

RESEARCH STUDY

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The Relationship Between the Age of Toddlers, the Provision of Formula Milk, and Residence Location with the Occurrence of Diarrhoea: An Analysis of DHS Data

Hubungan antara Usia Balita, Pemberian Susu Formula, dan Tempat Tinggal dengan Kejadian Diare: Sebuah Studi Analisis Data DHS

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ABSTRACT

Background: Approximately 16% of mortality in children under five years old is associated with diarrhoea. In Ghana, diarrhoea is the third most common cause of death among infants. Ghana is one of the countries in Africa with an estimated 1,700 deaths due to diarrhoea in infants.

Objectives: This study aimed to determine the relationship between toddlers' age, formula milk consumption, residence location, and diarrhoea occurrence.

Methods: This study was a cross-sectional, analytical, observational study. The data was obtained from the Ghana Demographic and Health Survey (DHS) database in 2019. The total number of respondents in the Ghana Demographic and Health Survey (DHS) was 8,362 individuals. Meanwhile, the total number of respondents who meet the inclusion criteria is 2,263 toddlers.

Results: This study demonstrated a significant relationship between the occurrence of diarrhoea in toddlers and characteristics related to the toddler's age (p -value <0.001 ; OR=0.696; 95% CI=0.579-0.837), formula milk consumption (p -value <0.001 ; OR=2.056; 95% CI=1.629-2.596), and residence location (p -value <0.001 ; OR=1.719; 95% CI=1.326-2.245).

Conclusions: Based on the results of the study, the incidence of diarrhoea in toddlers was correlated with the age of the toddler, formula feeding, and location of residence. Development of diarrhoea research will be needed in relation to health promotion in preventing diarrhoeal diseases.

INTRODUCTION

Diarrhoea illnesses remain a significant global public health threat, with over 1.7 billion cases reported annually¹. Diarrhoea is responsible for around 16% of mortality cases in children under the age of five. Diarrhoea ranks as the third leading cause of death among children under the age of five in Ghana, which is one of the African countries with an estimated child mortality rate of over 1,700². Diarrhoea is the second most common cause of death in children under the age of five, resulting in the death of 1 in 9 children and causing 21,195 deaths worldwide each day^{2,3}. As global health concerns continue to expand, diarrhoea is among the numerous health issues that frequently arise and are inadequately addressed, particularly in developing

nations³. Approximately 250 million young children in low- and middle-income countries risk failing to reach their maximum developmental capacity. Childhood diarrhoea is the leading cause of death worldwide¹. Diarrhoea continues to be a prominent cause of mortality among children below the age of five and has become a global health issue⁴.

Previous studies have demonstrated a correlation between diarrhoea disease in early childhood and subsequent malnutrition. Malnutrition and developmental retardation can result from the presence of pathogenic enteric bacteria in the digestive system, leading to diarrhoea and reducing a child's ability to absorb nutrients¹. Death is the most severe consequence of diarrhoea. In addition, it has long-lasting negative

effects throughout the first two years of life. Long-term implications of stunted growth include reduced physical and mental stamina and below-average academic performance⁴. Estimates indicate that environmental risk factors, such as contaminated drinking water, low socioeconomic status, insufficient sanitation, and inadequate hygiene, contribute to 94% of the burden of Diarrhoea illness². Research indicates a correlation between the drinking of formula milk and diarrhoea in children aged 0 to 6 months. Children who consume formula milk are four times more likely to have diarrhoea than those who do not⁵.

Research indicates that breastfeeding is a preventive measure against diarrhoea in children, effectively reducing the frequency and severity of this condition. Diarrhoea sickness is primarily caused by substandard water quality, inadequate sanitation and hygiene practices, and tropical climates worldwide. Three Brazilian studies have found a correlation between early-life diarrhoea in children and decreased cognitive performance¹. Diarrhoea illnesses in Africa account for about 16% of all deaths among children. Diarrhoea is a significant cause of disease and death in Ghana, particularly among children under the age of five². It ranks as the third leading cause of death in this age group, resulting in approximately 10,000 deaths annually. This location in Ghana aligns with other low-income countries where diarrhoea is also a significant health concern^{2,6}. Ghana's incidence of diarrhoea has been shown to reach its highest levels throughout October to March and July to August.²

The incidence of diarrhoea in developing countries such as Ghana has not received as much academic attention. It is estimated that slightly more than 1,700 children under the age of five perished in 2015. Furthermore, aside from the tangible expenses, there are significant financial repercussions for individuals and countries⁶. Aikins et al. conducted a study in Northern Ghana to determine the predicted treatment prices for outpatient and inpatient diarrhoea based on the length of therapy. The findings revealed that the estimated costs for outpatient diarrhoea ranged from US\$ 3.86 to US\$ 4.35; on the other hand, the costs for inpatient diarrhoea ranged from US\$ 65.14 to US\$ 133.86. These figures are based on the exchange rates of 2003 and 2004⁶. Oral rehydration solutions and antibiotics are the primary therapies for individuals with diarrhoea, whether they receive treatment in a hospital or as outpatients⁶.

Consequently, reducing the occurrence of diarrhoea in Ghana will have beneficial impacts on both public health and the economy. This study aimed to

examine the relationship between the occurrence of diarrhoea in Ghana in 2019 and factors such as children under five, formula milk consumption, and residence location. This study utilized secondary data from Ghana to contribute to the existing knowledge on this topic. This study is the first to investigate the relationship between diarrhoea, toddler age, formula milk consumption, and toddler housing among children under five years in Ghana. This research postulates a correlation between diarrhoea disease in toddlers and factors such as the toddler's age, formula milk consumption, and geographical location.

METHODS

Research Design, Setting, and Samples

This study employed a cross-sectional design and was an analytical observational study. The data was derived from secondary sources in Ghana's 2019 Demographic and Health Surveys (DHS) database. They had accessible data on the occurrence of diarrhoea, records of formula milk consumption, and information on their area of residence. The inclusion criteria consisted of children under the age of five. The study comprised a total of 2,623 children out of a group of 8,362 children who were under the age of five. The study excluded children who were beyond the age of five and those who did not have any records of experiencing diarrhoea. The study examined three independent variables: age (under five years, categorized as either less than 24 months or greater than 24 months), feeding method (formula-fed or not formula-fed), and residence location (rural or urban). The dependent variable was classified as either diarrhoea or no diarrhoea. Picture 1 displays the sample selection procedure. The survey was open to children between 12 and 59 months. The study utilized data from the 2019 Demographic and Health Surveys (DHS) for its instruments and data collection techniques.

Data Analysis

The hypothesis was tested using multivariate analysis, specifically multiple logistic regression (binary), with a significance level of 95% ($\alpha=0.05$). Descriptive statistical analysis was used to describe the frequency distribution of toddler age, formula milk consumption, residency, and incidence of diarrhoea. The data was analyzed using the 2x2 contingency chi-square table test to determine the relationship between the toddler's age, formula milk consumption, residency, and the occurrence of diarrhoea. Data analysis was conducted using the SPSS 21 software. Furthermore, the data were analyzed by calculating the odds ratio to ascertain the magnitude of the relationship between variables.

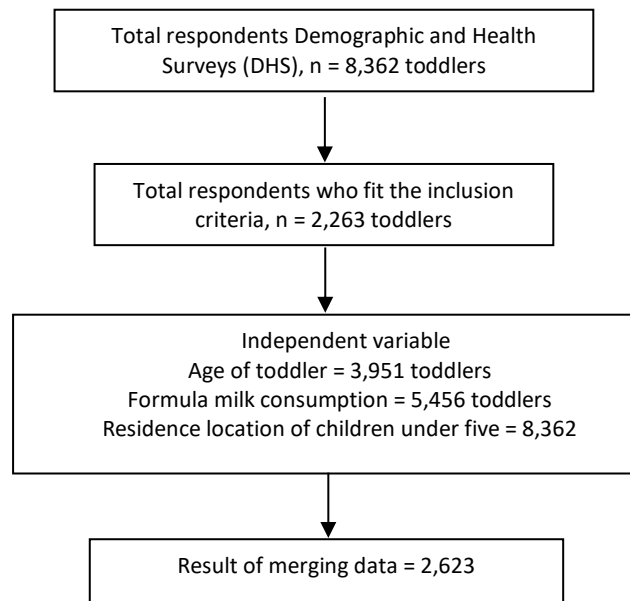


Figure 1. Research sample selection technique from Ghanaian DHS Database in 2019

RESULTS AND DISCUSSIONS

A total of 2,623 toddlers under the age of five who fit the specified criteria were included in the study. Most of these toddlers (63.2%) were younger than 24 months; on the other hand, the remaining toddlers (36.8%) were older than 24 months. Most toddlers experienced diarrhoea, precisely 72.9%; on the other

hand, 27.1% did not have diarrhoea. Most toddlers reside in rural settings (90%); on the other hand, a small minority (10%) dwell in urban areas. Table 1 reveals that a greater percentage of toddlers (86.6%) take formula milk compared to those who do not consume formula milk (13.4%).

Table 1. Characteristics of respondents

Variable	Frequency	Percentage
Diarrhoea		
Yes	1,913	72.9
No	710	27.1
Toddler Age		
<24 months	1,657	63.2
≥24 months	966	36.8
Formula Consumption		
Yes	352	86.6
No	2,271	13.4
Residence		
Rural	2,362	90.0
Urban	261	10.0
Total	2,623	100.0

This study demonstrates a significant association between the variables of toddler age, formula milk consumption, and home location and the occurrence of diarrhoea in children under the age of five, with a p-value of 0.05. The prevalence of diarrhoea in children younger than 24 months (18.7%) is higher than in children older than 24 months (8.3%). The incidence of diarrhoea in toddlers administered formula milk (5.5%) was reduced compared to toddlers who did not receive formula milk. The prevalence of diarrhoea among toddlers residing in rural areas (23.3%) exceeds that of toddlers residing in

urban areas. The test results indicate a correlation between all variables and diarrhoea in young children in Ghana. Diarrhoea in children under five is associated with their varying ages (p-value=0.000; OR=0.696). There was a significant association between the occurrence of diarrhoea in toddlers and being fed formula (p-value=0.000; OR=2.056). There is a significant relationship between the occurrence of diarrhoea in toddlers and the type of residence they live in (p-value=0.00; OR=1.719) (Table 2).

Table 2. The correlation between toddler age, formula milk consumption, and residence location with the occurrence of diarrhoea in Ghana 2019

Variable	Diarrhoea				p-value	OR Value	95% CI
	Yes		No				
	n	%	n	%			
Toddler Age							
<24 months	491	18.7	1,166	44.5	0.00	0.696	0.579-
≥24 months	219	8.3	747	28.5			0.837
Feeding Formula							
No	567	21.6	1,704	65.0	0.00	2.056	1.629-
Yes	143	5.5	209	8.0			2.596
Residence							
Rural	612	23.3	1,750	66.7	0.00	1.719	1.326-
Urban	98	3.7	163	6.2			2.245
Total	710	27.0	1,913	72.9			

Toddler Age

According to the research findings, the prevalence of diarrhoea is higher in the age range of 0-24 months compared to the age group over 24 months. This finding is consistent with multiple studies, including research conducted by Darmika, which indicates that the age range of 0-24 months experiences the highest diarrhoea⁷. The age group with the highest prevalence of diarrhoea in children under 24 months. During the initial two years of life, the infant's gastrointestinal defence system is underdeveloped. At birth, gastric acid secretion is not fully functional, which means it can take several months for the pH level to reach a level that can kill bacteria (pH <4). The evolving intestinal mucosal barrier, which changes with age, can impact the likelihood of experiencing diarrhoea. Furthermore, factors such as reduced levels of maternal antibodies, absence of active immunity in the infant, consumption of food that may be contaminated with germs, and direct contact with human or animal faeces when the infant begins crawling can also contribute to an increased risk of diarrhoea⁸.

A study conducted by Ahmed and his team found that the incidence of diarrhoea decreases as individuals become older, particularly in older age groups and children under the age of five⁹. A West African study on the incidence of diarrhoea in children under five years of age found that children aged 6 to 11 months have a higher occurrence of the disease compared to children aged 48 to 59 months¹⁰. A study conducted by Karambu et al. in Kenya revealed that the prevalence of diarrhoea was reduced in children older than four years compared to children aged between 12 and 48 months¹¹. The decline in occurrence with age can be attributed to the immunodeficiency in children and the potential exposure to tainted food during the weaning process, resulting from diminished immunity inherited from the mother⁹. Furthermore, toddlers begin to crawl throughout early childhood, heightening the likelihood of acquiring contaminated fingers and subsequently inserting them into their mouths during teething¹⁰.

The occurrence of diarrhoea is more prevalent in children older than six months of age¹². Children typically begin independently navigating and investigating their surroundings when they reach six months or older. They frequently engage in oral consumption, thus rendering themselves vulnerable to a multitude of illnesses. Because the mother lacks parenting skills, and this is a

household. Toddlers aged one to two years old are particularly vulnerable to fluctuations in water and mineral concentrations. Dehydration is a condition that impairs the body's capacity to retain both minerals and water¹³. Diarrhoea can cause malnutrition and exacerbate it by depleting the body of essential nutrients. Children with diarrhoea may lack appetite, and mothers may decline to provide food¹⁴.

Formula Consumption

The occurrence of diarrhoea in infants is intricately linked to several factors, including the practice of mothers providing adequate nourishment for their babies. Mothers often provide their baby's sustenance through breast or formula milk. When studying moms who practise breastfeeding with breast milk, it is evident that exclusively breastfeeding infant's results in enhanced immunity and a 4.8 times lower likelihood of developing diarrhoea than infants who do not receive exclusive breast milk¹⁵. However, examining the cultural practices of mothers who opt for formula milk to nourish their newborns reveals that formula milk consumption is associated with a higher incidence of diarrhoea and an increased vulnerability to this condition among infants. Another study reported that over half of the participants experienced diarrhoea in their newborns as a result of formula milk consumption¹⁶. Infants exhibit lactose intolerance due to their underdeveloped digestion, which lacks the necessary enzymes to break down lactose. This is corroborated by research indicating that infants who consume formula milk are 14 times more likely to get diarrhoea than those who do not use formula milk¹⁷. This might happen due to the underdeveloped nature of the digestive system in infants less than six months. Furthermore, the study elucidated that formula milk that is not properly presented carries an elevated risk of diarrhoea.

This assertion is corroborated by several studies, which affirm that inadequate formula milk consumption might detrimentally affect the well-being of toddlers¹². This will lead to the proliferation of bacteria, fungi, and other microorganisms. Coliform bacteria are the predominant type of bacteria typically present in formula milk. Formula milk is susceptible to bacterial contamination as a result of unclean bottles. This is impacted by the maternal Clean and Healthy Living Behaviour (PHBS). Hence, focusing on the proper

procedures for preparing and administering milk is crucial. This includes maintaining the cleanliness of the milk bottle, ensuring it is dry before use, washing it with baby-safe soap, utilising specialised tools for milk bottles, thoroughly cleaning all bottle components, rinsing it with flowing water, and sterilising it to minimise contamination¹². According to a 2020 study, formula milk consumption can be an option for insufficient breast milk supply¹⁸. Nevertheless, it is essential to acknowledge that consuming formula that does not comply with health regulations can also result in adverse repercussions for infants who consume it¹⁴.

The prevalence of formula milk usage among mothers can be attributed to many factors, including employment demands, biological considerations, maternal knowledge deficiencies, and other factors. In Indonesia, many moms view formula milk consumption as a convenient option to supplement breastfeeding and ensure their baby's nutritional requirements are met. According to Khasanah's research, 63% of the participants received formula milk to meet their nutritional requirements¹⁹. This is a result of the hectic schedules of employed mothers. The employed mothers rationalised that breastfeeding was burdensome. This factor is also associated with the physical exhaustion experienced after work, leading mothers to opt for a convenient approach, such as feeding their baby formula milk, rather than going through the effort of expressing or providing breast milk.

Meanwhile, some studies have found that additional factors impact formula milk consumption, specifically the biological state of the mother, which may result in reduced ability to produce breast milk¹⁶. Formula milk can be used as a substitute for insufficient breast milk production. Nevertheless, it is essential to acknowledge that providing formula milk that does not comply with health regulations can also result in adverse repercussions for individuals who drink it²⁰.

There is a strong correlation between using formula milk consumption and the occurrence of diarrhoea¹⁸. Other research has demonstrated that children given formula milk and introduced to solid meals early are more likely to experience diarrhoea²¹. This indicates that while formula milk is utilised as a substitute for breast milk, it does not eliminate the potential for adverse effects of formula milk consumption, such as diarrhoea. The decrease in breastfeeding rates and the rise in formula milk feeding rates can be attributed to the assertive marketing strategies employed by milk manufacturers, which subsequently affect the mindset of women in favouring formula milk²². This is supported by research indicating that up to 54.1% of participants are enticed to purchase formula milk due to the benefits and advantages of formula milk showcased in television advertisements²³. They may be unaware that formula milk might also have negative effects, such as diarrhoea.

Moreover, the study indicated that 63.9% of the participants experienced diarrhoea following the administration of formula milk. Furthermore, a study of a comparable nature also indicated that infants within the age range of 0-1 years suffered from diarrhoea when administered formula milk²⁴. Aside from extensive commercial promotion, inadequate adherence to health

rules when choosing formula milk is another contributing factor to diarrhoea in children.

Yuniarti and Vinnata's 2020 study revealed that diarrhoeal infections are frequently prevalent in communities due to contaminated food and drinks caused by inadequate hygiene practices¹². The mother is the adult who has the closest relationship with a toddler. The steps taken by the mother determine the course of the sickness in a toddler with diarrhoea. These activities are affected by various factors, such as the amount of education, information, and steps to prevent diarrhoea¹⁴. Diarrhoea can also arise from the baby's gastrointestinal system maturing and adjusting to non-breast milk diets. Exclusive breastfeeding reduces the likelihood of infants developing diarrhoea. This could be due to the absence of immunoglobulin A (IgA) in colostrum and breast milk formula. Immunoglobulin A (IgA) possesses a laxative property and protects infants against disorders like diarrhoea. Additionally, it safeguards the digestive system from infections or foreign substances during the initial stages of bowel movement. Infants require breast milk as their primary source of nourishment from birth until a few months later due to the incomplete development of their immune system²⁵.

Toddler Residence

The rapid urbanisation has resulted in the proliferation of informal settlements in numerous low- and middle-income countries (LMICs). These villages frequently have a very restricted sanitation infrastructure²⁶. Isolating human waste from direct human contact can help avoid exposure to enteric pathogens, which can lead to infection, diarrhoea²⁷, and potentially long-term health issues like environmental enteric dysfunction (EED)²⁸, linear growth deficits²⁹, impaired cognitive development²⁸, and reduced effectiveness of oral vaccines³⁰. Children residing in densely populated slum regions with widespread faecal contamination and poor sanitary facilities may face a higher likelihood of experiencing negative health consequences as a result of frequent exposure to enteric pathogens³¹.

An investigation conducted in Ethiopia revealed a significant occurrence of diarrhoeal sickness among children under the age of five residing in rural regions. There is a substantial correlation between the occurrence of diarrhoea and factors such as the type of roofing material, availability of hand washing facilities, existence of latrine facilities, presence of faeces around the latrine pit, presence of faeces around the home environment, and the risk of contamination in household storage. Previous research has established a correlation between urban regions, characterised by slum conditions and insufficient sanitation, and a higher incidence of diarrhoea³². However, this study highlights that children residing in rural areas are more prone to developing diarrhoea²⁰. In 2018, Mumuni et al. discovered a similar phenomenon, which revealed that diarrhoeal infections have become a significant health concern in developing nations due to the rise in urbanisation, associated sanitation issues, and limited access to safe drinking water. Inadequate water and sanitation are responsible for around 94% of the four billion diarrhoea cases

worldwide each year³³. Research findings indicate that children who consume water from sources that are not safe typically suffer from diarrhoea. Toddlers who have access to safe drinking water sources seldom suffer from diarrhoea. Toddlers who frequently suffer from diarrhoea are those who consume drinking water sourced from dug wells or boreholes. This can arise from the presence of harmful bacteria in contaminated drinking water, leading to the development of diarrhoea. Unsecured drinking water sources are highly vulnerable to pollution-induced contamination³³.

In Ghana, 12.7% of families consume water that is not suitable for consumption; on the other hand, 80.6% have inadequate toilet facilities, and 18.8% engage in open defecation. Gastrointestinal illness resulting from consuming water contaminated with pathogens is a highly prevalent condition frequently documented in healthcare institutions in Ghana. Furthermore, diarrhoea is responsible for around 25% of all deaths among children under the age of five in Ghana. The Joint Monitoring Programme reports from WHO and UNICEF have disclosed that over 4000 children in Ghana succumb to diarrhoea annually, and approximately 23% of Ghanaian children suffer from chronic malnutrition due to inadequate water and sanitation conditions³⁴. The study revealed that children who consume water from contaminated sources frequently experience diarrhoea. However, toddlers with access to safe drinking water seldom experience diarrhoea. Toddlers who frequently suffered from diarrhoea were those who consumed drinking water sourced from dug wells or boreholes. The presence of harmful bacteria in contaminated drinking water may be the cause of diarrhoea. Unsecured drinking water sources are more vulnerable to contamination³³. Unclean drinking water harbours pathogenic bacteria³⁴. In 2019, Harsa stated that boiling water until it reaches a cooked state is an effective method for treating home drinking water, as it efficiently kills germs. Using a simple and cost-effective strategy, implementing household water treatment methods can effectively decrease diarrhoea and enhance drinking water's microbiological integrity.

Meanwhile, the process of refilling water typically involves filtration and disinfection. The filtering process aims to separate suspended particles and colloidal mixes, which may include microorganisms, from water. Concurrently, the disinfection procedure aims to eradicate germs that were not removed by the preceding filtration process. To ensure the eradication of pathogenic microorganisms in drinking water before consumption. An inherent constraint of this study is the maternal feeding practices, which can potentially affect the likelihood of a child experiencing diarrhoea. The findings of this study align with previous research that indicates a correlation between latrine sanitation, access to clean water, and diarrhoea in toddlers³⁵. A study showed a correlation between sewerage (SPAL) and diarrhoea in young children³⁶. The community's utilisation of wastewater predominantly discharges into open sewers. It is infrequently maintained, hence facilitating the occurrence of diarrhoea due to a lack of awareness regarding the cleanliness of the surrounding environment.

CONCLUSIONS

These results support the hypothesis that the incidence of diarrhoea in Ghana is significantly affected by the toddler's age, formula milk consumption, and residency. The development of diarrhoea research will be very much needed in health promotion and preventing diarrhoea diseases.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

There are no conflicts of interest associated with this publication. This study did not obtain dedicated support from funding agencies, commercial entities, or not-for-profit organizations.

AUTHOR CONTRIBUTIONS

AD: conceptualisation, data curation, formal analysis, investigation, methodology, project, resources, software, role/writing-early draft, writing & editing review. SS: software, supervision, validation, visualisation, role/writing-early draft, writing & editing review. ERI: resources, software, supervision, validation, visualisation, role/writing-early drafts, writing & editing review. ANS: funding acquisition, investigation, methodology, project administration. TM: conceptualisation MM: conceptualisation. RSM: conceptualisation, conceptualisation, data curation, formal analysis.

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