vulnerable, the risk is considerably higher for those whose mothers are less educated, perhaps reflecting differences in parentally provided inputs, particularly on hygiene and nutrition. The risk associated with well water, for example, is 2.10 times higher among children whose mothers are less educated but only 0.93 among those whose mothers have high education. Turning to the lack of toilet facilities, a similar pattern emerges where the highest risk is among the children of less educated mothers. While the absence of a toilet increases the risk of diarrhea by 44 percent among children of less educated mothers, there is no statistical difference among their counterparts whose mothers are highly educated.

[5]There is an epidemiological link between street food and diarrheal morbidity in Ghana (see, Mensah, 1997; Mensah *et al.,* 2002)

Table 3: A Multivariate LogisticModel on the Risk of Childhood Diarrhea in Ghana

DRINKING WATER	Model 1	Model 2	Model 3	Model 4
Well	1.49*	1.60**	1.56*	1.48*
Borehole	1.29!	1.53*	1.47*	1.40!
Stream/Dam/Lake	1.51**	1.75***	1.67***	1.61***
Piped (reference)	1.00	1.00	1.00	1.00
TOILET FACILITY				
None	1.41**	1.31***	1.35***	1.24*
Have toilet (reference)	1.00	1.00	1.00	1.00
EDUCATION				
Secondary		0.70***	0.71***	0.74**
Below secondary (reference)		1.00	1.00	1.00
RESIDENCE				
Urban		1.52**	1.47**	1.47***
Rural (reference)		1.00	1.00	1.00
MATERNAL AGE AT BIRTH				
under 20 years			1.42*	1.42*
30-34			0.87	0.84
35 years and above			0.76	0.75!
20-29 years (reference)			1.00	1.00
BIRTH ORDER				
1			1.11	1.13
4-5			1.40**	1.40**
6+			1.82***	1.80***
2-3 (reference)			1.00	1.00
AGE OF CHILD				
under 6 months			0.93	0.92
6-11 months			2.00***	2.00**
12-24 months			2.15***	2.17***
over 24 months			1.00	1.00
MARITAL UNION				
Polygamy				1.33***
Not currently married				0.90
Monogamy (reference)				1.00
ETHNCITY				
Ga-Adangbe				0.91
Ewe				0.78
Mole-Dagbani				1.07
Others				1.12
Akan (reference)				1.00
NEGATLIVE LOG LIKELIHOOD	1430	1423	1385	1380
WALD CHI SQUARE	29	42	123	141
Df	5	6	15	21
PROB > CHI SQAURE	0.000	0.000	0.000	0.000

Statistical significance: ***<0.00; **<0.01; *<.05; !<0.10.

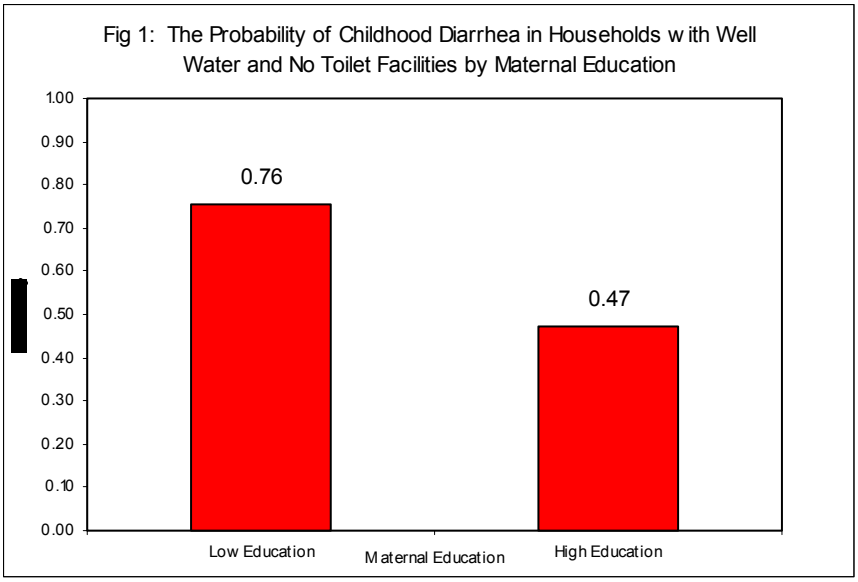
Statistical significance: ***<0.00; **<0.01; *<.05; !<0.10.

Table 4: A Multivariate Logistic Model of Childhood Diarrhea Stratified by Education

	MATERNAL EDUCATION	
	LOW	HIGH
DRINKING WATER FACILITY		
Piped (reference)	1.00	1.00
Well	2.10***	0.93
Borehole	1.84*	1.21
Stream/Dam/Lake	2.16***	1.30
TOILET FACILITY		
Have toilet (reference)	1.00	1.00
None	1.44**	0.97

Statistical significance: ***<0.00; **<0.01; *<.05.
The model controls for all the covaraites in Table 3.

It is thus clear from Table 4 that the children of less educated are the most prone to diarrhea in the absence of piped water and toilet facilities. In Figure 1, we estimate the probabilities of contracting diarrhea for children in households with wells and no toilet facilities from estimates of the stratified models. The probability is estimated to be 0.76 for children of less educated mothers compared with 0.47 for their counterparts with highly educated mothers. There is thus evidence that although children in households without piped water and toilets are exogenously exposed to a higher risk of diarrhea, educated mothers in such households act in ways to reduce the risk among their children.



The study is, however, not without limitations. First, it needs to be noted that, the measure of diarrhea morbidity was based on mother's report in the two weeks preceding the survey. While an objective assessment would have been more desirable, the subjective response of mothers is all that is available. We cannot therefore rule out the likelihood of bias in the prevalence rates. For instance, the accuracy of reporting of diarrhea in the DHS has been found highest among highly educated women (see Boerma *et al.,* 1991). These limitations notwithstanding, a major advantage of using population based data as we have done in this paper is the ability to statistically control for potential child-specific and mother-specific confounders that would otherwise bias the estimates. Again, by using the Huber-White procedure to correct for clustering and model misspecification, the estimates from the regression models are more robust.

Conclusion

This study sought to examine the effects of toilet and drinking water facilities on childhood diarrhea and whether the effects vary by maternal education using data from Ghana. The results corroborate the conventional findings regarding household facilities and the risk of diarrhea. The highest risk was found in households without toilets and piped water facilities. When the analysis was stratified by maternal education, however, it became evident that children whose mothers were less educated were the most vulnerable in the absence of water and toilet facilities. The major conclusion is that highly educated mothers protect their children against diarrhea much better under unhygienic circumstances than their less educated counterparts. While it is true maternal education is a proxy for household resources as Ware (1984) has pointed out, these results suggest it goes beyond that.

If maternal education adequately reflects hygiene behavior and home management practices as we have argued in this paper, then more needs to be done to minimize the disadvantages associated with untreated water of toilet facilities. Children do not become sick because their mothers are less educated but mainly because such mothers rarely practice better hygiene and nutrition. Throughout the years in school, however, educated women are regularly exposed to the importance of hygiene and nutrition. As a result, they are more aware of disease causation and therefore indulge in good sanitary practices and other preventive measures to reduce the risk among their children.

Overall, the findings have important policy implications for health intervention and support the view that investing in girls' education may have substantial benefits on child health and survival in sub-Saharan Africa. While the long term solution to reducing diarrhea might involve the provision of good drinking water and better sanitation to the entire populace, we have found that education provides a solution. In the short term thus effective educational programs that emphasize on hygiene and good home management practices such as boiling and filtering of untreated water could stimulate some of the benefits of formal education. The educational campaign becomes more important given that some mothers in Ghana are unaware of the causal agents of childhood diseases and often attribute such causes to activities of witches and other supernatural forces (Ghana and UNICEF, 1990). If causes of diseases are explained in spiritual terms, then issues relating to sanitation, hygiene and nutrition become secondary. More needs to be done to dispel these deep-seated traditional notions of disease causation.

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