



## **Hygienic Disposal of Children's Stools Practices Among Women of Children With Diarrhoea in Sub-Saharan Africa**

Authors: Essuman, Mainprice Akuoko, Storph, Rebecca Peniel, Ahinkorah, Bright Opoku, Budu, Eugene, and Yaya, Sanni

Source: Environmental Health Insights, 17(1)

Published By: SAGE Publishing

URL: <https://doi.org/10.1177/11786302231204764>

---

BioOne Complete ([complete.BioOne.org](https://complete.BioOne.org)) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at [www.bioone.org/terms-of-use](https://www.bioone.org/terms-of-use).

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.


---

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

# Hygienic Disposal of Children's Stools Practices Among Women of Children With Diarrhoea in Sub-Saharan Africa

Environmental Health Insights  
Volume 17: 1–12  
© The Author(s) 2023  
Article reuse guidelines:  
sagepub.com/journals-permissions  
DOI: 10.1177/11786302231204764



Mainprice Akuoko Essuman<sup>1</sup>, Rebecca Peniel Storph<sup>2</sup> ,  
Bright Opoku Ahinkorah<sup>3</sup>, Eugene Budu<sup>4</sup> and Sanni Yaya<sup>5,6</sup>

<sup>1</sup>Department of Medical Laboratory Science, School of Allied Health Sciences, College of Health and Allied Sciences, University of Cape Coast, Cape Coast, Central, Ghana. <sup>2</sup>Laboratory Department, Cape Coast Teaching Hospital, Cape Coast, Ghana. <sup>3</sup>School of Public Health, Faculty of Health, University of Technology Sydney, Sydney, Australia. <sup>4</sup>Korle Bu Teaching Hospital, Accra, Greater Accra, Ghana. <sup>5</sup>School of International Development and Global Studies, University of Ottawa, Ottawa, ON, Canada. <sup>6</sup>The George Institute for Global Health, Imperial College London, London, UK.

## ABSTRACT

**BACKGROUND:** Diarrhoea stools contain infectious agents and pose a public health threat to children and members of the entire family when exposed to them. Therefore, their hygienic disposal is essential. Empirical data are needed to stir the needed public health interventions to encourage or enforce proper disposal practices to curb associated clinical issues. This study assessed the prevalence and correlates of hygienic stool disposal practices by mothers of children with diarrhoea in sub-Saharan Africa (SSA).

**METHODS:** The Demographic and Health Surveys (DHS) data of 16 sub-Saharan African countries from 2015 to 2021 involving 22 590 mother-child pairs were analysed. Multilevel binary logistic analysis was conducted to assess the individual- and household-level factors associated with the hygienic disposal of stool practices by mothers of children with diarrhoea. The results were presented using adjusted odds ratios (AOR) and 95% confidence intervals (CI) at a statistical significance of  $P < .05$ .

**RESULTS:** The overall prevalence of hygienic disposal of children's stools among women of children with diarrhoea was 49.01% (95% CI: 48.40–49.62) and ranged from 15.70% in Liberia to 86.6% in Rwanda. The practice of hygienic disposal of stools of children with diarrhoea was likely to increase among mothers who are working (AOR: 1.19; 95% CI: 1.09–1.30), those with partners with primary level of education (AOR: 1.18; 95% CI: 1.06–1.31), Muslims (AOR: 1.69; 95% CI: 1.49–1.91) and widowed/divorced (AOR: 8.94, 95% CI: 3.55–22.53). Again, mothers in the richer (AOR: 1.23; 95% CI: 1.08–1.39) wealth index had increased odds of disposing of stools hygienically compared to those in the poorest wealth index. Women who were 20 years and above, to who belonged to Traditional Religions (AOR: 0.57; 95% CI: 0.43–0.74), and those with unimproved sources of water (AOR: 0.89; 95% CI: 0.82–0.98) and toilet facilities (AOR: 0.63; 95% CI: 0.58–0.69) were less likely to dispose of child's diarrhoea stool hygienically than their counterparts.

**CONCLUSION:** The study reveals that the unhygienic disposal of the stool of children with diarrhoea is prevalent in SSA and requires a concerted effort to curb it. Sanitation practices such as educating mothers about hygienic disposal of children's stool and improving water and sanitation facilities are crucial in lowering the high prevalence of unhygienic disposal of the diarrhoeic stool of children. Additional country-level research is needed to assess children's defecation behaviours and the disposal of diarrhoeic stools using different methodologies.

**KEYWORDS:** Disposal, mother, stool, sub-Saharan Africa, diarrhoea, children

**RECEIVED:** June 4, 2023. **ACCEPTED:** September 13, 2023.

**TYPE:** Original Research

**FUNDING:** The author received no financial support for the research, authorship, and/or publication of this article.

**DECLARATION OF CONFLICTING INTERESTS:** The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

**CORRESPONDING AUTHOR:** Sanni Yaya, School of International Development and Global Studies, University of Ottawa, Ottawa, Ontario K1N 6N5, Canada. Email: sanni.yaya@gmail.com

## Background

In holistic practice, hygiene helps to ensure a person's good health and well-being. The World Health Organization (WHO) continues to place a high premium on proper sanitation and hygiene practices to promote global health. Sanitation is a key element of the Sustainable Development Goals (SDG), which has a global agenda intended to promote the health and well-being of people everywhere. In addition, a crucial component of the global agenda of SDG 6 is widespread access to water and sanitation to boost public health.<sup>1,2</sup> Poor sanitation

results in high rates of illness and mortality. It results in illnesses such as diarrhoea, cholera, hepatitis A, dysentery, typhoid and polio, all brought on by the spread of infections through faeces and urine.<sup>3,4</sup> In addition, it may cause the spread of parasitic diseases such as trachoma, schistosomiasis and soil-transmitted helminth illnesses.<sup>5–7</sup> Poor sanitation contributed to 775 000 premature deaths worldwide in 2017.<sup>8</sup> This estimate accounted for about 5% of total deaths in low- and middle-income countries, which is higher than the global average of 1.4%.<sup>9,10</sup> According to a WHO/UNICEF estimate, around



Creative Commons Non Commercial CC BY-NC: This article is distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 License (<https://creativecommons.org/licenses/by-nc/4.0/>) which permits non-commercial use, reproduction and distribution of the work without further permission provided the original work is attributed as specified on the SAGE and Open Access pages (<https://us.sagepub.com/en-us/nam/open-access-at-sage>).

2.3 billion people worldwide lack access to better sanitation,<sup>5</sup> and only 28% of people in sub-Saharan Africa (SSA) have access to basic sanitation.

After pneumonia, diarrhoea caused by poor sanitation through the oral-faecal route is the second most common cause of death in children under 5 years old.<sup>11</sup> According to Boschi-Pinto, poor hygiene in developing countries contributes to 1.87 million fatalities of children under 5 and around 1.7 billion instances of diarrhoea per year, or 2.9 episodes per child on average.<sup>12</sup> Children aged 6 to 11 months have the largest diarrhoea disease burden, with an average of 4.5 occurrences per child yearly in low- and middle-income countries.<sup>13</sup> Persistent diarrhoea is thought to be the cause of 50% of diarrhoea deaths in developing countries, and in areas where access to effective treatment is frequently scarce.<sup>14</sup> The situation is dire in SSA where over 70% of the region's population does not have improved sanitation and the practice of open defecation is still common.<sup>15</sup>

Diarrhoea is characterised by a reduced stool consistency and hence the passage of loose stools which is caused by the intestine's inefficient absorption of water and electrolytes.<sup>16</sup> This means that children are likely to frequently pass stools which when not properly disposed of can result in infection. Evident in several studies indicate that in comparison to normal stool which consists of normal flora, children's diarrhoeal stools harbour protozoan (such as *Giardia intestinalis*, *Cyclospora cayentanensis*, *Entamoeba coli*), helminthic (such as *Trichuris trichiura*, hookworm and *Ascaris lumbricoides*) and viral (such as adenovirus) pathogens which can affect the children and members of the immediate family.<sup>17-20</sup> Comparatively, to adults, it is recorded yearly that 2.5 billion cases of diarrhoea among under-five children result in death or other medical outcomes. Greater than 50% of these cases occur in Africa and South Asia with under-five mortality due to diarrhoea accounting for 1.5 million each year. About 80% of the deaths are still in Africa.<sup>21</sup> A worrying situation is the possibility of detecting antimicrobial-resistant (such as *floR*, *bla<sub>CARB-2</sub>* and *mphA* genes of *Salmonella*) strains of enteropathogens in these children's diarrhoeal stools<sup>20</sup> as these pathogens could cause infection to the child, mother and other members of the family when stool samples are not properly disposed.

An increased rate of diarrhoea is influenced by unfavourable attitudes and perceptions of children's faeces and therefore puts children and other members of the family at risk of infection and other morbidities. For example, the perception that children's faeces are harmless compared to adults leads to unsafe faeces disposal practices that increase the risk of diarrhoeal diseases and their related morbidities.<sup>14,22</sup> Previous studies in SSA have shown a 23% increased risk of diarrhoea when children's faeces are not handled safely,<sup>23</sup> and unsafe handling increases the risk of helminth infections in children by 35%.<sup>24</sup> In addition, unhygienic disposal of children's faeces results in poor growth outcomes such as stunting, wasting and underweight in children.<sup>25</sup> Children who crawl and play on

the ground run the risk of contaminating their fingers with faeces from open defecation sites, which they then ingest and get diarrhoeal disorders. Hygienic child stool disposal is therefore seen as an effective way to stop diarrhoea and other enteropathies among children.<sup>14,22</sup>

According to the WHO/UNICEF Joint Monitoring Program (JMP) for Water Supply and Sanitation, a child's faeces are safely disposed of if the child is made to use a toilet/latrine for defecation, or if their faeces are disposed of in a toilet/latrine or buried.<sup>26</sup> Hygienic or safe disposal of children's stools is influenced by individual and contextual variables and has been demonstrated in a handful of studies.<sup>27-30</sup> In most of these studies, the practices of safe disposal of children's stools were low. In a recent survey of 15 SSA countries, it was found that only 58.73% of childbearing women safely disposed of their children's stools which varied from 26.38% in Chad to 85.90% in Rwanda.<sup>9</sup> Individual and contextual variables such as age, parental education, media exposure, access to water and toilet facilities, wealth, place of residence and household number have been linked to the hygienic disposal of children's stool.<sup>9,31</sup> Because infants' stools are smaller, smell less and contain less visible food remnants, many cultures regard them to be less dangerous than those of adults.<sup>14</sup> Consequently, sanitation programs have paid little attention to the proper disposal of children's faeces.

In the context of children's diarrhoeal stool disposal, very little has been explored. To the best of our knowledge, no published study has explored the individual and household variables that influence the safe disposal of diarrhoea stool in children in SSA and other regions of the world. We used nationally representative data from 16 sub-Saharan African countries to examine the factors associated with the hygienic disposal of diarrhoeal stools of children in SSA. Given the deleterious effects stool has on the growth of children and the possibility of causing infection and other morbidities in members of the family, empirical information is required to initiate focused interventions to ensure hygienic disposal to curb the harm that comes with it. Therefore, it is hoped that the findings of this study could be considered when planning and executing sanitation programmes and policies in SSA.

## Methods and materials

### Data source

The study used data from the most recent Demographic and Health Surveys (DHS), which were conducted in 16 Sub-Saharan African countries between 2015 and 2021. The information was gathered from the women's recode files in each of the 16 countries. The DHS is a nationally representative survey that is done in over 90 low- and middle-income countries throughout the world.<sup>32</sup> The survey adopted a cross-sectional design, and respondents were chosen using a 2-stage cluster sampling procedure, as detailed in the literature.<sup>33</sup> The researchers employed standardised and structured

**Table 1.** Distribution of the countries, survey years and sample used in this study.

COUNTRIES	SURVEY YEAR	WEIGHTED SAMPLE	WEIGHTED PERCENTAGE
Angola	2015-16	1496	6.6
Benin	2017-18	1109	4.9
Burundi	2016-17	2431	10.8
Cameroon	2018	933	4.1
Ethiopia	2016	781	3.5
Gambia	2019-20	1032	4.6
Liberia	2019	598	2.7
Madagascar	2021	983	4.4
Mali	2018	1398	6.2
Malawi	2015-16	3103	13.7
Nigeria	2018	3048	13.5
Rwanda	2019-20	736	3.3
Sierra Leone	2019	488	2.2
Uganda	2016	2438	10.8
Zambia	2018	1083	4.8
Zimbabwe	2015	931	4.1
All countries	2015-2021	22590	100.0

questionnaires developed by MEASURE DHS to collect information from participants on numerous health and social factors, such as how children's excrement is disposed of.<sup>32</sup> The questionnaires were originally developed in English and translated into the local language of the respective survey populations to make it easier for interviewers to ask questions in a language that respondents could understand. The questionnaires are reviewed and modified in 7 phases of The DHS Program, adopted by the participating countries but collect data that are comparable across countries. Further information on the DHS questionnaires could be obtained from <https://dhsprogram.com/Methodology/Questionnaires.cfm>. A detailed methodology of the DHS procedures has been discussed extensively elsewhere.<sup>32</sup> The study included mothers whose youngest child under age 5 had diarrhoea in the 2 weeks preceding the survey.<sup>34</sup> Only women with complete information on the variables of interest were investigated, yielding a total of 22 590 women in the final study (Table 1). The datasets used in the study are accessible for free at <https://dhsprogram.com/data/available-datasets.cfm>. The manuscript was written in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement guidelines.<sup>35</sup>

### Outcome variable

The study's outcome variable was the hygienic disposal of children's stools. This information was acquired from a DHS questionnaire inquiry concerning the technique utilised to dispose of the child's stool during their most recent bowel movement. The replies were then recoded to form a binary variable based on the WHO/UNICEF definition.<sup>36</sup> Responses indicating that the stool was disposed of in a drain or ditch, in the rubbish, out in the open or not disposed of at all received a '0' and were deemed unhygienic. Responses indicating that the child used a toilet or latrine, that the stool was disposed of in a toilet or latrine, or that the stool was buried, on the other hand, were coded as '1' and considered hygienic.

### Explanatory variables

The explanatory variables used in this study included a total of 12 variables, which were categorised as either individual-level variables or household-level variables. The selection of these variables was based on their availability in the DHS dataset and their association with the hygienic disposal of a child's stool.<sup>9,22,28,37-39</sup> The individual-level variables included maternal age (15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49), employment status (working or not working), educational level (no education, primary, secondary or higher), partner's educational level (no education, primary, secondary or higher), religious affiliation (Christianity, Islam, Traditionalist or other), marital status (married, cohabiting or widowed/divorced) and exposure to mass media (either exposed or unexposed). The household-level variables included wealth (poorest, poorer, middle, richer or richest), source of water facility (either improved or unimproved), type of toilet facility (either improved or unimproved), place of residence (urban or rural) and sub-region (Western SSA, Eastern SSA, Central SSA or Southern SSA).

### Operational definitions

**Wealth index:** The wealth index was calculated using an asset-based method in the DHS. The data were gathered on the possession of a variety of durable goods (such as a vehicle, refrigerator and television) as well as housing features (such as the kind of flooring and roofing used in homes as well as the availability of restrooms). Women were asked if they had the aforementioned possessions or not. The poorest, poorer, middle, richer or richest categories of these scores were determined using principal component analysis. The wealth quintiles are stated in terms of quintiles of people in the population.<sup>34</sup>

**Employment status:** Women were said to be currently working if they were employed in the last 12 months.

**Residence:** Each country's definition was used to determine if a cluster is 'urban' or 'rural'. The conventional division of a

nation into urban and rural regions has been predicated on the supposition that metropolitan areas, whichever they are defined, provide a different way of life and typically a higher level of living than rural ones.

**Religious affiliation:** This is the self-identified association of respondents with a religion, denomination or sub-denominational religious group. Religion was recorded in the original DHS as Catholic, Methodist, Presbyterian, Pentecostal/charismatic, other Christian, Islam, Traditional/spiritual and No religion. For better comparison, however, we grouped religious affiliation into Christianity (Catholic, Methodist, Presbyterian, Pentecostal/charismatic and other Christians), Islam, Traditional/African religion and other religion.<sup>40</sup> Traditional religion involves the worship of many gods and has diverse and less clearly articulated doctrines.

**Media exposure:** A respondent was said to be exposed to media if they listened to the radio, read a newspaper or watched television in the week to the study.

**Source of toilet facility:** Based on WHO's guidelines,<sup>36</sup> the source of toilet facilities was said to be 'unimproved' if pit latrines without slabs or platforms, open pits, hanging latrines, bucket latrines or open defecation is used by the household. The toilet facilities are considered 'improved' if a flush toilet, ventilated improved pit latrine, pit latrine with a slab, composting toilet or Ecosan were used by the household.

**Source of water:** The source of water is said to be "improved" if the water comes from a protected well, protected spring, precipitation, bottled water, a public tap or standpipe, a tube well or borehole or a neighbour. Water from all other sources was considered 'unimproved'.<sup>41</sup>

### Statistical analysis

Stata version 17.0 was used to analyse the research data in four steps. The first step was to calculate the prevalence of hygienic disposal of children's stools among women in SSA whose children had diarrhoea in the previous 2 weeks and present them using a pooled meta-analysis in a forest plot. The weighted frequencies and percentages for the explanatory variables were reported in the second stage. A bivariate analysis was done in the third phase to assess the association between the sanitary disposal of children's stools and explanatory factors, and a chi-square test was used to find significant correlations. We selected all the variables that showed statistical significance for a multilevel binary logistic regression modelling which was used due to the hierarchical nature of the data.<sup>42,43</sup> First, we fitted the empty model, that had no predictors (random intercept). This procedure was followed by Model I, which contained only the individual-level variables, Model II with only household-level variables, and Model III, with both individual- and household-level variables. These generated both the fixed and random effects results. The fixed effects results showed the measures of association between the variables and

were presented using the adjusted odds ratios (AOR) and corresponding 95% confidence intervals (CI) for all models. The random effect results produced the log-likelihood ratio (LLR) and Akaike Information Criterion (AIC). The highest log-likelihood and the lowest AIC were used to show the best-fit model. The analyses were weighted, and the survey command (svy) was employed in the regression analyses to account for the complicated sampling structure of the data. All missing values were dropped using listwise deletion, and a *P*-value less than .05 was considered statistically significant.

### Ethical consideration

In this study, ethical clearance was not sought due to the public availability of the DHS dataset. The datasets were obtained from the MEASURE DHS after registration and approval were given for its usage. All the ethical guidelines concerning the use of secondary datasets in the publication were strictly adhered to. Detailed information about the DHS data usage and ethical standards is available at <http://goo.gl/ny8T6X>.

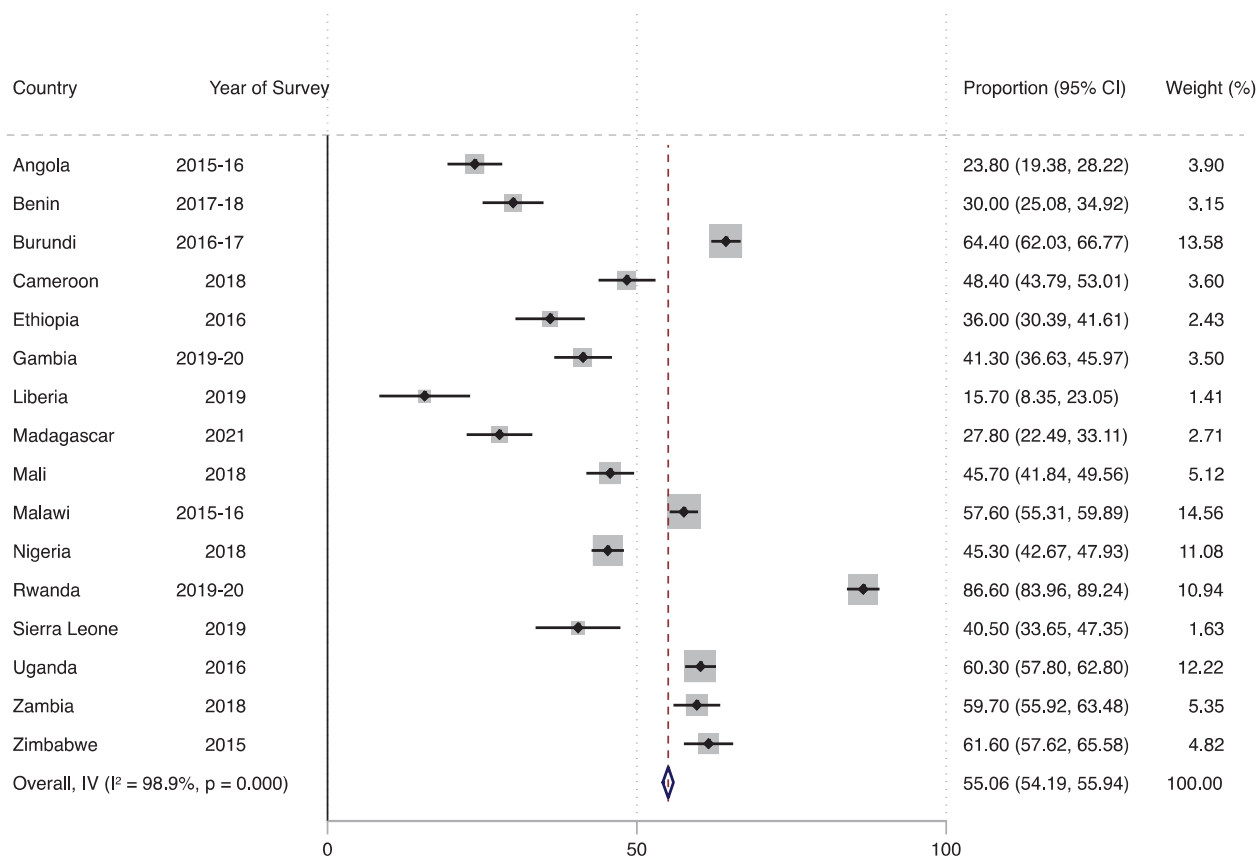
## Results

### *Prevalence of hygienic disposal of child's stool by mothers of children with diarrhoea*

Figure 1 shows the prevalence of hygienic disposal of children's stools by women with children with diarrhoea. The overall prevalence of hygienic disposal of child's stool among women with children with diarrhoea was 49.01% (95% CI: 48.40–49.62) and ranged from 15.70% in Liberia to 86.6% in Rwanda.

### *Distribution of hygienic disposal of child's stool by sociodemographic characteristics*

Table 2 summarises the proportion of hygienic stool disposal prevalence across the included explanatory variables. Apart from place of residence, all other individual- and household-level variables showed significant associations with hygienic disposal of child's stool by women of children with diarrhoea in SSA. The practice of hygienic disposal of child's stool by women of children with diarrhoea was highest among women in the 15 to 19 age category (56.4%), those with primary level education (53.6%), those employed (49.3%) and those in richer wealth index (50.9%). Hygienic disposal of a child's stool was also high among women having partners with primary-level education (55.0%). Hygienic disposal of a child's stool was high among women who have divorced/widowed (90.6). Based on religion, hygienic disposal of stool was common among Christians (50.4%) but low among traditionalists (25.5%). Hygienic disposal of a child's stool stood at 50.6% and 53.8% among women with an improved source of water and toilet facilities and 49.7% among women unexposed to social media. Hygienic disposal of a child's stool was prevalent among



**Figure 1.** Prevalence of hygienic disposal of child's stool by mothers of children with diarrhoea.

women living in the east and south sub-regions but low among women in Western and Central SSA.

*Model fit statistics*

Based on the random effects analysis, the complete model (Model III) which included all the individual- and household-level factors in the model was considered the best-fit model for predicting the practice of hygienic stool disposal by women. This model had the lowest AIC of 31 857.43 and the highest log-likelihood ratio of -15 898.717.

*Individual and household-level determinants of hygienic disposal of a child's stool*

In terms of the individual-level factors, the analysis of the data showed that hygienic stool disposal practice is less likely to occur among women aged 20 to 49 years compared to women in the 15 to 19 age category. Working mothers were more likely to dispose of stools hygienically than those who were not working (AOR: 1.19; 95% CI: 1.09-1.30). The practice of hygienic disposal of a child's stools was more likely to occur among women with partners having primary level education (AOR: 1.18; 95% CI: 1.06-1.31) than those with partners with no education. In terms of religion, the odds increases from 1.69 (95% CI: 1.49-1.91) for Islamics and reduces to 0.61 (95% CI: 0.39-0.95) and 0.57 (95% CI: 0.43-0.74) for Traditionalists

and those of other religions when compared to Christians. In addition, the odds of hygienic disposal of children's stool were higher among mothers who were widowed/divorced (AOR=8.94, 95% CI: 3.55-22.53) compared to those who were married.

The analysis of the household-level factors showed that the odds of disposing of a child's stool hygienically were 1.33, 1.40 and 1.23 times higher among women in poorer (AOR: 1.33; 95% CI: 1.21-1.47), middle (AOR: 1.40; 95% CI: 1.25-1.56) and richer (AOR: 1.23; 95% CI: 1.08-1.39) wealth index than women in the poorest wealth index, respectively. Women with the unimproved source of water (AOR: 0.89; 95% CI: 0.82-0.98) or toilet (AOR: 0.63; 95% CI: 0.58-0.69) facilities were less likely to dispose of children's stool hygienically than those with improved water and toilet facilities. Also, mothers who lived in the Southern (AOR: 3.40; 95% CI: 2.96-3.91) and Eastern (AOR: 2.51; 95% CI: 2.20-2.86) Regions were more likely to dispose of stool hygienically than those in the Western and Central Regions.

**Discussion**

This study assessed the individual- and household-level correlates of hygienic stool disposal practices among mothers of children with diarrhoea in SSA. Although several studies have explored the determinants of hygienic or safe disposal of a child's stool by mothers and caregivers, the present study is

**Table 2.** Distribution of hygienic disposal of child's stool by mothers of children with diarrhoea in selected countries in SSA by sociodemographic and household-level characteristics.

VARIABLES	FREQUENCY	PERCENTAGE	HYGIENIC DISPOSAL OF CHILDREN'S STOOL (%)	P-VALUE
Age				<.001
15-19	1346	6.0	56.4	
20-24	5693	25.2	54.7	
25-29	6477	28.7	49.4	
30-34	4692	20.8	49.0	
35-39	2902	12.8	46.7	
40-44	1181	5.2	38.8	
45-49	297	1.3	33.2	
Educational level				<.001
No education	6534	28.9	43.8	
Primary	8777	38.8	53.6	
Secondary	6358	28.1	48.3	
Higher	921	4.1	51.4	
Employment status				.041
Not working	5119	22.7	48.8	
Working	17 471	77.3	49.3	
Place of residence				.058
Urban	8406	37.2	46.9	
Rural	14 184	62.8	50.5	
Wealth index combined				<.001
Poorest	2374	10.5	40.4	
Poorer	4089	10.1	48.4	
Middle	5115	22.6	50.6	
Richer	5700	25.2	50.9	
Richest	5312	23.5	50.5	
Partner's education				<.001
No education	5340	23.6	43.3	
Primary	7470	33.1	55.0	
Secondary	7531	33.3	47.6	
Higher	2249	10.0	49.4	
Religion				<.001
Christianity	15 039	66.6	50.4	
Islam	6894	30.5	48.3	
Traditionalist	166	0.7	25.5	
Other	491	2.2	32.7	

(Continued)

Table 2. (Continued)

VARIABLES	FREQUENCY	PERCENTAGE	HYGIENIC DISPOSAL OF CHILDREN'S STOOL (%)	P-VALUE
Marital status				<.001
Married	17745	78.5	50.3	
Cohabiting	4782	21.2	44.5	
Widowed/divorced	63	0.3	90.6	
Source of water				<.001
Improved	16669	73.8	50.6	
Unimproved	5921	26.2	45.1	
Source of toilet facility				<.001
Improved	12983	57.5	53.8	
Unimproved	9607	42.5	43.0	
Exposure to mass media				<.001
Exposed	6601	29.2	48.0	
Unexposed	15989	70.8	49.7	
Sub region				<.001
Western SSA	7673	34.0	40.0	
Eastern SSA	8036	35.6	56.5	
Central SSA	2429	10.7	33.3	
Southern SSA	4452	19.7	60.4	

perhaps the first to consider only the stools of children with diarrhoea. Stool samples contain infectious agents and pose a public health threat to children and members of the entire family when exposed to them.<sup>17-20</sup> The occurrence of diarrhoea increases when stool samples are not disposed of safely.<sup>22,44</sup> Again, stool disposal practices are associated with the general well-being and growth of children.<sup>25</sup> Empirical data are needed to stir the needed public health interventions to encourage or enforce proper disposal practices to curb associated clinical issues. The present study included one of the largest cohorts of participants and therefore its findings represent the situation on the ground. Analysis of the data showed that 49.2% of mothers of children with diarrhoea dispose of their child's stool hygienically. As expected, variations across countries were observed with a prevalence as low as 15.7% in Liberia and as high as 86.6% in Rwanda being observed. Individual-level variables such as age, educational level, partner's educational level, religion, marital status and exposure to mass media were significantly associated with hygienic stool disposal practices among mothers of women of children with diarrhoea in SSA. Again, household-level factors like wealth index, source of water, source of toilet facilities and sub-region had associations with hygienic disposal of stool by mothers of children with diarrhoea in SSA.

While most studies exploring the hygienic disposal of the stool have not particularly paid much attention to children's diarrhoea stool, the current prevalence corroborates with an earlier study that reported that 58.73% of mothers dispose of their child's stool safely in SSA.<sup>9</sup> This reflects the generally poor stool disposal practices in SSA as evidenced in Nigeria,<sup>44</sup> Ethiopia,<sup>45</sup> Zambia<sup>29</sup> and Ghana.<sup>37</sup> The observation of variations in prevalence across SSA countries also reflects the efforts made to ensure the provision of proper sanitation in these countries. It is not surprising to see comparatively higher stool disposal practices in Rwanda as sanitation is high on the country's development agenda, as indicated in its Poverty-reduction Strategic Papers and National Water Supply and Sanitation policies.<sup>46,47</sup> Evidently, access to improved sanitation facilities in rural areas has doubled between 1990 and 2015.<sup>46</sup> This suggests that institutional commitment to the implementation of proper sanitation policies may go a long way to improve stool disposal practices among mothers in SSA.

In this study, the odds of practising hygienic disposal of child stool reduced as mothers' age increased beyond 20 years (Table 3). Unlike mothers aged 20 years and above, mothers between 15 and 19 years are likely to be unemployed. This, therefore, gives them the chance to offer all the needed attention to their children, unlike older mothers who must juggle



**Table 3.** Determinants of hygienic stool disposal practices among mothers of children with diarrhoea in SSA.

VARIABLES	NULL MODEL	MODEL I	MODEL II	MODEL III
		AOR (95% CI)	AOR (95% CI)	AOR (95% CI)
<b>Age</b>				
15-19		Reference (1.0)		Reference (1.0)
20-24		0.80** (0.69-0.93)		0.76*** (0.65-0.88)
25-29		0.74*** (0.63-0.86)		0.71*** (0.61-0.82)
30-34		0.70*** (0.59-0.81)		0.67*** (0.57-0.79)
35-39		0.64*** (0.54-0.75)		0.61*** (0.51-0.72)
40-44		0.47*** (0.38-0.57)		0.44*** (0.36-0.54)
45-49		0.37*** (0.27-0.51)		0.35*** (0.26-0.48)
<b>Employment status</b>				
Not working		Reference (1.0)		Reference (1.0)
Working		1.07 (0.98-1.17)		1.19*** (1.09-1.30)
<b>Educational level</b>				
No education		Reference (1.0)		Reference (1.0)
Primary		1.30*** (1.18-1.43)		1.02 (0.92-1.13)
Secondary		1.16* (1.03-1.31)		0.98 (0.86-1.11)
Higher		1.44** (1.14-1.83)		1.15 (0.89-1.48)
<b>Partner's education</b>				
No education		Reference (1.0)		Reference (1.0)
Primary		1.45*** (1.31-1.61)		1.18* (1.06-1.31)
Secondary		1.06 (0.94-1.18)		0.98 (0.88-1.11)
Higher		1.07 (0.90-1.27)		1.05 (0.88-1.26)
<b>Religion</b>				
Christianity		Reference (1.0)		Reference (1.0)
Islam		1.00 (0.91-1.11)		1.69*** (1.49-1.91)
Traditionalist		0.37*** (0.24-0.58)		0.61* (0.39-0.95)
Other		0.50*** (0.39-0.65)		0.57*** (0.43-0.74)
<b>Marital status</b>				
Married		Reference (1.0)		Reference (1.0)
Cohabiting		0.73*** (0.66-0.80)		0.90* (0.82-1.00)
Widowed/Divorced		9.69*** (3.90-24.11)		8.94*** (3.55-22.53)
<b>Exposure to mass media</b>				
Exposed		Reference (1.0)		Reference (1.0)
Unexposed		1.05 (0.97-1.13)		1.02 (0.94-1.11)

(Continued)

Table 3. (Continued)

VARIABLES	NULL MODEL	MODEL I	MODEL II	MODEL III
		AOR (95% CI)	AOR (95% CI)	AOR (95% CI)
Wealth index combined				
Poorest			Reference (1.0)	Reference (1.0)
Poorer			1.32*** (1.20-1.46)	1.33*** (1.21-1.47)
Middle			1.36*** (1.22-1.52)	1.40*** (1.25-1.56)
Richer			1.18** (1.05-1.33)	1.23** (1.08-1.39)
Richest			1.02 (0.90-1.16)	1.07 (0.93-1.23)
Source of water				
Improved			Reference (1.0)	Reference (1.0)
Unimproved			0.89** (0.81-0.97)	0.89* (0.82-0.98)
Source of toilet facility				
Improved			Reference (1.0)	Reference (1.0)
Unimproved			0.61*** (0.57-0.67)	0.63*** (0.58-0.69)
Sub region				
Western SSA			Reference (1.0)	Reference (1.0)
Eastern SSA			1.92*** (1.74-2.12)	2.51*** (2.20-2.86)
Central SSA			0.67*** (0.58-0.79)	0.96 (0.81-1.14)
Southern SSA			2.49*** (2.23-2.77)	3.40*** (2.96-3.91)
Random effect result				
PSU variance (95% CI)	0.52 (0.42-0.65)	0.53 (0.42-0.66)	0.47 (0.38-0.57)	0.45 (0.37-0.55)
ICC	0.1370323	0.1386759	0.1239473	0.1205907
Wald chi-square		353.50***	636.76***	843.36***
Model fitness				
Log-likelihood	-46262.352	-45401.674	-44427.958	-43774.642
AIC	92528.7	90845.35	88877.92	87609.28
N	22590	22590	22590	22590
Number of groups	1081	1081	1081	1081

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval; ICC, intra-class correlation; AIC, Akaike's information criterion; SE: Null model = a baseline model without any determinant variable.

Model I = Individual-level variables.

Model II = Household-level variables.

Model III = The final model adjusted for individual- and household-level variables.

\* $P < .05$ . \*\* $P < .01$ . \*\*\* $P < .001$ .

between motherhood and their career. Again, among first-timers, younger mothers tend to be more competent in managing a child's behaviour and making decisions in taking care of the child than older mothers.<sup>48</sup> This observation was contrary to a study among women from 15 SSA countries<sup>9</sup> and in Ethiopia which found that the odds of hygienic stool disposal increased as mothers' age increased.<sup>45</sup> A possible reason for this variation is that while these studies considered all kinds of

stool samples, the present study involved only mothers of children with diarrhoea.

This study demonstrated that mothers with partners having primary-level education dispose of their child's diarrhoea stool hygienically as opposed to those who have no formal education. This result was consistent with an earlier study also conducted in SSA.<sup>39</sup> The likely explanation is that educated partners can comprehend the causes of childhood illnesses and may be well

aware of the negative impacts of improper disposal of children's stool.<sup>49</sup> An educated father is most likely to show concern about how a child's stool is disposed of and be in the position to provide the needed materials, such as sanitary pans, needed for safe disposal practices. The influence of marital status on child stool disposal remains to be ascertained. In a study conducted in Nigeria, marital status did not significantly influence stool disposal practices.<sup>28</sup> However, similar to another study,<sup>9</sup> the practice of hygienic disposal of a child's stool was likely to be higher among women without partners (widowed or divorced) as observed in the present study. Women who have been widowed or divorced may be more likely than married women to dispose of children's stools safely because they may have taken on more responsibility for childcare in the absence of a partner. A greater understanding of health and hygiene standards, including the proper disposal of child excrement, may result from this increased duty. Additionally, being solely accountable for their child's well-being may inspire these mothers to prioritise and actively adhere to good hygiene practices.

This study found religion to be associated with the practice of hygienic stool disposal consistent with observations from similar studies.<sup>9,50</sup> Compared to Christians, Muslims were more likely to practice hygienic stool disposal while Traditionalists and those in 'other' religions were less likely to do so. This could be explained by the differences in beliefs and practices, especially about sanitation. The Christian and Islamic Religions in Africa place a lot of importance on hygiene and instruct followers to uphold and practice cleanliness. Again, this indicates that religious leaders could be engaged to educate women on the safe disposal of stools.

The study revealed that women from households with unimproved toilet and water facilities were less likely to practice hygienic stool disposal compared to those with improved toilet and water facilities consistent with previous studies.<sup>44,51,52</sup> Compared to those living in homes that rely on public restrooms, people in low-income urban households having access to within-compound toilet facilities are more likely to utilise latrines for child defecation and stool disposal.<sup>53</sup> Stool disposal practices seem to improve with the availability of water resources on the compound.<sup>52</sup> This is likely because of the convenience of accessing these toilet and water facilities. A lack of water could hamper mothers' ability to clean nappies and potties used by children after defecation. Child stools are likely to be disposed of unhygienically, particularly at night, if the toilet facilities are far from the home.<sup>44</sup> There is a need to facilitate the provision of toilet and water facilities to ensure that mothers feel convenient in the disposal of stools. In this study, a higher level of the household wealth index was associated with a higher likelihood of hygienic stool disposal practices by women. Compared to women from households with the poorest wealth index, women from households with poorer, middle and richer wealth indexes were more likely to dispose of their children's diarrhoeal stool hygienically. This finding is consistent with stool disposal

practices in Ethiopia<sup>51,54</sup> and Burkina Faso<sup>55</sup> and that generally reported among 34 SSA countries.<sup>39</sup> Mothers in more affluent homes probably enjoy a better quality of living with access to proper water and toilet facilities and know more about how to properly dispose of their children's stool.

Consistent with earlier studies in Ethiopia<sup>51</sup> and Cambodia,<sup>50</sup> geographic variation in stool disposal practices was observed in which the odds of hygienic stool practice increased in the Eastern and Southern Regions when compared to women in the West. A possible explanation for the observed geographic variation in stool disposal practice might be differences in the availability of toilet and water facilities, as well as policies guiding sanitation in the sub-regions. In SSA, there exist substantial inequalities in the distribution and use of water, sanitation and hygiene (WASH) facilities across countries. It is predicted that about 42.5% of people in SSA use improved sanitation, with countries such as Ghana, Guinea-Bissau, Equatorial Guinea and Rwanda having higher estimates.<sup>56</sup> The study shows that for many countries, access to improved drinking water, improved sanitation and open defecation remains a challenge. Differences in education received on the risk associated with waste disposal could also contribute to the observed differences in hygienic stool disposal practices. It is important to identify deprived areas and educate women in these areas on the dangers associated with improper disposal of stools and provide them with the deprived resources in planning policies to achieve proper sanitation.

### *Strengths and limitations*

Using a multilevel logistic regression model that takes into consideration the linked nature of DHS data and the use of nationally representative data improved the generalisability of the findings of the study. However, the current study has some limitations that need to be considered in interpreting the findings of the study. First, a cross-sectional research design was used in conducting the study; hence, causality cannot be claimed for the findings obtained. Again, the outcome variable, disposal of a child's diarrhoea stool, was collected based on reported practice rather than direct observation. To reduce biases, future studies on this topic could use spot checks and structured observations rather than questionnaires. Due to the secondary nature of the data, unmeasured confounders including mothers' awareness regarding child stool disposal and other household-level characteristics such as the social and cultural norms around the disposal of the stool of children with diarrhoea were unable to be examined. Another limitation of this study was the possibility of social desirability bias from respondents which could decrease the likelihood that people would report unhygienic child stool disposal practices. Finally, associations are sometimes exaggerated based on the sample size for a variable as observed in the case of variables such as religion, employment status and marital status in the present study. This error may lead to model findings that indicate high

levels of significance for a variable while the conclusion may not be generalisable due to the variable's sample size. Our models contained quite a number of variables, thus some of the significant findings could be due to chance.

## Conclusion

The study reveals that unhygienic disposal of stool samples of children with diarrhoea practices is prevalent in SSA and requires conscious effort to curb it. We have identified that factors such as age, educational status, religion, marital status, wealth index and access to water and toilet facilities affect the hygienic disposal of a child's diarrhoea stool in SSA. Sanitation activities such as educating mothers about hygienic children's stool disposal, as well as improving sanitation facilities, are crucial in encouraging the hygienic disposal of children's stool. Postnatal education for mothers should include messages on the need and means to properly dispose of the diarrhoeic stools of their children. Such educational interventions should consider identifying deprived localities with special needs and involve community and religious leaders. Additional country-level research is needed to assess children's defecation behaviours and the disposal of diarrhoeic stools using different methodologies. For example, combining participatory and observational techniques with qualitative study designs may provide more thorough, accurate and ecologically valid results.

## Acknowledgements

The authors thank the MEASURE DHS project for their support and for free access to the original data.

## Author Contributions

SY conceptualised and designed the study. RPS, MAE, BOA, EB and SY acquired, analysed, interpreted the data and drafted and revised the manuscript. SY and BOA critically reviewed the manuscript. SY had the final responsibility to submit for publication. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

## Availability of Data and Materials

Data used in this study were obtained from the DHS Program and available at: <https://dhsprogram.com/data/available-datasets.cfm>.

## Consent for Publication

Not applicable.

## Ethics Approval and Consent to Participate

In this study, ethical clearance was not sought due to the public availability of the DHS dataset. The datasets were obtained from the MEASURE DHS after registration and approval were given for its usage. All the ethical guidelines concerning the use of secondary datasets in the publication were strictly adhered to. The procedures and questionnaires used for the DHS surveys are approved by the ICF Institutional Review

Board and appropriate IRBs in the survey countries. Informed consent is obtained from participants and/or their parents or guidance before data collection. Detailed information about the DHS data usage and ethical standards is available at <http://goo.gl/ny8T6X>.

## ORCID iD

Rebecca Peniel Storph  <https://orcid.org/0000-0002-6800-7837>

## REFERENCES

1. Miller-Petrie MK, Voigt L, McLennan L, Cairncross S, Jenkins MW. Infant and young child feces management and enabling products for their hygienic collection, transport, and disposal in Cambodia. *Am J Trop Med Hyg.* 2016; 94:456-465.
2. UN. *United Nations-Water Decade Programme on Advocacy and Communication and WSSCC*, in *The Human Right to Water and Sanitation*. 2012.
3. Wolf J, Prüss-Ustün A, Cumming O, et al. Systematic review: assessing the impact of drinking water and sanitation on diarrhoeal disease in low- and middle-income settings: systematic review and meta-regression. *Trop Med Int Health.* 2014;19:928-942.
4. WHO. *Fact Sheet: Drinking Water*. WHO; 2019.
5. Freeman MC, Garn JV, Sclar GD, et al. The impact of sanitation on infectious disease and nutritional status: A systematic review and meta-analysis. *Int J Hyg Environ Health.* 2017;220:928-949.
6. WHO. *Guidelines on Sanitation and Health*. World Health Organization; 2018.
7. Wolf J, Prüss-Ustün A, Cumming O, et al. Systematic review: assessing the impact of drinking water and sanitation on diarrhoeal disease in low- and middle-income settings: systematic review and meta-regression. *Trop Med Int Health.* 2014;19:928-942.
8. GBD 2017 Risk Factor Collaborators. Global, regional, and national comparative risk assessment of 84 behavioural, environmental and occupational, and metabolic risks or clusters of risks for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet.* 2018;392:1923-1994.
9. Seidu A-A, Ahinkorah BO, Kissah-Korsah K, et al. A multilevel analysis of individual and contextual factors associated with the practice of safe disposal of children's faeces in sub-Saharan Africa. *PLoS One.* 2021;16:e0254774.
10. WHO. *Fact Sheet on Sanitation*. WHO; February 20, 2020. Accessed April 7, 2023. <http://www.who.int/en/news-room/fact-sheets/detail/sanitation>
11. Walker CLF, Rudan I, Liu L, et al. Global burden of childhood pneumonia and diarrhoea. *Lancet.* 2013;381:1405-1416.
12. Boschi-Pinto C, Velebit L, Shibuya K. Estimating child mortality due to diarrhoea in developing countries. *Bull World Health Organ.* 2008;86:710-717.
13. Fischer Walker CL, Perin J, Aryee MJ, Boschi-Pinto C, Black RE. Diarrhea incidence in low- and middle-income countries in 1990 and 2010: a systematic review. *BMC Public Health.* 2012;12:220.
14. Brown J, Cairncross S, Ensink JH. Water, sanitation, hygiene and enteric infections in children. *Arch Dis Child.* 2013;98:629-634.
15. Markle A, Donnenfeld Z. *Refreshing Africa's Future: Prospects for Achieving Universal WASH Access by 2030*. Institute for Security Studies Papers. 2016;17:1-28.
16. Corinaldesi R, Stanghellini V, Barbara G, Tomassetti P, De Giorgio R. Clinical approach to diarrhea. *Intern Emerg Med.* 2012;7:255-262.
17. Uga S, et al. Parasites detected from diarrheal stool samples collected in Nepal. *Southeast Asian J Trop Med Public Health.* 2004;35:19-23.
18. Mathurin K, Martial N, Thomas K, Yao D. Molecular characterization of intestinal protozoan parasites from children facing diarrheal disease and associated risk factors in Yamoussoukro, Côte d'Ivoire. *Afr J Environ Sci Technol.* 2014;8:178-184.
19. Maçin S, Kaya F, Çağdaş D, et al. Detection of parasites in children with chronic diarrhea. *Pediatr Int.* 2016;58:531-533.
20. Harb A, Abraham S, Rusdi B, Laird T, O'Dea M, Habib I. Molecular detection and epidemiological features of selected bacterial, viral, and parasitic enteropathogens in stool specimens from children with acute diarrhea in Thi-Qar Governorate, Iraq. *Int J Environ Res Public Health.* 2019;16:1573.
21. Sinmegn Mihrete T, Asres Alemie G, Shimka Teferra A. Determinants of childhood diarrhea among under-five children in Benishangul Gumuz Regional State, North West Ethiopia. *BMC Pediatr.* 2014;14:102.
22. Bawankule R, Singh A, Kumar K, Pedgaonkar S. Disposal of children's stools and its association with childhood diarrhea in India. *BMC Public Health.* 2017;17:12-19.

23. Gil A, Lanata C, Kleinau E, Penny M. *Children's Faeces Disposal Practices in Developing Countries and Interventions to Prevent Diarrheal Diseases*. A Literature Review. Environmental Health Project. US Agency for International Development, Washington, DC, p.67.
24. Sultana R, Mondal UK, Rimi NA, et al. An improved tool for household faeces management in rural Bangladeshi communities. *Trop Med Int Health*. 2013;18:854-860.
25. Bauza V, Guest JS. The effect of young children's faeces disposal practices on child growth: evidence from 34 countries. *Trop Med Int Health*. 2017;22:1233-1248.
26. World Health Organization. *Core Questions on Drinking Water and Sanitation for Household Surveys*. World Health Organization; 2006.
27. Selar GD, Bauza V, Bisoyi A, Clasen TF, Mosler HJ. Contextual and psychosocial factors influencing caregiver safe disposal of child feces and child latrine training in rural Odisha, India. *PLoS One*. 2022;17:e0274069.
28. Aliyu AA, Dahiru T. Factors associated with safe disposal practices of child's faeces in Nigeria: evidence from 2013 Nigeria demographic and health survey. *Niger Med J*. 2019;60:198-204.
29. Beardsley R, Cronk R, Tracy W, et al. Factors associated with safe child feces disposal in Ethiopia, India, and Zambia. *Int J Hyg Environ Health*. 2021;237:113832.
30. Addis M, Worku W, Bogale L, Shimelash A, Tegegne E. Hygienic child feces disposal practice and its associated factors among mothers/caregivers of under five children in West Armachiho District, Northwest Ethiopia. *Environ Health Insights*. 2022;16:11786302221114738.
31. Nkoka O. Correlates of appropriate disposal of children's stools in Malawi: a multilevel analysis. *BMC Public Health*. 2020;20:604-610.
32. Corsi DJ, Neuman M, Finlay JE, Subramanian SV. Demographic and health surveys: a profile. *Int J Epidemiol*. 2012;41:1602-1613.
33. Aliaga A, Ruilin R. Cluster optimal sample size for demographic and health surveys. Paper presented at: 7th International Conference on Teaching Statistics-ICOTS; 2006.
34. Demissie GD, Yeshaw Y, Aleminev W, Akalu Y. Diarrhea and associated factors among under five children in sub-Saharan Africa: evidence from demographic and health surveys of 34 sub-Saharan countries. *PLoS One*. 2021;16:e0257522.
35. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The strengthening the reporting of observational studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies. *Int J Surg*. 2014;12:1495-1499.
36. World Health Organization. WHO/UNICEF Joint Water Supply, Sanitation Monitoring Programme. *Progress on sanitation and drinking water: 2015 update and MDG assessment*. World Health Organization, 2015.
37. Tetteh J, Adomako I, Udofia EA, et al. Hygienic disposal of stools and risk of diarrheal episodes among children aged under two years: Evidence from the Ghana Demographic Health Survey, 2003-2014. *PLoS One*. 2022;17:e0266681.
38. Mugel SG, Clasen TF, Bauza V. Global practices, geographic variation, and determinants of child feces disposal in 42 low- and middle-income countries: an analysis of standardized cross-sectional national surveys from 2016-2020. *Int J Hyg Environ Health*. 2022;245:114024.
39. Demissie GD, Zerihun MF, Ekubagewargies DT, et al. Associated factors of safe child feces disposal in sub-Saharan Africa: evidence from recent demographic and health surveys of 34 sub-Saharan countries. *PLoS One*. 2023;18:e0281451.
40. Ganle JK, Mahama MS, Maya E, Manu A, Torpey K, Adanu R. *Understanding factors influencing home delivery in the context of user-fee abolition in Northern Ghana: evidence from 2014 DHS*. *Int J Health Plann Manage*. 2019;34:727-743.
41. Moschovis PP, Wiens MO, Arlington L, et al. Individual, maternal and household risk factors for anaemia among young children in sub-Saharan Africa: a cross-sectional study. *BMJ Open*. 2018;8:e019654.
42. Austin PC. A tutorial on multilevel survival analysis: methods, models and applications. *Int Stat Rev*. 2017;85:185-203.
43. Gelman A, Hill J. *Data Analysis Using Regression and Multilevel/Hierarchical Models*. Cambridge University Press; 2006.
44. Aluko OO, Afolabi OT, Olaoye EA, Adebayo AD, Oyetola SO, Abegunde OO. The management of the faeces passed by under five children: an exploratory, cross-sectional research in an urban community in Southwest Nigeria. *BMC Public Health*. 2017;17:178.
45. Sahiledengle B. Prevalence and associated factors of safe and improved infant and young children stool disposal in Ethiopia: evidence from demographic and health survey. *BMC Public Health*. 2019;19:970.
46. Ekane N, Kjellén M, Westlund H, Ntakarutimana A, Mwesige D. Linking sanitation policy to service delivery in Rwanda and Uganda: from words to action. *Dev Policy Rev*. 2020;38:344-365.
47. Tsinda A, Abbott P, Chenoweth J, Mucyo S. Understanding the political economy dynamics of the water, sanitation and hygiene (WaSH) sector in Rwanda. *Int J Urban Sustain. Dev*. 2021;13:265-278.
48. Tarkka MT. *Predictors of maternal competence by first-time mothers when the child is 8 months old*. *J Adv Nurs*. 2003;41:233-240.
49. Mwambete KD, Joseph R. Knowledge and perception of mothers and caregivers on childhood diarrhoea and its management in Temeke municipality, Tanzania. *Tanzan J Health Res*. 2010;12:47-54.
50. Vong P, Banchonhattakit P, Sim S, Pall C, Dewey RS. Unhygienic stool-disposal practices among mothers of children under five in Cambodia: Evidence from a demographic and health survey. *PLoS One*. 2021;16:e0249006.
51. Sahiledengle B, Teferu Z, Tekalegn Y, et al. Geographical variation and factors associated with unsafe child stool disposal in Ethiopia: a spatial and multilevel analysis. *PLoS One*. 2021;16:e0250814.
52. Majorin F, Freeman MC, Barnard S, Routray P, Boisson S, Clasen T. Child feces disposal practices in rural Orissa: a cross sectional study. *PLoS One*. 2014;9:e89551.
53. Ritter RL, Peprah D, Null C, et al. Within-compound versus public latrine access and child feces disposal practices in Low-Income neighborhoods of Accra, Ghana. *Am J Trop Med Hyg*. 2018;98:1250-1259.
54. Azage M, Haile D. Factors associated with safe child feces disposal practices in Ethiopia: evidence from demographic and health survey. *Arch Public Health*. 2015;73:40-49.
55. Curtis V, Kanki B, Mertens T, et al. Potties, pits and pipes: explaining hygiene behaviour in Burkina Faso. *Soc Sci Med*. 1995;41:383-393.
56. Pullan RL, Freeman MC, Gething PW, Brooker SJ. Geographical inequalities in use of improved drinking water supply and sanitation across Sub-Saharan Africa: mapping and spatial analysis of cross-sectional survey data. *PLoS Med*. 2014;11:e1001626.