

INTERACTION EFFECTS OF MATERNAL EDUCATION AND HOUSEHOLD ENVIRONMENT ON CHILD MORTALITY IN NIGERIA

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ABSTRACT

Various intervention programmes targeted at different preventable childhood infections that can lead to child mortality have been implemented in Nigeria. While these global initiatives and programmes may have contributed to decline in childhood mortality rates over the years, the rate is still high in Nigeria. The causes of death are specific to different age categories; child mortality (ages 12 to 59 months) has been linked in several studies in Nigeria to household environment and maternal characteristics, among others. However, there is a dearth of information on the interaction effect of maternal education and household characteristics on child mortality in Nigeria. The key question is does maternal education affect the handling of household environment and related practices to the extent of being a significant predictor of child mortality? This paper therefore examined the interaction of maternal education and household environment on child mortality in Nigeria. Using Mosley and Chen's analytical framework, 45,603 children (12-59 months) were selected from NDHS 2013 dataset. Interaction of maternal education and household environment is significant ($p < 0.05$) predictor of child mortality in Nigeria. Children aged 12 to 59 months that live in a disadvantaged household environment and whose mothers do not have formal education have a higher risk of child mortality than those with formal education. This study confirms the significance of maternal education to child survival in Nigeria.

Key words: Maternal education, child mortality, Household environment, Nigeria.

BACKGROUND

One of the priority targets of the United Nations' Sustainable Development Goals (SDGs) is to "end preventable deaths of newborns and under-five children by 2030" (United Nations, 2015). In spite of the substantial progress at improving child survival worldwide over the years, 85% of the 6.3 million children and young adolescent deaths occurred in the first five years. Sub-Saharan Africa has the highest under five deaths in the world with 76 deaths per 1000, which is 14 times higher than under-five mortality rate (U5MR) in developed countries. Among the countries in sub-Saharan Africa, Nigeria has one of the highest U5MR with 100 deaths per 1000 live births (United Nations Inter-Agency Group for Child Mortality Estimation, 2018). This translates to 1 in 10 children dying in Nigeria before reaching their fifth birthday as at the end of 2017.

Several factors may be attributed to the slow decline of childhood mortality in Nigeria; from slow implementation of under-five health care policies to limited or inequitable access to health care delivery (Adetoro, & Amoo, 2014; Liu, Hill, Oza, Hogan, Chu, Cousens, S., & Robert, 2015; Adeyanju, Tubeuf, & Ensor, 2017; Gyuse, Ayuk, & Okeke, 2018). In addition, the risk of deaths among children aged 12 to 59 months varies significantly across ages, regions and periods of increased vulnerability (Ezeh, Agho, Dibley, Hall, & Page, 2015; Adewemimo, Kalter, Perin, Koffi, Quinley, & Black, 2017).

In specific terms, while several scholars have associated the causes of increasing deaths among under-five children in sub-Saharan Africa with malaria, measles, infections from birth injury, sepsis, pneumonia and diarrhea among other diseases (Renschler, Walters, Newton, & Laxminarayan, 2015; Adewemimo, Kalter, Perin, Koffi, Quinley, & Black, 2017), others implicated high cost of seeking health care, distance from health facilities (Koffi, Kalter, Loveth, Quinley, Monehin, & Black, 2017) and ethnic disparities in under-five mortality (Teerawichitchainan, & Phillips, 2008; Fayehun, & Omololu, 2009; 2011). Many scholars are also of the view that household environmental conditions influence childhood mortality. These are housing materials

such as sources of drinking water, types of main floor materials to ambient air quality (Iyun, 2000; Murray, Laakso, Shibuya, Hill, & Lopez, 2007; Adebowale, Morakinyo, & Ana, 2017; Lelieveld, Haines, & Pozzer, 2018).

Behavioural characteristics of mothers have also been found to influence childhood mortality in less developed countries. This includes practices that guide handling of drinking water and sanitation, poor hygiene and overcrowded housing units among others (Rustein, 2000; Fayehun, 2011; National Bureau of Statistics, 2011). Other behavioural characteristics that influence child survival are the use of mosquito bed nets for sleeping, exclusive breastfeeding and child vaccination (Darkwah, Boachie-Yiadom, & Tawiah, 2014).

These behavioural characteristics that guides practices in the household are assumed to be influenced by maternal education. As Pandey (2009) observed, educated mothers have more knowledge of reproductive health and care of under-five children compared to mothers with low level of education. The children of educated mothers tend to eat nutritious food as well as living in a much healthier environment when compared to less educated mothers. Studies have also shown that mothers with formal education have reduced under-five mortality when compared to those with no formal education (Adepoju, Akanni, & Falusi, 2012; Yaya, Bishwajit, Okonofua., & Uthman, 2018).

The Center for Disease Control and Prevention (2014) also noted that under-five children who are exposed to mix of the smoke from a lit cigarette by smokers in the households result to various health problems, which include asthma attacks, respiratory infections, ear infections and sudden infant death syndrome (SIDS). As Chaudhari, Srivastava, Moitra and Desai (2008) added, the influence of passive smoking over the health of under-five children in Surat City, India, particularly among children born to illiterate mothers were more at risk of smoke from lit cigarette than children born to mothers with formal education. Admasie, Kumie and Worku (2018) also reported that unclean fuel use for cooking and carrying a child while cooking, especially in poorly ventilated houses is significantly related to risk factors for developing acute respiratory infection in under-five children.

Mishra and Retherford in 2007 observed that the traditional role of women in food preparation exposed children (aged 12 to 59 months) to the vulnerable risk of biomass smoke emission from firewood, burning coal and other sources of cooking fuel. Children in this age group who are exposed to such smoke emissions are more likely to have increased vulnerability of death compared to those with cleaner cooking fuels (Mishra, & Retherford, 2007). Against this background, this paper examined the interaction effects of maternal education and household environment characteristics as it predicts childhood mortality in Nigeria.

Theoretical Framework

Mosley and Chen's (1984) analytical framework was used in this study. The framework explains the causes of under-five mortality through proximate determinants in developing countries. The model is premised on the predisposing factors of childhood mortality, which function through intermediate variables that ultimately trigger the occurrence of under-five deaths in a population. To Mosley and Chen (1984), morbidity and mortality were considered as the outcome variable for the interaction of various factors (social and biological). The assumptions of the framework are that:

- (i) Survival rates for newborn should be above 97%, which is yet to be achieved within the context of Nigeria's newborn rate of survivability.

- (ii) The probability of survival is lowered through the interaction of social, economic, biological and environmental factors. In Nigeria, the interplay of culture, income levels, age of mothers and household characteristics affects the chances of survival of under-five children. The higher the income levels of mothers, for instance, the more likely mothers tend to maintain a healthy environment, feed under-five children adequately with nutritious meals, use non-biomass fuel for cooking, prevent children from mosquito bites through the use of mosquito insecticide treated nets and complete immunization dosage for children.
- (iii) The socio-economic factors should operate through the proximate determinants, which include but not limited to mothers' educational attainment and quality of the living environment. Most mothers with higher educational attainment are more exposed to information about the importance of exclusive breastfeeding and other healthy living information than those with less educational attainment. Hence, they are more likely to reduced rates of childhood mortality compared to mothers with less educational levels.
- (iv) Diseases and deficiencies of the survivors may be regarded as biological indicators of proximate determinants. That is to say, the lack of access of some mothers to adequate food supplements for children or information about the care of under-five children due to poverty may result to malnutrition and consequently lead to higher risk of morbidity and childhood mortality compared to those who have access to adequate food supplements and information about healthy and hygienic environment for their children.
- (v) Mortality in children is the outcome of the consequences of several disease processes. Because of the fragile nature of children and their exposure to poor toilet facilities, main floor materials, solid cooking fuels and unimproved sources of drinking water common among mothers with no formal education and whose residences are in rural areas, there is an increased risk of child morbidity and mortality more than those with formal education and whose residences are in urban areas.

The framework further distinguishes between proximate determinants and socioeconomic determinants, where Mosley and Chen (1984) identified fourteen (14) proximate determinants classified into five categories, namely: maternal factors, environmental factors, nutrient deficiency, injury to the child and personal illness control. As Mosley and Chen (1984) argued, all socioeconomic determinants must operate through the intermediate variables to affect child survival. For the socioeconomic determinants, there are three levels, namely: individual-level variable, household-level variable and community-level variable. This means that the intrinsic knowledge of mothers acquired through formal education (individual level) would impact significantly on the care for children. Similarly, the knowledge will translate to maintenance of healthy and hygienic environment for the care of under-five children, such as boiling water for drinking for children, removal of sharp object that could harm under-five children within the environment (at the household level), while the cultural practices of exclusive breastfeeding, vaccination or immunization are upheld at the community level.

The individual-level of intermediate variable (measured by maternal level of education) proposed to be fundamentally significant for the child's survival in the developing countries (Caldwell, 1979). As Levine and Rowe (2009) pointed out, maternal education increases women's health knowledge in two ways: (1) it exposes women to the importance of hands washing, boiling water before drinking and oral rehydration therapy; (2) it impacts indirectly on health knowledge by the acquisition of literacy skills through education. Galster (2010) also noted that there is a link between household environment and the health outcomes of all inhabitants in such environment. Based on this framework, it is proposed that increasing women's health knowledge about proper handling of household environment variables (smoking in the house, sources of drinking water, types of toilet used, types of cooking fuel used, types of main floor materials and the use of



mosquito bed nets for sleeping) acquired through formal education would influence children's (aged 12-59 months) well-being and chances of survival in the population.

DATA AND METHODS

This study used secondary data from NDHS conducted in 2013 having obtained permission to download the dataset from ICF Macro Inc., USA. The survey was the fifth in the series of NDHS and provided basic and health information about women of reproductive age (15-49) and children under the age of five across Nigeria. The information in the sample survey included birth history, child health, and household characteristics among others. This study used birth recode file of NDHS 2013 because child mortality (death of children aged 12-59 months) is the dependent variable in this study. The main independent variable is household environment. The indicators for the household environment in this study are smoking inside the house, type of cooking fuel, source of drinking water, toilet facilities use in the household, household flooring materials, and use of mosquito nets. Although there were 119,386 births recorded in the survey, the analytical sample was restricted to children aged 12-59 months, which amounted to a total of 45,603 births used for analysis in this study.

Data was analysed at bivariate and multivariate levels. While the Chi-square test was performed at the bivariate level to show the association between maternal education and household environment characteristics; logistic regression was used to examine the interaction effects of maternal education and household environment variables on child mortality in Nigeria at $p < 0.05$ significance level. The use of logistic regression was necessitated by the need to determine the degree of predictive influence of the interaction effects of maternal education and household environment characteristics on childhood mortality in Nigeria.

Variable Measurement

Table 1 displays the measurements of dependent and independent variables of the study. Child mortality, a dichotomous variable, is the dependent variable with a response (yes/no) to the question on "is child alive", the independent variables are maternal education and household environment characteristics. The classification of the independent variables (e.g. sources of drinking water and types of toilet facilities) follow the WHO and UNICEF Joint Monitoring Programme for water supply and sanitation into improved and unimproved sanitation (WHO, 2008). Further classifications of household environment variables are stated and described in the Table 1 as follows:

Table 1: Measurement of Variables

VARIABLES	DEFINITION AND RESPONSES	MEASUREMENT
DEPENDENT VARIABLE CHILD MORTALITY	Is child alive?	Child mortality 1= Yes 0= No
INDEPENDENT VARIABLE (i) MATERNAL EDUCATION	No education Primary education Secondary education Tertiary education	Maternal educational level 1= No education → 1=No education 2= Primary education } 2=Formal education 3= Secondary education } 4= Tertiary education
(ii) HOUSEHOLD ENVIRONMENT/ CHARACTERISTICS	(a) Smoking (smokes cigarettes, smokes pipe, uses chewing tobacco, uses snuff, smoking others and does not use tobacco).	Smokes nothing in the house: 1=Yes 0= No
	(b) Drinking water sources as improved sources - piped into yard/plot, public tap or standpipe, piped water-piped into dwelling; other protected spring, protected dug well, tube well/borehole, rainwater, bottled water; Unimproved sources- unprotected dug well;- cart with small tank/drum, unprotected spring, surface water and tanker truck).	Drinking water sources re-categorised into: 1= Improved 0= Unimproved
	(c) Toilet facility type (improved flush - flush to septic tank, flush/pour flush to pit, flush to piped sewer system; other improved facility - VIP latrine, composting toilet, pit latrine with slab, unimproved facility - pit latrine without a slab/open pit, flush/pour or flush elsewhere, bucket, hanging toilet).	Type of toilet facilities re-categorised as: 1= Improved 0= Unimproved
	(d) Cooking fuel type (Non-biomass fuel - LPG, electricity, kerosene and biogas; biomass fuel - crop residue/dung cake, wood, straw, charcoal and lignite).	Cooking fuel type re-categorised into: 1= Non-biomass fuel 0= Biomass fuel
	(e) Flooring material type (finished – polished wood, parquet, ceramic tiles, vinyl/asphalt strips, carpet; rudimentary – bamboo, wood plank; natural - sand, earth, dung).	Type of flooring materials re-categorised as: 1= Finished 0= Rudimentary
	(f) Use of mosquito nets for U5 in the house	Use mosquito nets: 1=Yes 0=No

*NB; LPG= Liquefied Petroleum Gas; VIP =Ventilated Improved Pit latrine

RESULTS

Table 2 presents the association between maternal education and household environment in Nigeria. There is significant (p<0.05) association between all the selected household environment variables and maternal education. The proportion of children aged 12 to 59 months exposed to smoke in the household was lower across all educational levels. However, the percentage of children whose mothers had higher education was the lowest as exposure to smoke in the household was measured by mothers’ response to the smoking of cigarettes, snuffs and tobacco.

Also, there is a significant association between sources of drinking water and education; more educated mothers had improved sources of drinking water in the household than less educated mothers. Unimproved source of drinking water, such as unprotected dug well, cart with small tank/drum, unprotected spring, surface water and a tanker truck, is common among mothers with none or primary education.

Table 2: Association between Maternal Education and Household Environment

Household Environment Characteristics	Maternal Education				Chi Square	P-Value
	No education (n=24098)	Primary (n=11625)	Secondary (n=7649)	Tertiary (n=2231)		
Tobacco Smoking in the house*						
No	98.5%	98.2%	99.2%	99.1%	33.87	0.000*
Yes	1.5%	1.8%	0.8%	0.9%		
Sources of drinking water*					2147.16	0.000*
Unimproved	48.9%	41.4%	23.3%	16.9%		
Improved	51.1%	58.6%	76.7%	83.1%		
Types of toilet facilities*					1831.81	0.000*
Unimproved	56.0%	57.8%	38.5%	19.1%		
Improved	44.0%	42.2%	61.5%	80.9%		
Types of main floor materials*					7483.76	0.000*
Rudimentary	62.8%	35.1%	15.6%	7.4%		
Finished	37.2%	64.9%	84.4%	92.6%		
Types of cooking fuel*					8528.71	0.000*
Biomass	98.1%	87.0%	64.7%	52.7%		
Non-biomass	1.9%	13.0%	35.3%	47.3%		
Use of mosquito bed nets*					101.15	0.000*
No	32.3%	34.2%	38.0%	38.2%		
Yes	67.7%	65.8%	62.0%	61.8%		

Source: NDHS 2013

*Significant at p<0.05

Additionally, there is significant association between types of toilet facilities and maternal education. The higher the level of mothers' education, the higher the percentage of children (aged 12 to 59 months) who use improved toilet facilities such as flush to septic tank, flush/pour flush to pit and flush to piped sewer system among others. Flooring material is also significantly associated with maternal education as the percentage of children whose mothers have higher level of education live in a household with finished floor materials than those with lower educational levels. At least 84 percent of children whose mothers have secondary and higher level of education lived in the household whose main floor materials are polished wood, parquet, ceramic tiles, carpet and vinyl/asphalt strips among.

Cooking fuel, a predictor of child's exposure to biomass fuel, has a significant to maternal education. Exposure of children to non-biomass fuel is measured by mothers' response to liquefied petroleum gas (LPG), electricity, kerosene and biogas; while that of biomass fuel is measured by crop residue/dung cake, wood, straw, charcoal and lignite. Although the majority of mothers in Nigeria use cooking fuels classified as biomass, the proportion of children whose mothers had attained higher educational levels and used non-biomass as cooking fuel are more than those with lower educational qualifications. This implies that children (aged 12-59 months) whose mothers had lower educational levels are more likely to be exposed to smoke emissions from biomass fuel in the household than those whose mothers had higher educational qualifications in Nigeria.

It is also observed that more than half of the children (aged 12-59 months) lived in households that used mosquito bed nets for sleeping across all educational levels. Indeed, there seems to be a higher percentage of mosquito bed net usage in the households with lower educational levels

than those with higher educational qualifications. There is a possibility that households where the mother's level of education is high having other informed means of controlling mosquitoes. Hence, the use of mosquito bed nets for sleeping may be reduced compared to those in the lower educational level categories.

Interaction effects of maternal education and household environment on child mortality

Table 3 presents odds of child mortality in Nigeria based on the interaction effects of maternal education and household environment variables using logistic regression. An odds ratio that is greater than one implies that the group has higher chances of death of children aged 12 to 59 months (child mortality) than the reference category. Interaction effect is measured in five groups.

The Group I interacts maternal education and tobacco smoking in the household. There is significant ($p < 0.05$) interaction effects of maternal education and tobacco smoking in the house on child mortality. Irrespective of the smoking status of the household, the odds of child mortality are significantly higher among women with no formal education than those with formal education. Children whose mothers have no formal education and live in a non-smoking household have the highest odds (2.6 times) of death between age 12 and 59 months. Children whose mothers had no formal education and are exposed to tobacco smoking in the house are 1.9 times more likely to experience child mortality than those in the reference group.

Table 3: Odds of Child Mortality by Interaction Effect of Maternal Education and Household Environment

Group	Interaction of maternal education and household environment	Odds Ratio
I	Maternal Education & Tobacco smoking in the house	
	Formal education*No smoking in the house (ref.)	1.000
	Formal education*Smoking in the house	0.722
	No formal education*No smoking in the house	2.632*
II	Maternal Education & Sources of drinking water	
	Formal education*Improved sources of drinking water (ref.)	1.000
	Formal education*Unimproved sources of drinking water	1.263*
	No formal education*Improved sources of drinking water	2.700*
III	Maternal Education & Toilet facilities	
	Formal education*Improved toilet facilities (ref.)	1.000
	Formal education*Unimproved toilet facilities	1.332*
	No formal education*Improved toilet facilities	3.035*
IV	Maternal Education & Main floor materials	
	Formal education*Finished floor materials (ref.)	1.000
	Formal education*Rudimentary floor materials	1.829*
	No formal education* Finished floor materials	2.483*
V	Maternal Education & Cooking fuel types	
	Formal education*Non-biomass cooking fuels (ref.)	1.000
	Formal education*Biomass cooking fuels	1.611*
	No formal education*Non-biomass cooking fuels	1.249
VI	Maternal Education & Use of mosquito bed nets	
	Formal education*Mosquito bed nets (ref.)	1.000
	Formal education*No mosquito bed nets	0.825*
	No formal education*Mosquito bed nets	2.633*
	No formal education*No mosquito bed nets	2.126*

Source: Raw data from NDHS 2013

*Significant at $p < 0.05$

Group II is on the interaction of maternal education and source of drinking water in the household and child mortality. The odd of child mortality is lowest among children whose mothers have formal education and improved source of drinking water. The likelihood of death for children age 12 to 59 months is highest among those whose mothers do not have formal education and live in households with unimproved source of drinking water, such as unprotected spring, unprotected dug well, cart with small tank/drum, surface water and a tanker truck. Children who lived in household with improved source of drinking water and whose mothers had no formal education are 3 times more likely to experience death than those who have the same source of drinking water in the household but mothers have formal education. This implies that even though drinking water is from an improved source, mother's educational level predicts different odds of death for children aged 12 to 59 months.

Odds of child mortality based on the interaction of maternal education and toilet facilities in the household are significantly higher among children whose mothers have no formal education as shown in Group III. Regardless of the type of toilet facilities used in the household— improved or unimproved, children whose mothers had no formal education in Nigeria are 3 times more likely to experience death between ages 12 and 59 months than those with formal education with the same type of toilet facilities. Children whose mothers have no formal education and live in households with unimproved toilet facilities have about 3 times higher odds of death than those with formal education but the same type of toilet facilities.

Group IV is on the interaction effects of maternal education and main flooring materials in the household on childhood mortality. The flooring materials are grouped into finished and rudimentary. The likelihood of child mortality is significantly ($p < 0.05$) highest among children who lives in the household with rudimentary main floor materials and their mothers do not have formal education. Even where the flooring material is classified as finished, (such as polished wood, parquet, ceramic tiles, vinyl/asphalt strips and carpet), the odds of child mortality in the households of mothers with no formal education is 2 times higher than those with formal education. This implies that the mother's education has likely effect on the care of children aged 12 to 59 months under the condition of rudimentary main floor materials in the household.

Interaction of maternal education with type of cooking fuel predicts the odds of child mortality is presented in Group V. Cooking fuel is classified into biomass and non-biomass fuel. Continuous inhaling of smoke from biomass cooking fuel such as crop residue/dung cake, wood, straw, charcoal and lignite, has adverse effect on the health of both children and adult. The use of biomass cooking fuel significantly has higher odds of child's death irrespective of mother's educational level than household where cooking fuel type is non-biomass. Although the odd of child mortality is higher in households where they use a biomass type of cooking fuel, it is significantly higher when mothers in such household do not have formal education. Children age 12-59 months who live in a household environment where biomass fuel is used for cooking are three times more likely to die when their mothers have no formal education than groups. This is a strong indicator of interaction of maternal education and household environment that can predict child's death in Nigeria.

In Group VI, the interaction effects of maternal education and use of insecticide treated mosquito bed nets on child mortality. Children whose mothers had no formal education, but use mosquito bed nets have the highest risk of death compared to others. The odds of deaths among children age 12 to 59 months whose mothers had no formal education and use mosquito bed nets is 3 times higher than those children that live in households with formal education and use mosquito bed nets.

DISCUSSION

Caldwell (1979) assertion that maternal education plays a crucial role in the survival of under-five children in less developed countries is still a fact in the twentieth century. Findings from this study indicated that the interaction of maternal education and household environment variables is significant on child mortality. This suggests that the ways through which household environment variables are handled by mothers in the care of children aged 12 to 59 months are influenced by their levels of education. It also confirms Mosley and Chen's (1984) posit that among the proximate determinants of child survival/mortality, maternal factors and environmental health factors affects child survival. The argument that individual-level (mother's educational attainment), household-level (household environment) and community-level variables are very significant in determining child survival in developing countries in which Nigeria is not an exemption; although this study is limited because of non-inclusion of community level variables.

As previous studies (Iyun, 2000; Adebowale, Morakinyo, & Ana, 2017; Lelieveld, Haines, & Pozzer, 2018) have reported significant relationship between the conditions of the environment and diseases predisposing children to mortality, this study also established that child mortality is more prevalent in disadvantaged households where there is no formal education among mothers than where mothers have formal education. Consequently, children born to mothers with no formal education and live in a disadvantaged household environment where they are exposed to smoke have a higher likelihood of childhood mortality than those born to mothers with formal education.

This aligns with the reports of Centre for Disease Control and Prevention (2014) that household with the mix of smoke from lit cigarette by smokers (secondhand smoke) result to numerous health problems among under-five children ranging from respiratory infections to Sudden Infant Deaths Syndrome (SIDS). It further supports Chaudhari, Srivastava, Moitra and Desai (2008), who in their study of the influence of passive smoking over the health of under-five children in Surat City, India found that children born to mothers with formal education are less likely to have risk of secondhand smoking effects compared to those born to mothers with no formal education.

Also, exposure of children under-five to smoke emissions from firewood, burning coal and other categories of biomass cooking fuel made children aged 12 to 59 months more vulnerable to the risk of child morbidity such as developing acute lower respiratory tracts infections (Mishra, & Retherford, 2007; Irfan, Cameron, & Hassan, 2018; Admasie, Kumie, & Worku, 2018). In spite of this, there are significant differences in the odds of child mortality based on maternal education. There is a higher risk of child death in the household where children are exposed to smoke from biomass fuel and mothers had no formal education (4 times) than those with formal maternal education and same exposure. This suggests that formal maternal education is significant in the way and manner under-five children are exposed to smoke/emission particularly biomass cooking fuels.

The pattern of child mortality in household with unimproved sources of drinking water corroborates Rustein (2000), Murray *et al.*'s (2007), and Fayehun and Omololu's (2011) studies that poor sources of drinking water increase children's vulnerability to mortality in developing countries. Indeed, the likelihood of child mortality in households with unimproved water source and mother had no formal education is three times more than households with mothers who had formal education.

Levine and Lowe's (2009) study reported that maternal education is vital in exposing women to specific knowledge of hygiene such as washing of hands which is acquired through formal

education. Pandey (2009) also noted that due to low knowledge of sanitary practices among women without formal education, child mortality is significantly higher than those with formal education (Pandey, 2009). In this study, interaction of maternal education with type of toilet facilities affirmed previous study; children of mothers without formal education and unimproved toilet facilities are three times more likely to die than those whose mothers have formal education in the same type of households.

Fayehun, 2010; Adebowale, Morakinyo, & Ana, 2017 observed at different times in different studies that types of main floor materials significantly predict childhood mortality in Nigeria. The findings from this study also implied that the odds of child mortality in households of mothers with no formal education are significantly higher than those with formal maternal education with improved/unimproved main floor materials in Nigeria.

The use of treated mosquito bed nets for sleeping has been found to reduce child mortality (Darkwah *et al.*, 2014); findings indicate that significant variations exist in the odds of childhood mortality in household with formal maternal education and no formal maternal education relative to the use of mosquito bed nets for sleeping. The probability of dying before the fifth birthday in households of mothers with no formal education is two times higher than those with formal education. As already established in the literature, formal education either directly or indirectly improve the specific knowledge about health practices (Levine, & Rowe, 2009). Therefore, maternal education can mitigate the likelihood of death of children age 12 to 59 months.

Conclusion

This study focused on the effect of interaction of mothers' education and household environment on child mortality in Nigeria. Child mortality is more prevalent in disadvantaged households where mothers have no formal education than where mothers have formal education. Consequently, children born to mothers without formal education and in a disadvantaged household environment have a higher likelihood of child mortality than those born to mothers with formal education. These have implications for children's survival given that attaining formal education increases the chances of survival for children aged 12 to 59 months as a result of health knowledge practices acquired through formal education. The knowledge acquired through formal education can enhance good behavioural practices in the household that can prevent child mortality.

Therefore, skills and best practices for handling of household environment, that can be acquired through formal education, should be encouraged among mothers while efforts to improve the well-being of children through maternal education are to be supported by all members of the society. Also, policy interventions that will champion the female children's access to education should be formulated and implemented. This would facilitate and enhance literacy skills among mothers that will in turn improve maternal knowledge of health and sanitation practices across households in Nigeria.

Acknowledgements:

We appreciate ICF Macro Inc., USA for the permission to download 2013 NDHS dataset for the analysis of this study.

REFERENCES

- Adebowale, S. A., Morakinyo, O. M., & Ana, G. R. 2017. Housing materials as predictors of under-five mortality in Nigeria: evidence from 2013 demographic and health survey. *BioMed Central (BMC) pediatrics*, 17(1), 30.
- Adepoju, A. O., Akanni, O., & Falusi, A. O. 2012. Determinants of child mortality in Rural Nigeria. *World Rural Observations*, 4(2), 38-45.
- Adetoro, G. W., & Amoo, E. O. 2014. A Statistical analysis of child mortality: Evidence from Nigeria. *Journal of Demography and Social Statistics*, 1, 110-120.
- Adewemimo, A., Kalter, H. D., Perin, J., Koffi, A. K., Quinley, J., & Black, R. E. 2017. Direct estimates of cause-specific mortality fractions and rates of under-five deaths in the northern and southern regions of Nigeria by verbal autopsy interview. *PLoS one*, 12(5), e0178129.
- Adeyanju, O., Tubeuf, S., & Ensor, T. 2017. Socio-economic inequalities in access to maternal and child healthcare in Nigeria: changes over time and decomposition analysis. *Health policy and planning*, 32(8), 1111-1118.
- Admasie, A., Kumie, A., & Worku, A. (2018). Children under Five from Houses of Unclean Fuel Sources and Poorly Ventilated Houses Have Higher Odds of Suffering from Acute Respiratory Infection in Wolaita-Sodo, Southern Ethiopia: A Case-Control Study. *Journal of environmental and public health*, 2018.
- Caldwell, J.C. 1979. Education as a factor in mortality decline: An examination of Nigerian Data. *Population Studies*, 33(3), 395-414.
- Center for Disease Control and Prevention. 2014. Health effects of secondhand smoke. Retrieved October 24, 2016 from http://www.cdc.gov/tobacco/data_statistics/fact_sheets/secondhand_smoke/health_effects/.
- Chaudhari, V. P., Srivastava, R. K., Moitra, M., & Desai, V. K. 2008. Risk of passive smoking among under-five children. *Journal of Mahatma Gandhi Institute of Medical Sciences*, 13(2), 46-52.
- Darkwah, K. F., Boachie-Yiadom, S., & Tawiah, R. 2014. Analysis of under-five mortality in Ghana using logit model. *International Journal of Statistics and Applications*, 4(4), 192-197. DOI: 10.5923/j.statistics.20140404.03.
- Ezeh, O. K., Agho, K. E., Dibley, M. J., Hall, J. J., & Page, A. N. 2015. Risk factors for post-neonatal, infant, child and under-5 mortality in Nigeria: a pooled cross-sectional analysis. *British Medical Journal Open*, 5(3), e006779.
- Fayehun, O. A. 2010. Household environmental health hazards and child survival in Sub-Saharan Africa. *Demographic Health Survey (DHS) Working Papers No. 74*. Calverton, Maryland, United States of America: ICF Macro.
- Fayehun, O. A., & Omololu, O.O. 2009. Prevalence and treatment of childhood diarrhea among Nigerian ethnic groups. *The Nigerian Journal of Sociology and Anthropology*, 7, 14-28.
- _____. 2011. Ethnicity and child survival in Nigeria, *African Population Studies*, 25 (1) (Supplement), 92-112.
- Galster, G. C. 2010. The Mechanism(s) of neighborhood effects theory: Evidence, and policy implications. *Paper presented at the Economic and Social Research Centre (ESRC) Seminar: Neighbourhood Effects: Theory & Evidence*. Scotland, United Kingdom: St. Andrews University.
- Gyuse, A. N., Ayuk, A. E., & Okeke, M. C. 2018. Facilitators and barriers to effective primary health care in Nigeria. *African journal of primary health care & family medicine*, 10(1), 1-3.
- Irfan, M., Cameron, M. P., & Hassan, G. (2018). *The Causal Impact of Solid Fuel Use on Mortality: A Cross-Country Panel Analysis* (No. 12/18).
- Iyun, B. F. 2000. Environmental factors, situation of women and child mortality in south western Nigeria. *Social Science and Medicine*, 51(10):1473-1489.
- Koffi, A. K., Kalter, H. D., Loveth, E. N., Quinley, J., Monehin, J., & Black, R. E. 2017. Beyond causes of death: The social determinants of mortality among children aged 1-59 months in Nigeria from 2009 to 2013. *PLoS one*, 12(5), e0177025.

- Lelieveld, J., Haines, A., & Pozzer, A. 2018. Age-dependent health risk from ambient air pollution: a modeling and data analysis of childhood mortality in middle-income and low-income countries. *The lancet Planetary health*, 2(7), e292-e300.
- Levine, R. A., & Rowe, M. L. 2009. Maternal literacy and child health in less-developed countries: evidence, processes, and limitation. *Journal of Developmental & Behavioral Pediatrics*, 30(4), 340.
- Liu, L., Hill, K., Oza, S., Hogan, D., Chu, Y., Cousens, S., & Robert, B. E. 2015. Levels and causes of mortality under age five years. *International Bank for Reconstruction and Development, World Bank. Reproductive, maternal, newborn, and child health: disease control priorities*, 2, 71-83.
- Mishra, V., & R. D. Retherford. 2007. Does biofuel smoke contribute to anaemia and stunting in early childhood? *International Journal of Epidemiology* 36: 117-129.
- Mosley, H., & Chen, L. 1984. An analytic framework for the study of child survival in developing countries. *Population and Development Review*, 10, 25-45.
- Murray, C.J., Laakso, T., Shibuya, K., Hill, K., & Lopez, A. D. 2007. Can we achieve Millennium Development Goal 4? New analysis of country trends and forecasts of Under-5 Mortality to 2015. *The Lancet*, 370, 1040-1054.
- National Bureau of Statistics, NBS. 2011. *Nigeria: Monitoring the situation of children and women. Nigeria Multiple Indicator Cluster Survey 2011 Summary Report*. Abuja: National Bureau of Statistics.
- Pandey, M. J. 2009. Maternal health and child mortality in rural India. *Australia South Asia Research Centre (ASARC) Working Paper 12*. Delhi, India: Institute of Economic Growth
- Renschler, J. P., Walters, K. M., Newton, P. N., & Laxminarayan, R. 2015. Estimated under-five deaths associated with poor-quality antimalarials in sub-Saharan Africa. *The American Journal of Tropical Medicine and Hygiene*, 92(6_Suppl), 119-126.
- Rustein, S.O. 2000. Factors associated with trends in infant and child mortality in developing countries during the 1990s. *Bulletin of the World Health Organization*, 78, 1256-1270.
- Teerawichitchainan, B., & Phillips, J. F. 2008. Ethnic differentials in parental health seeking for childhood illness in Vietnam. *Social Science & Medicine*, 66(5), 1118-1130.
- United Nations Inter-agency Group for Child Mortality Estimation (UN IGME). 2018. *'Levels & Trends in Child Mortality: Report 2018, Estimates developed by the United Nations Inter-agency Group for Child Mortality Estimation*. United Nations International Children's Emergency Fund (UNICEF): New York.
- United Nations. 2015. *Transforming our world: The 2030 agenda for sustainable development*. Retrieved March 31, 2017 from https://www.un.org/.../120815_outcome-document-of-Summit-for-adoption-of-the-p...
- World Health Organization. 2008. World Health Organization and United Nations children's fund Joint Monitoring Programme for water supply and sanitation. Progress on drinking water and sanitation: special focus on sanitation. In *World Health Organization and United Nations children's fund Joint Monitoring Programme for water supply and sanitation (JMP). Progress on drinking water and sanitation: special focus on sanitation*. World Health Organization.
- Yaya, S., Bishwajit, G., Okonofua, F., & Uthman, O. A. 2018. Under five mortality patterns and associated maternal risk factors in sub-Saharan Africa: A multi-country analysis. *PloS one*, 13(10), e0205977.