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Original article

Effect of Household Drinking Water on the Risk of Diarrhoeal Morbidity in Children under Five in Togo

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Abstract - *The objective of this research is to show the degree of exposure to diarrheal morbidity related to drinking water sources in Togo. The particular focus on diarrhea in this study is relative to its contribution to the many deaths of children under five years. Using the Demographic and Health Survey (DHS, 2014) and then employing Cox proportional hazards methods, the results show that diarrhea is the preferred channel of drinking water-related mortality in children. Apart from drinking water, diarrhea in Togo is determined by different factors among others the mother's level of education, the child's age and sex, the state of toilets, the place of residence, and the modes of elimination of stools. It should also be noted that the occurrence of diarrhea associated with private borehole water is twice as high as that of tap water.*

Keywords - *Drinking water; Diarrhea, Cox model, Education, Mortality;*

I. INTRODUCTION

Drinking water is one of the basic needs of every living being. It is both a strategic resource and a fundamental building block necessary for a healthy economy (Vissin et al., 2016). It is because of its users that the United Nations at the World Water Forum established it as a human right. According to them, the water right is a precondition for the realization of other human rights. Thus, each individual has the right to have sufficient access to drinking water at an affordable cost to lead a healthy, productive life and that the vulnerable are protected against water-related diseases (UN, 2003). However, it is clear that access to this natural resource still poses enormous difficulties in developing countries.

Unfortunately, in sub-Saharan Africa, access to water is still a major concern for governments and populations. In these countries, the rate of coverage in drinking water has remained low compared to those of industrialized countries. While a European consumes 266 liters of water per day, an African consumes only 67 liters (Mehmet et al., 2007).

Although vital, water is associated with a diverse set of hazards that need to be known to be better controlled (WHO, 2019; Heaney et al., 2019). Water which is good and contributes to economic progress is paradoxically the most common vector for disease transmission (Woodall, 2009; Yang, 2020). Difficulties in access to water present significant health challenges there (Banza-Nsungu, 2006; Dos Santos, 2009), particularly in terms of diarrheal morbidity and malnutrition in children under five.

According to the World Health Organization (WHO), about 844 million people do not have access to a basic drinking water service, i.e. a source of drinking water protected from contamination and nearly 30% of the world's population did not have a well-managed drinking water service, a source located on-site, available on time and free from contamination (UNICEF, 2017). This situation has been accompanied by a very high infant mortality rate in the world over the last two decades (Doua and Gahe, 2016). According to statistics, Sub-Saharan Africa alone bears almost half of the burden of under-five deaths worldwide (3 million in 2015) (United Nations, 2015).

Togo is not spared from this situation from the moment its infant and child mortality rate is 88‰, remained high compared to the PNDS targets (EDST, 2014). Rural and semi-urban populations drink water from alternative sources such as boreholes mistakenly considered potable, rivers, and wells. As a corollary, many children die every day from diarrheal and other water-borne diseases due to lack of sanitation. According to Amegadge's research results (2007), intestinal parasitosis represents more than 53.5% of the causes of consultation in health facilities in Togo. These intestinal parasitoses (amoebiasis, hookworm, giardiasis, trichomonas, and others) are very frequent in all the environments of the country. The overall prevalence of diarrhea in children has increased from 15% in 2006 to 20, 6% in 2010 and represents 14% of the causes of child mortality after malaria (NSP, 2012; UNICEF, 2016). Diarrhea is the second most common reason for consultation of children under 5 years old and its prevalence remains high.

Because of the above, it is clear that the problem of diarrhea is primarily related to the quantity and quality of water consumed. According to data from the MICS survey (2010), 124 children out of 1000 live births die from preventable diseases such as diarrhea due to poor access to drinking water, lack of sanitation facilities, and poor hygiene practices. Poor drinking water quality is therefore a factor in the growth of infectious diarrheal diseases (Kouadio et al, 2019). Based on the socio-cultural and institutional values of the country, there would be a misconception that borehole water would be safe to drink and would not have an effect on child survival.

Therefore, an important question deserves to be raised: Which household drinking water is a factor of diarrhoeal morbidity in children under five in Togo? Based on the generally accepted idea that diarrheal morbidity is strongly determined by hygiene conditions, the question is whether the development of this disease in Togo is the result of the failure of certain drinking water supply systems? What would be then the degree of exposure to diarrhea linked to the types of drinking water in Togo? It is around this question that the present research will be developed. Its main objective is to contribute to the improvement of the living conditions of households in Togo and the fight against diarrhoeal diseases of children under five years of age-linked to water consumption in particular.

To achieve the assigned objectives, the rest of this research is organized as follows. The next section presents the literature review on the determinants of childhood diarrhea. The methodological approach, as well as the results, are presented in the third part. The last part would be devoted to the conclusion and policy implications.

A. Conceptual elements and determinants of diarrhea in children under five

Diarrhea affecting children under five years of age accounts for about 63% of the global burden (Walker et al., 2012; Zhang et al., 2016) and is the second leading cause of child mortality in developing countries (Randremanana, 2012; O'Reilly et al, 2013; Platts-Mills et al., 2015; Kotloff, 2017; Rajegowda et al.,2018; WHO, 2019; Ugboko et al., 2020) where poor sanitation and inadequate drinking water supply are key factors (Chakravarty et al, 2017; Squire and Ryan, 2017). Household socio-economic and demographic factors are used to explain children's exposure to diarrhoeal diseases. Building on the work of Mosley and Chen (1984) and Dos Santos (2012); Bouba -Djourdebbé et al. (2015) devise a conceptual framework that identifies two groups of factors explaining the occurrence of diarrhea in children. The latter distinguishes between direct and indirect factors. The direct factors group together (residence environment, drinking water supply, household unsanitary conditions, toilet types, severe malnutrition, and maternal and child demographic and biological factors). Household unhealthiness (as measured by the presence of garbage in and around the household, the management of household waste and wastewater, and the presence of small ruminants in the compound) increases the occurrence of diarrhea. Compared to children residing in salubrious households (25.9%), the occurrence of diarrhea is higher among children residing in moderately salubrious (28.7%) and unsanitary households (29.2%) (Bouba -Djourdebbé et al., 2015). Previous studies have shown that inadequate hygiene practices open the door to the proliferation of disease vectors (Bouba -Djourdebbé et al., 2015; Warsame, 2016; UNICEF, 2018; Voth-Gaeddert et al., 2020). The induced effects of household drinking water supply in the concession are different from those of alternative sources (boreholes, rivers; Wells). The causal link between access to drinking water and children's health has been the subject of several studies (Victora et al, 1988; Woldemicael, 2000; Zhang, 2012; Yang, 2020). The environments of residence also affect the health of children. Indeed, the environment of residence constitutes a framework of favorable or unfavorable access to drinking water or sanitation services. Consequently, access or not to quality drinking water and sanitation services influences diarrheal morbidity in children.

The basket of indirect factors includes household socio-economic factors, cultural factors (ethnicity, religion), and the health context. Traditions, customs, and beliefs condition household consumption habits. These habits can have repercussions on household health. Also, the quality of care or the inexistence of health centers in a given area can lead to deaths. The conceptual diagram is presented in Appendix.

Diarrhoeal diseases are a health concern and have a disproportionate effect on the health of children. The World Health Organization defines diarrhea as three or more loose or watery stools per day (or more frequent than normal for the individual) (WHO, 2007). It is mainly a symptom of a gastrointestinal infection (Fuhrimann et al., 2017; Ugboko et al, 2020). Very often, diarrhea is caused by the ingestion of pathogenic microorganisms, be it bacteria, viruses, or parasites.

According to UNICEF, nearly 4 billion cases of diarrhea are seen each year, mostly in children under 5 years of age, and 2.2 million of them end up dying (UNICEF, 2018). Despite recent improvements, inadequate water, sanitation, and hygiene services remain a major global risk factor. Lack of access to safe drinking water and basic sanitation, as well as poor hygiene, account for nearly 90% of diarrhea deaths, mainly among children (WHO, 2018; Rajegowda et al., 2018). It is estimated that one in four people worldwide does not have access to a handwashing facility with soap and water on-site and only 26% of potential fecal contacts are followed by handwashing with soap. WHO estimates that 94% of diarrhoeal episodes are preventable through environmental changes, including interventions to increase the availability of quality water, improve hygiene and sanitation (WHO, 2007).

Indeed, diarrhea is strongly correlated with unsafe water. A longitudinal study found that the use of unprotected water sources is the main determinant of increased disease transmission to children (Plate et al., 2004). The presence of surface water used for drinking doubles the risk of diarrhoeal disease compared to protected water sources. Surface water contains microorganisms, which when consumed transmit diarrhea to children and all kinds of waterborne diseases (Assani et al. 2019). The effect of improving water quality in reducing morbidity and mortality from diarrhea is increasingly recognized (Ngnikam et al., 2014). Sufficient available clean water is essential to reduce the risk of environmental diseases in children (Haines et al, 2012). Children who live in households with clean water in their homes are less exposed to diseases, and therefore less likely to be infected (Mehmet et al., 2007). Doua and Gahe (2016) found lower diarrheal prevalence in households with good quality water and an internal source of supply. These authors confirm that children who drink water from unimproved sources or purchased from resellers are about twice as likely to fall ill with diarrhea as those who drink tap water. Ferrié and Troesken (2008) have shown that quality water has health benefits for children. Not only does drinking water reduce the mortality rate from diseases that it directly transmits such as typhoid fever and diarrhea; it also reduces the mortality rate from diseases that would not have been identified as waterborne diseases such as pneumonia, heart disease, and tuberculosis. Fuentes et al (2006) attempted to measure the effect of water and sanitation on the incidence of diarrhea using a Logit model. They showed that the risk of diarrhea incidence is significantly reduced when the water source is piped. In the Democratic Republic of Congo, it was found that lack of water for hygiene and lack of sanitation together contribute to 88% of deaths caused by diarrhoeal diseases. These infections are more common when there are shortages of safe water for drinking, cooking, washing, and cleaning (Assani et al, 2019).

In Togo, the water shortage is characterized by low production, which pushes households to turn to alternative sources, sometimes of dubious quality, the use of which is an obstacle to the economic emergence of the society. The problem of drinking water in the capital is aggravated by the demographic growth and anarchic urbanization of the city. The nonexistence of the tap water network in these districts leads households to find alternative sources of water such as traditional wells and boreholes. However, these sources of water consumed in the outskirts constitute a channel for the transmission of waterborne diseases and a vector for the spread of diarrhea. As Semba et al. (2009) pointed out in Indonesia, children from families that buy cheap water suffer more diarrhea than their counterparts whose families buy more expensive water. Kouadio et al. (2019) showed that the risks of drinking water from wells and boreholes remain high for children under 5 years of age. Improving the quality of water supplies generally reduces the incidence of diarrhea. A study in China showed that the incidence of diarrhea among children served by tap water was lower than among those using water from wells and rivers (Chen et al., 1991).

Hygienic practices are essential since the collected water may be safe to drink at the source but infected by handling. Water that is stored inside the home is found to have a higher risk of contamination than water taken directly from the source, most likely due to post-collection contamination (Shields et al., 2015; WHO, 2019). Water contamination could occur during transport and storage in the home. Poor handling of drinking water is significantly associated with an increased risk of childhood diarrhea (Doua and Gahe, 2016). For these authors, when children consume water stored in uncovered containers and jars, the risk of diarrheal morbidity increases 3-fold and 1.9-fold, respectively. Oloruntoba and Sridhar (2007) concluded in a study conducted in Ibadan, Nigeria that the quality of drinking water deteriorated significantly among households after collection and storage due to poor handling. Trevett et al. (2004) reiterated that there are multiple points of contamination between collection and use of drinking water in which pollution could occur. In addition, Jagal et al. (2003) state that unhygienic treatment of domestic water is identified as a possible source of contamination.

An extensive literature establishes a relationship between maternal education and child health (Doua and Gahé, 2016; Bita et al., 2017; Mallick et al., 2020). The mechanisms of influence of a mother's education are multiple. For Bita et al. (2017), the incidence of diarrheal diseases decreases with the level of education when moving from primary school. The higher the educational level of mothers the less diarrhea is experienced among their children (Mallick et al., 2020). An educated mother has increased autonomy and can break with certain traditions that are not conducive to her children's health (Caldwell and McDonald, 1982). She can also take steps to ensure household sanitation, improve hygiene, nutrition, and intervene in family health care decisions (Kuaté-Defo, 1997). Using a Logit regression on survey data from Rwanda, Burundi, and Tanzania, O'connell et al. (2017) arrived at the results that children whose mothers had more than secondary education were less likely to have diarrhea than those who had no education. Education level is a risk factor as it has been shown that the likelihood of developing diarrhea is 2.5 times higher in children whose mothers had no formal education (Diakité et al., 2018). A study conducted in Côte d'Ivoire reveals that children whose mothers have primary education or illiterate mothers have about 1.3 and 1.5 times the risk of falling into a morbid condition, respectively than those whose mothers have a higher level of education (Doua and Gahe, 2016). Educated mothers have better knowledge of the means of transmission of diarrhea and take preventive measures to this effect.

B. Methodology and data sources

The data used are from the Togo Demographic and Health Survey conducted between November 2013 and April 2014; by the General Directorate of Statistics and National Accounting (DGSCN) of the Ministry of Planning, Development, and Territorial Management, in close collaboration with the Ministry of Health. The survey was financed by the Togolese government and financial partners such as the United States Agency for International Development (USAID), the United Nations Population Fund (UNFPA), the United Nations Children's Fund (UNICEF), the African Development Bank (ADB) and the United Nations Development Programme (UNDP). A total of 9899 nationally representative households were selected and surveyed. The information contained in this survey concerns the characteristics of households, notably the fertility rate, family planning, infant and child mortality rates, female migration, female mortality, and their status. Considering the whole sample, the majority of heads of households are men (81.65%). The proportion of heads of households who are not in school is 3.2%. Overall, 44.7% of heads of households have attained primary or secondary schooling and 46.8% have not. Only 5.4% of heads of households have a university degree. Three-quarters of heads of households live in rural areas. In terms of marital status, the majority of heads of households are married and live together with their wives. Most heads of households live in housing they do not own (82.1%). Of the heads of households interviewed, more than half are poor. The rich and very rich heads of household represent 14.22% and 11.59% of the sample respectively.

C. Risk perception analysis

Few studies attempt to identify the factors influencing the perception of risks related to water consumption. Nevertheless a few exist with different methods of analysis (Canter et al., 1992; De Franca Doria et al., 2005; Dupont, 2005; Nauges and Van Den Berg, 2009; Hyun et al., 2019). Risk perception related to drinking water is a complex process. For Canter et al. (1992), physical conditions, media, interest groups, international organizations, and prevailing state policies explain the risk perception of drinking water. Using structural equation models, De Franca Doria et al. (2005) suggest that the risk perception of tap water is driven by external information such as previous health problems, color, and taste. In contrast, the use of tap water at home presents a moderate risk. The risk of drinking water is analyzed through these attributes including color, odor, and taste (Nauges and Van Den Berg, 2009). A study conducted in the European Union attributes the risk to three distinct predictive factors namely: chemical pollution, algal blooms, and ecosystem changes (Skuras and Tyllianakis, 2018). All these studies analyze water-related risk by exogenous factors. However, this research proposes to capture the risk related to household drinking water by the occurrence of diarrhea in children under five. To achieve our objective, we use the Cox proportional hazard model.

a) Model specification

The general form of the equation for measuring health risk is :

$$Y_i = f(Z_i; X_i) \quad [1]$$

Where Y_i represents the health risk reflecting the occurrence of diarrhea. It is a dichotomous variable that is worth 1, if the child has suffered from diarrhea and 0 otherwise; Z_i the types of water used in the household and the X_i control variables.

Using the Cox formulation, we will have:

$$y(t) / y_0(t) = \exp(\beta Z_i + \varphi_i X_i) \quad [2]$$

Applying the logarithm to equation [2], we get:

$$Ln[y(t) / y_0(t)] = h_i(t) = \beta_i Z_i + \sum \alpha_i X_i + \varepsilon_i \quad [3]$$

With β_i , the coefficients related to the variables of interest (tap water, private borehole water); α_i represents the coefficients related to the control variables and ε_i the error.

b) Empirical specification and presentation of variables

Wibowo and Tisdell (1993) proposed a model of health risk defined as follows

$$MD = f(WT; ASS)$$

With MD: diarrheal morbidity ; ASS: sanitation (latrines; stool disposal) and WT : types of water consumed (tap, borehole)

Based on this basic model, we add other control variables. These are the age of the child, the level of education of the head of the household, the sex of the child, the wealth index, the area of residence, the religion of the parents, the possession of latrines and the mode of elimination of the children's stools. The model then becomes:

$$MD = f(WT, LAT, NE, MR, ReM, MODE, SEX, IR, AGE)$$

WT : types of water consumed (boreholes; tap water)
NE : education levels
LAT : latrines
MR : place of residence
ReM : the religion of the head of the household
MODE : Stool elimination patterns in children
SEX : the sex of the child
IR : the wealth index
AGE : age of the child

The outcome variable is diarrhea morbidity, captured by the occurrence of diarrhea in a child in the household. It is a dichotomous variable that is worth 1 if the child has suffered from diarrhea and 0 otherwise. The variables of interest are the types of water consumed (tap water, borehole water) which are binary, and both take the value 1 if the household uses source (i) and 0 otherwise. As for the control variables, they represent the socioeconomic characteristics of the household and the demographic characteristics of children under five.

In the literature, it has been proven that the interaction between the educational level of parents and the types of water consumed reduce diarrheal morbidity in children (Jyotsna, 2003; O'connell et al., 2017). This leads us to measure the effect of interactive variables between the types of water used and the education levels of the household head.

Table 1. Presentation of variables

Variables	Definition	coding
Types Water (WT) Source of drinking water	the household uses tap water the household uses borehole water	Yes=1, otherwise=0 Yes=1,otherwise=0
SEX: The sex of the child	Mal Female	Yes=1,otherwise=0 Yes=1,otherwise =0
AGE Age of the child	[6-11] [12-23] [24-35] [36-47] [48-59]	Yes=1, otherwise=0 Yes=1, otherwise=0 Yes=1, otherwise=0 Yes=1; otherwise=0 Yes=1, otherwise=0
Educ mother: Mother's education level	The mother has a higher level Mother has a high school education The mother has a primary school education The mother has no level	Yes=1, otherwise=0 Yes=1, otherwise=0 Yes=1, otherwise=0 Yes=1; otherwise=0
Latrine: Types of facilities used in the household	Elementary Interme diate Modern	Yes=1, otherwise=0 Yes=1, otherwise=0 Yes=1, otherwise=0
Place of residence	n areas l areas	Yes=1, otherwise=0 Yes=1, otherwise=0
Status: Marital status	Married couple Divorced couple	Yes=1, otherwise=0 Yes=1, otherwise=0
Region Region of residence	Region of residence of the household	Yes=1, otherwise=0
Mode of Stool Elimination (MODE)	Improper Clean	Yes=1, otherwise=0 Yes=1, otherwise=0
Religion The religion of the mother	Animist ; Christian Muslim	Yes=1, otherwise=0 Yes=1, otherwise=0 Yes=1, otherwise=0
Wealth Index : Wealth level of the household head	Poor Rich	Yes=1, otherwise=0 Yes=1, otherwise=0

II. RESULTS

The results of the estimation using the Cox proportional hazards model are presented here. The results of the estimation of the Cox model are shown in Table 2. Under the proportional hazards model, the overall significance test is equivalent to considering the null hypothesis $H_0 : \beta_1 = \beta_2 = \beta_P = 0$ against its alternative $H_1 : \beta i \neq 0$. Thus, our estimation reveals that overall the Cox model is significant in the sense of the Wald test and the likelihood ratio (LR/Prob= 0.000), which explains that at least one of the independent variables (age, level of education, wealth index, latrines, types of water, etc.) has an influence on the dependent variable (diarrhea). The explanatory variables are globally significant (χ2 significant), as the associated probability is less than 0.05. Also the global test on the residuals gives a probability equal to 0.19 thus validating the hypothesis of independence of the explanatory variables as a function of time.

Table 2. Potential risk factors for diarrhea

	Proportional risk	
Variable explained: Diarrhea	**Coefficient**	**Z-stat**
Types of water		
Tap	0,60	5 ,71***
Borehole	1,45	5,93***
Education of the head of household		
Primary	1,07	0,48
Secondary	0,61	0,95
University	0,41	7,92***
Unimproved latrine	1,25	1,91*
Rural Areas	0,91	0,41
Degree of wealth	0,83	0,92

Religion	1,05	0,32
Age of the child		
6-11 months	1,91	2,02***
12-23 months	1,84	2,04***
24-35 months	1,44	1,19
36-47 months	0,92	0,34
47-59 months	0,74	0,93
Mode of stool elimination	0,67	1,93*
Child_Gender	0,79	1,76*
Significance tests		
Number of observations: 6979; Wald: 51.64; Prob>chi2: 0.000 ; Log_ pseudo-likelihood = -8185.6399 ; Global residuals test : χ2 (Prob=0.19) ; *** ; **and * denote significance at the 1%; 5%; and 10% threshold respectively		

Waterborne diseases such as diarrhea are closely linked to the quality of water used in households for food preparation and drinking (Prost, 1986 and 1996; Ngwé, 1999; Amegadge, 2007; Hounga et al, 2015 and Kouassi et al, 2015). In Togo, diarrhea represents the second most common disease that kills children. Using the Cox proportional hazards model, we find that the types of water consumed are responsible for diarrhea suffered by children among many other factors. According to the regression results in Table 5, tap water has a low risk (0.60) of diarrhea compared to water from private boreholes (1.45). The risk of diarrhea in children is twice as high if households use water from boreholes.

Estimates suggest at the 5% threshold that water from private boreholes poses a health risk to children under five. One of the causes would be the maintenance of alternative sources to tap water. In the case of borehole water, it is stored in tanks before being used. An examination of these tanks reveals that they contain bacteria that are responsible for 86% of respiratory infections (Jiang et al. 2020). Abouteir et al (2011) showed that in the absence of tap water in a setting, the mortality rate of children correlates with the prevalence of diarrhea. They also show that in the territory of Palestine, the majority of those who suffer from diarrhea buy water from private suppliers. Hardy et al (2019) show that the causes of diarrhea are directly attributed to the consumption of alternative water that is usually not potable. Also, an abundance of literature has shown a positive relationship between unsafe water use and the occurrence of diarrheal diseases (Gentry-Shields and Bartram, 2014; Luby, 2017; Geere and Hunter, 2019).

The risk of diarrhea linked to the use of tap water, although it is potable at the source, deserves to be explained. Firstly, the handling and storage of water are a source of contamination. Secondly, the dilapidated water piping systems are accompanied by repeated water cuts. K'Akumu (2016) points out that the quality of water from piped sources is also questionable because poor management of the structures is likely to lead to contamination. Luby (2017) finds in a study conducted in India that when the tap water distribution system is not regular and suffers cuts, the water that comes out of the tap is often contaminated and can cause diarrhea in children. However, it shows that tap water would reduce deaths from typhoid fever by 78% and other causes of death by 19%.

Regarding the age group of the child, the results reveal that the age groups between 6 to 11 months and 12 to 23 months record a very high proportional risk of 1.91 and 1.84 coefficient respectively. Kouassi et al (2015) found a similar result in three countries as Cameroon, Cote d'Ivoire, and Togo. They conclude that compared to the 36-47 months age group, those in the 12-23 months age group are twice as likely to have diarrhea. According to the nutritionists, a mother can give the child drinking water from the age of 6 months. During this same period, other food rations can be added to complement breast milk. The child's body is not prepared and if the water administered is not drinkable, diarrhea may occur. From the regression coefficients obtained, it can be seen that the risk of diarrhea tends to decrease as the child gets older.

A joint examination of latrine types and children's stool disposal patterns shows that the incidence of diarrhea is significant as long as children do not meet hygiene standards. In concessions with unimproved latrines where several people use them at the same time, the risk of developing diarrhea is probably high. The absence of latrines in the concession is associated with a high risk of diarrhea (Anthonj et al., 2018). Also, the risk of diarrhea contamination is high when children use community latrines. In addition, children's stool disposal patterns are pockets of high diarrhea risk. Using the binomial model, VothGaeddert et al (2020) found a significant relationship between diarrhea and waste handling, distance to toilets, sanitation, types of water consumed, and toilet sharing. In terms of comparison, Wibowo and Tisdell (1993) worked on the impact of drinking water and sanitation in Indonesia. Diarrhea accounts for 75% of waterborne diseases and bacillary dysentery for about 18% in Indonesia. According to their results based on health production functions, the provision of safe water is a more important factor than sanitation in reducing diarrhoeal morbidity.

Finally, male children have a higher probability of developing diarrhea than their opposite-sex counterparts. For biological reasons, male children are more susceptible than female children (Brucker-Davis et al, 2011). For Voth-Gaeddert et al (2020), the common exposure factors related to both sexes are the types of water consumed but girls and boys do not share the same significance in terms of diarrhea occurrence. Furthermore, the authors find that sharing toilets between families are correlated with reported cases of diarrhea in the last three months among female children. Kwiringira et al (2014) presented a qualitative study on gender in Uganda and conclude that toilet sharing increases the risk of diarrhea infection among girls than boys. When Baker et al. (2016), their results suggest that the household that shares toilets with neighbors has a significantly higher probability of having one of their children with diarrhea.

Table 3. Regression of the interaction effect between the level of education of the head of household and the types of water.

VARIABLES	Male	Female	urban	Rural
	(I)	(II)	(I)	(II)
	Coeff	Coeff	Coeff	Coeff
Tap*education	0,76**	0,78	0,74**	0,84
Borehole*education	1,35**	0,85	1,09	1,37**
Tap*high education	0,00006***	0,00003***	0,000025***	
Borehole*high education		1,00e-19	1,16e-17***	
Gender of the child	0,84	0,61	0,63**	0,89
Clean latrine	1,2	0,82	0,8	1,60**
Unclean latrine	1,28	2,02	1,01	1;82*
Wealth index	0,84	1,16		
Method of disposal	0,75	0,53	0,49**	1,03
Christian	1,04	0,81	0,68	1,01
Muslim	2,39	1,73	1,3	1,38
Place of residence	1,02*	0,73		
AGE				
6-11 months	2,35**	1,54	2,47	1,85
12-23 months	2,01*	1,55	2,99**	1,49
24-35 months	1,53	1,77	2,17	1,2
36-47 months	1	0,87	1,19	0,85
47-59 months	0,96	0,26	1,12	0,68

*Coeff: regression coefficient; ***; **; * respectively significant at 1%, 5% and 10% threshold;* Wald chi2(12) / Prob > chi2 = 0.0002

The socio-economic status of the household, in this case, the level of education of the head of the household, plays a significant role in the prevention of diseases in children. The regressions were performed according to the gender of the household head. The interaction results show that in households headed by women with higher education and using borehole water as a source of water, no children suffer from diarrhea. In general, the interaction between education level and water type leads to a decrease in diarrhea cases. A study in Sub-Saharan Africa shows that female-headed households are 17.6% more likely to have access to improved water sources than male-headed households (Armah et al., 2018). Furthermore, Yilgwan and Okolo (2012) indicate that maternal schooling and exclusive breastfeeding are viable measures in the control of diarrhea among infants. Our results are in line with those found by Hardy et al (2019) who state that high maternal education significantly reduces diarrhea in children.

To deepen the results and to highlight the disparities between the areas of residence, we carried out the interactions between the level of education of the head of household and the types of water used. Overall, whatever the area of residence, the interaction between the level of education and the types of water reduces the prevalence of diarrhea. The regression results indicate that when the head of the household residing in rural areas is educated and uses borehole water, these children are not at risk of diarrhea. The risk is almost zero when the head of the household reaches university level. The level of education of the heads of households plays a determining role in the use of the types of water. The analysis also reveals a significant effect of the religion of the head of the household. In urban areas, children from Christian families have a low risk of diarrhea. The same effect was observed in rural areas for their Muslim counterparts.

III. CONCLUSION

The general objective of this research is to analyze the risk of diarrhoeal morbidity linked to household water sources in Togo to contribute to the implementation of appropriate and sustainable measures to fight this pathology. Diarrhoeal morbidity and mortality constitute a crucial public health problem. To achieve this objective, the demographic and health survey data from November 2013 to April 2014 of Togo are used. Morbidity and mortality related to household drinking water are analyzed using the Cox model. Recognizing that no two water sources can have the same degree of morbidity risk, this study revealed that the risk of diarrhea is twice as high for borehole water than tap water. Furthermore, the results show that the prevalence of diarrhea in children is determined by the type, level of education of the mother, age and sex of the child, the state of the toilet, and the modes of elimination of the stools. Analysis by residence shows that in cities, the risk of diarrhea prevalence is the same for both sources of drinking water. Given that a large part of the population has limited access to tap water, these results merit economic policy proposals to the authority for the success of the national development plan (NDP), the achievement of the objectives relating to health and access for all to drinking water advocated in the Sustainable Development Goals by 2030 (SDGs). As the risk associated with tap water is not zero, it is essential to monitor pipes and control leaks. On the supply side, we propose that the heritage company builds water supply systems in the districts not served by the distribution network.

Finally, awareness-raising should be done throughout the country to show households good water conservation practices and water treatment techniques. It is also important to emphasize that knowledge, attitudes, and practices, and socio-economic status is important determinants in ensuring good water management at home.

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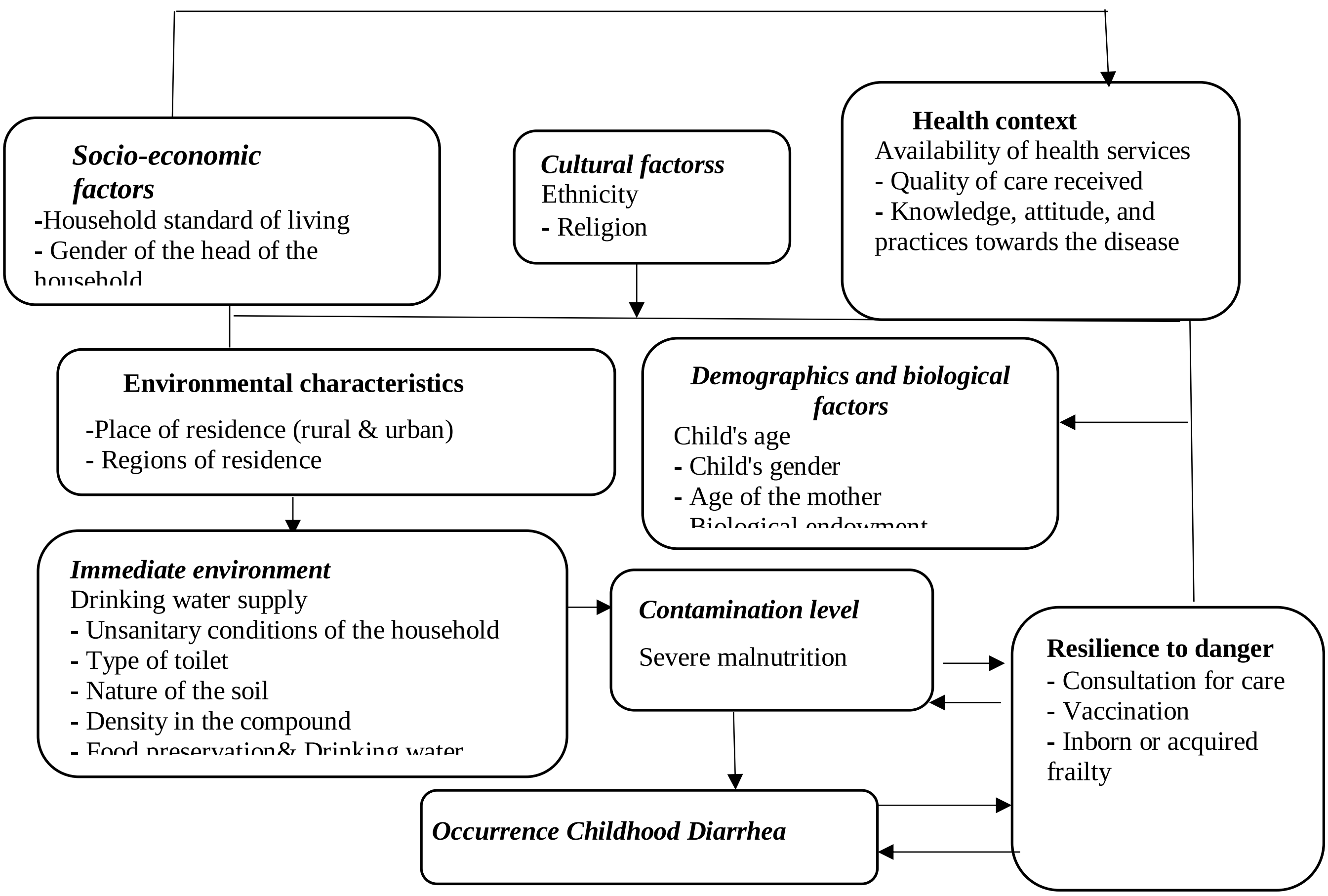

Fig.1 Adopted and modified Boub Djourdebbé et al. (2015) conceptual framework used to analyze diarrhea in children