

RESEARCH ARTICLE

# Infant feeding practices and diarrhoea in sub-Saharan African countries with high diarrhoea mortality

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**Data Availability Statement:** The analysis used the Demographic and Health Survey (DHS) data for the countries studied. Approval to use these data was sought from Measure DHS/ICF International, and permission was granted for this use. The data can be applied for online at <https://dhsprogram.com/data/available-datasets.cfm>.

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## Abstract

### Background

The impacts of optimal infant feeding practices on diarrhoea have been documented in some developing countries, but not in countries with high diarrhoea mortality as reported by the World Health Organisation/United Nations Children's Fund. We aimed to investigate the association between infant feeding practices and diarrhoea in sub-Saharan African countries with high diarrhoea mortality.

### Method

The study used the most recent Demographic and Health Survey datasets collected in nine sub-Saharan African countries with high diarrhoea mortality, namely: Burkina Faso (2010, N = 9,733); Demographic Republic of Congo (2013; N = 10,458); Ethiopia (2013, N = 7,251); Kenya (2014, N = 14,034); Mali (2013, N = 6,365); Niger (2013, N = 7,235); Nigeria (2013, N = 18,539); Tanzania (2010, N = 5,013); and Uganda (2010, N = 4,472). Multilevel logistic regression models that adjusted for cluster and sampling weights were used to investigate the association between infant feeding practices and diarrhoea in these nine African countries.

### Results

Diarrhoea prevalence was lower among children whose mothers practiced early initiation of breastfeeding, exclusive and predominant breastfeeding. Early initiation of breastfeeding and exclusive breastfeeding were significantly associated with lower risk of diarrhoea (OR =

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0.81; 95% confidence interval (CI): 0.77–0.85,  $P < 0.001$  and OR = 0.50; 95%CI: 0.43–0.57, respectively). In contrast, introduction of complementary foods (OR = 1.31; 95%CI: 1.14–1.50) and continued breastfeeding at one year (OR = 1.27; 95%CI: 1.05–1.55) were significantly associated with a higher risk of diarrhoea.

## Conclusion

Early initiation of breastfeeding and exclusive breastfeeding are protective of diarrhoea in sub-Saharan African countries with high diarrhoea mortality. To reduce diarrhoea mortality and also achieve the health-related sustainable development goals in sub-Saharan African, an integrated, multi-agency strategic partnership within each country is needed to improve optimal infant feeding practices.

## Introduction

In the past three decades, the world has made significant improvements in child survival; however, these gains have been disproportionate between and within countries [1]. Despite significant investments in the prevention of diarrhoeal-related morbidity and mortality, diarrhoea remains one of the leading sources of under-5 mortality (U5M) worldwide, leading to more than 2,100 under-5 deaths daily [2]. Of these deaths, more than three-quarters occur in the mostly poor and less developed countries of the world [3], 42% in sub-Saharan Africa [4]. The impact of diarrhoea-related morbidity and mortality on child survival is most significant in children from developing countries because of suboptimal infant feeding practices, unimproved water and sanitation, a lack of access to vaccination, and inadequate treatment of diarrhoea [3, 5].

In recent years, an increasing number of studies have reported on the benefits of the breast milk and optimal breastfeeding practices for the mother-infant pair [6–9]. These benefits include lower risk for infectious diseases (e.g. diarrhoea) [10, 11], U5M [8], higher intelligence for the infant [11], improved family planning, and reduce risk for breast and ovarian cancers for the mother [6, 12]. Mechanisms for why breast milk is an ‘individualised medicine’ for the infant include stimulation of the infant immune system, maintenance of the microbial changes in the infant’s gastrointestinal system, and stimulation of the epigenetic programming of the infant [13–16]. Given the benefits of optimal breastfeeding to the mother-infant pair, the World Health Organisation and United Nations Children’s Fund (WHO/UNICEF) recommend the initiation of breastfeeding within the first hour of birth and exclusive breastfeeding and introduction of safe and nutritionally adequate complementary foods around the age of six months with continued breastfeeding until 2 years and beyond [17]. Optimal breastfeeding practices are feeding behaviours that are consistent with recommended infant and young child feeding practices (IYCF).

Globally, various attempts have been made to improve IYCF practices, including the International Code of Marketing of Breast milk Substitutes–The Code, the baby friendly hospital initiative–BFHI, and the Global Strategy for Infant and Young Child Feeding. Sub-Saharan Africa has one of the highest prevalence of breastfeeding at one year worldwide; however, only 37% of infants aged less than six months are exclusively breastfed [6]. Lower proportions in infant feeding practices have been reported in many sub-Saharan African countries, where diarrhoea remains a significant source of morbidity and mortality among children under-5

years [18–23]. Plausible reasons attributable to suboptimal exclusive breastfeeding practice in Africa included: lower socio-economic status [20, 23], home birthing [22], culture [20, 24], and poor implementation and monitoring of The Code [20, 25]. Most studies from sub-Saharan Africa that have examined the relationship between infant feeding practices and diarrhoea only focused on early initiation of breastfeeding, exclusive breastfeeding [26], and partial breastfeeding, and these studies were mainly conducted in African countries with lower burden of diarrhoeal mortality [26, 27]. Previously published reports, however, have suggested that other infant feeding behaviours (i.e., predominant breastfeeding, bottle feeding and introduction of solid, semi-solid and soft foods) play significant roles in contributing to the burden of diarrhoeal mortality, particularly in developing countries [28–31].

To date, no studies have investigated the association between these infant feeding practices (i.e. early initiation of breastfeeding, exclusive breastfeeding, predominant breastfeeding, bottle feeding, introduction of solid, semi-solid and soft foods and continued breastfeeding at one year) and diarrhoea in sub-Saharan Africa countries with high diarrhoea mortality using country-level data. It is important to focus on high diarrhoea mortality countries as these are the population with the one of the largest disease burden in the region, and where interventions would have maximum impacts. Thus, this study aimed to investigate the association between infant feeding practices and diarrhoea in sub-Saharan African countries, with high diarrhoea mortality. Evidence based on local data is important to provide timely, culturally-appropriate and context-specific information to advocate for targeted interventions to improve optimal infant feeding practices [31, 32].

In many sub-Saharan African countries, government expenditure as source (i.e., health care spending from the national budget) remains low, [33] despite the commitment made by various national governments to increase funding for the health care sector in the Africa continent. [34] Given this, sub-Saharan Africa receives the largest amount of developmental assistance for health worldwide. Findings from this study will not only be of interest to public health practitioners in sub-Saharan Africa, but also to the international community to assess the scope to which optimal infant feeding practices can influence diarrhoea in sub-Saharan African countries.

## Method

### Data sources

The most recent Demographic and Health Survey (DHS) data for Burkina Faso (2010, N = 9,733); Demographic Republic of Congo (2013; N = 10,458); Ethiopia (2013, 7,251); Kenya (2014, N = 14,034); Mali (2013, N = 6,365); Niger (2013, N = 7,235); Nigeria (2013, N = 18,539); Tanzania (2010, N = 5,013); and Uganda (2010, N = 4,472) were used for this analysis. These countries were selected based on a previous study and a report by the World Health Organisation/United Nations Children Fund which indicated that diarrhoea mortality was highest among these countries in the sub-Saharan African region [3, 35]. The DHS data were collected by country-specific department of health and population in collaboration with Inner City Fund (ICF) International using standardised household questionnaires. A two-stage sampling strategy was employed, where a country was divided into enumeration areas (clusters) based on the census frames in the country, and then, households were randomly selected within each cluster. The DHS datasets were housed within Measure DHS/ ICF International domain and were freely available to apply for online, with all identifier information removed. Permission to use the data was sought from Measure DHS/ ICF International, and approval was granted. Information on household demographics, maternal and child health (including infant and young child feeding practices) were obtained from eligible women aged 15–49 years who were permanent residents in each household surveyed. A total sample of

83,100 maternal responses was used for these analyses, with response rate in the surveys ranging from 96–99%. The DHS provides significant information on infant and young child feeding practices in developing countries [36]. Additional information on the data source and methodology has been described elsewhere in country-specific DHS reports [37].

Diarrhoea was the main outcome in this study, and was defined as the passage of three or more loose or liquid stool per day. Information on childhood diarrhoea was also obtained from mothers, whether each child under-5 years of age in the household had experienced diarrhoea symptoms in the 2 weeks prior to the interview. Additionally, this study restricted analyses to the youngest living child aged less than 24 months, living with respondent (woman aged 15–49 years), and measurement of diarrhoea was based on the child age group for each IYCF practices consistent with a previously published study [31].

The exposure variables were the infants and young feeding indicators (early initiation of breastfeeding, exclusive breastfeeding, predominant breastfeeding, continued breastfeeding at one year and introduction of solid, semi-solid and soft foods), assessed based on the World Health Organisation (WHO) definitions for assessing IYCF practices. [36] For this study, the selection of these indicators was based on previous reports [31, 32, 38].

**Early initiation of breastfeeding:** The proportion of children 0–23 months of age who were put to the breast within one hour of birth.

**Exclusive breastfeeding:** The proportion of infants 0–5 months of age who received breast milk as the only source of nourishment, but allowed oral rehydration solution, drops, or syrups of vitamins and medicines.

**Predominant breastfeeding:** The proportion of infants 0–5 months of age who received breast milk as the main source of nourishment, but allows water, water-based drinks, fruit juice, oral rehydration solution, drops, or syrups of vitamins and medicines.

**Continued breastfeeding at one year:** The proportion of children 12–15 months of age who were fed breast milk.

**Bottle feeding:** The proportion of infants 0–23 months of age who received any liquid (including breast milk) or semi-solid food from a bottle with nipple/teat.

**Introduction of solid, semi-solid and soft foods:** The proportion of infants 6–8 months of age who received solid, semi-solid or soft foods.

A number of potential confounding factors (categorized as socio-economic, health service, individual and household factors) were considered in the analyses based on previously published studies [31, 32]. Socio-economic factors included maternal education, household wealth and maternal employment; and health service factors comprised antenatal care visits and place of delivery. Individual factors included maternal age, child age, sex and gender; and household factors comprised place of residence (i.e. rural or urban), source of drinking water and type of toilet. These socio-economic, health services, individual and household factors varied across countries, and are described in detail in [Table 1](#).

The analyses also included a measure of sanitation (type of toilet) and source of drinking water as *a priori* effect measure modifiers to assess if the association between IYCF indicators and diarrhoea differ by levels of sanitation type and drinking water source. In the DHS, the source of water and type of sanitation for each household were obtained by asking respondents about the ‘main source of drinking water’ and the ‘type of toilet facility’ that were used by household members. The source of drinking water and type of toilet were categorised as ‘improved’ or ‘unimproved’ in this study based on the taxonomy of the World Health Organisation and United Nation Children’s Fund Joint Monitoring Programme (JMP) for Water and Sanitation [39]. ‘Improved’ sources of water were defined as a piped water into dwelling, piped water to yard/plot, public tap or standpipe, tube-well or borehole, protected dug well, protected spring or rainwater; while ‘unimproved’ water sources comprised unprotected

Table 1. Characteristics of the study population by country.

|                           | Burkina Faso |      | Congo DR |      | Ethiopia |      | Kenya |      | Mali |      | Niger |      | Nigeria |      | Tanzania |      | Uganda |      |
|---------------------------|--------------|------|----------|------|----------|------|-------|------|------|------|-------|------|---------|------|----------|------|--------|------|
|                           | N            | %    | N        | %    | N        | %    | N     | %    | N    | %    | N     | %    | N       | %    | N        | %    | N      | %    |
| <b>Socio-economic</b>     |              |      |          |      |          |      |       |      |      |      |       |      |         |      |          |      |        |      |
| Mother's employment       |              |      |          |      |          |      |       |      |      |      |       |      |         |      |          |      |        |      |
| Not working               | 1495         | 26.2 | 2305     | 33.9 | 3097     | 73.9 | 1591  | 47.0 | 2243 | 59.0 | 3957  | 80.3 | 4479    | 38.3 | 706      | 22.7 | 916    | 31.5 |
| Working                   | 4213         | 73.8 | 4491     | 66.1 | 1095     | 26.1 | 1795  | 53.0 | 1559 | 41.0 | 973   | 19.7 | 7224    | 61.7 | 2406     | 77.3 | 1993   | 68.5 |
| Mother's education        |              |      |          |      |          |      |       |      |      |      |       |      |         |      |          |      |        |      |
| No schooling              | 4750         | 83.2 | 1234     | 18.2 | 2798     | 66.7 | 809   | 11.5 | 3109 | 81.8 | 4203  | 85.3 | 5573    | 47.6 | 799      | 25.7 | 371    | 12.7 |
| Primary education         | 621          | 10.9 | 2886     | 42.5 | 1204     | 28.7 | 3845  | 54.7 | 335  | 8.8  | 474   | 9.6  | 2082    | 17.8 | 2084     | 67.0 | 1863   | 64.0 |
| Secondary or above        | 337          | 5.9  | 2677     | 39.4 | 191      | 4.5  | 2370  | 33.8 | 358  | 9.4  | 248   | 5.0  | 4057    | 34.6 | 229      | 7.4  | 679    | 23.3 |
| Household wealth          |              |      |          |      |          |      |       |      |      |      |       |      |         |      |          |      |        |      |
| Poor                      | 2379         | 41.7 | 3004     | 44.2 | 1910     | 45.6 | 3162  | 45.0 | 1599 | 40.5 | 1950  | 39.6 | 5331    | 45.5 | 1407     | 45.2 | 1289   | 44.3 |
| Middle                    | 2465         | 43.2 | 2634     | 38.8 | 1614     | 38.5 | 2482  | 35.3 | 1567 | 41.8 | 2072  | 42.0 | 4337    | 37.0 | 1256     | 40.4 | 1107   | 38.0 |
| Rich                      | 866          | 15.2 | 1159     | 17.1 | 669      | 16.0 | 1380  | 19.7 | 676  | 17.8 | 908   | 18.4 | 2044    | 17.5 | 450      | 14.5 | 517    | 17.8 |
| <b>Health service</b>     |              |      |          |      |          |      |       |      |      |      |       |      |         |      |          |      |        |      |
| Frequency of ANC visits   |              |      |          |      |          |      |       |      |      |      |       |      |         |      |          |      |        |      |
| None                      | 208          | 3.6  | 683      | 10.1 | 2373     | 56.6 | 276   | 3.9  | 954  | 25.1 | 617   | 12.5 | 4141    | 35.4 | 73       | 2.3  | 162    | 5.6  |
| 1–3                       | 3629         | 63.6 | 2927     | 43.1 | 1085     | 25.9 | 2908  | 41.4 | 1277 | 33.6 | 2655  | 53.9 | 1556    | 13.3 | 1839     | 59.1 | 1408   | 48.3 |
| 4 and above               | 1872         | 32.8 | 3185     | 46.9 | 735      | 17.5 | 3838  | 54.7 | 1571 | 41.3 | 1658  | 33.6 | 6015    | 51.4 | 1201     | 38.6 | 1343   | 46.1 |
| Place of birth            |              |      |          |      |          |      |       |      |      |      |       |      |         |      |          |      |        |      |
| Home                      | 1484         | 26.0 | 1342     | 19.8 | 3717     | 88.6 | 2425  | 34.6 | 1597 | 42.0 | 3237  | 65.7 | 7296    | 62.3 | 1528     | 49.1 | 981    | 33.7 |
| Health facility           | 4225         | 74.0 | 5453     | 80.3 | 476      | 11.4 | 4591  | 65.4 | 2205 | 58.0 | 1693  | 34.4 | 4416    | 37.7 | 1584     | 50.9 | 1931   | 66.3 |
| Postnatal clinic visits   |              |      |          |      |          |      |       |      |      |      |       |      |         |      |          |      |        |      |
| None                      | 847          | 14.8 | 3536     | 52.0 | 3825     | 91.2 | 5056  | 72.0 | 2067 | 54.4 | 2902  | 58.9 | 6815    | 58.2 | 2098     | 67.4 | 1873   | 64.3 |
| 0–2 days                  | 2210         | 38.7 | 1027     | 15.1 | 143      | 3.4  | 1150  | 16.4 | 1181 | 31.1 | 1328  | 26.9 | 3389    | 28.9 | 466      | 15.0 | 545    | 18.7 |
| 3–42 days                 | 2653         | 46.5 | 2234     | 32.9 | 225      | 5.4  | 818   | 11.6 | 554  | 14.6 | 701   | 14.2 | 1508    | 12.9 | 549      | 17.6 | 494    | 17.0 |
| <b>Individual</b>         |              |      |          |      |          |      |       |      |      |      |       |      |         |      |          |      |        |      |
| Gender                    |              |      |          |      |          |      |       |      |      |      |       |      |         |      |          |      |        |      |
| Male                      | 2894         | 50.7 | 3404     | 50.1 | 2166     | 51.7 | 3589  | 51.1 | 1924 | 50.6 | 2478  | 50.3 | 5869    | 50.1 | 1539     | 49.5 | 1448   | 49.7 |
| Female                    | 2816         | 49.3 | 3393     | 49.9 | 2027     | 48.4 | 3435  | 48.9 | 1878 | 49.4 | 2452  | 49.7 | 5843    | 49.9 | 1573     | 50.6 | 1465   | 50.3 |
| Child age (months)        |              |      |          |      |          |      |       |      |      |      |       |      |         |      |          |      |        |      |
| 0–5                       | 1504         | 26.4 | 1935     | 28.5 | 1248     | 29.8 | 1673  | 23.8 | 974  | 25.6 | 1480  | 30.0 | 2926    | 25.0 | 837      | 26.9 | 784    | 26.9 |
| 6–11                      | 1469         | 25.7 | 1747     | 25.7 | 1111     | 26.5 | 1871  | 26.6 | 1061 | 27.9 | 1279  | 25.9 | 3198    | 27.3 | 793      | 25.5 | 811    | 27.9 |
| 18–23                     | 1286         | 22.5 | 1753     | 25.8 | 1000     | 23.9 | 1892  | 26.9 | 877  | 23.1 | 1331  | 27.0 | 3306    | 28.2 | 772      | 24.8 | 680    | 23.4 |
| 12–17                     | 1451         | 25.4 | 1363     | 20.1 | 834      | 19.9 | 1589  | 22.6 | 890  | 23.4 | 841   | 17.1 | 2282    | 19.5 | 710      | 22.8 | 637    | 21.9 |
| Mother's age              |              |      |          |      |          |      |       |      |      |      |       |      |         |      |          |      |        |      |
| 15–24                     | 2005         | 35.1 | 2323     | 34.2 | 1282     | 30.6 | 2697  | 38.4 | 1267 | 33.8 | 1618  | 32.8 | 3629    | 31.0 | 1160     | 37.3 | 1120   | 38.5 |
| 25–34                     | 2586         | 45.3 | 3201     | 47.1 | 2077     | 49.5 | 3307  | 47.1 | 1840 | 48.4 | 2385  | 48.4 | 5675    | 48.5 | 1342     | 43.1 | 1281   | 44.0 |
| 35–49                     | 1118         | 19.6 | 1273     | 18.7 | 834      | 19.9 | 1020  | 14.5 | 675  | 17.8 | 927   | 18.8 | 2408    | 20.6 | 611      | 19.6 | 511    | 17.6 |
| <b>Household</b>          |              |      |          |      |          |      |       |      |      |      |       |      |         |      |          |      |        |      |
| Household location        |              |      |          |      |          |      |       |      |      |      |       |      |         |      |          |      |        |      |
| Urban                     | 982          | 17.2 | 2104     | 31.0 | 557      | 13.3 | 2456  | 35.0 | 768  | 20.2 | 677   | 13.7 | 4180    | 35.7 | 631      | 20.3 | 419    | 14.4 |
| Rural                     | 4728         | 82.8 | 4694     | 69.1 | 3635     | 86.7 | 4568  | 65.0 | 3034 | 79.8 | 4254  | 86.3 | 7533    | 64.3 | 2481     | 79.7 | 2493   | 85.6 |
| ?Type of toilet           |              |      |          |      |          |      |       |      |      |      |       |      |         |      |          |      |        |      |
| Not improved              | 4322         | 75.8 | 4220     | 62.1 | 3837     | 91.6 | 3870  | 55.6 | 2302 | 60.7 | 4045  | 82.1 | 5759    | 49.4 | 2646     | 85.4 | 994    | 39.0 |
| Improved                  | 1384         | 24.3 | 2573     | 37.9 | 354      | 8.5  | 3096  | 44.5 | 1490 | 39.3 | 880   | 17.9 | 5909    | 50.6 | 451      | 14.6 | 1463   | 61.0 |
| !Source of drinking water |              |      |          |      |          |      |       |      |      |      |       |      |         |      |          |      |        |      |
| Not improved              | 1497         | 26.2 | 4250     | 62.5 | 2332     | 55.6 | 2702  | 38.5 | 1330 | 35.0 | 1677  | 34.0 | 5098    | 43.5 | 2531     | 81.3 | 2438   | 83.7 |

(Continued)

**Table 1.** (Continued)

|          | Burkina Faso |      | Congo DR |      | Ethiopia |      | Kenya |      | Mali |      | Niger |      | Nigeria |      | Tanzania |      | Uganda |      |
|----------|--------------|------|----------|------|----------|------|-------|------|------|------|-------|------|---------|------|----------|------|--------|------|
|          | N            | %    | N        | %    | N        | %    | N     | %    | N    | %    | N     | %    | N       | %    | N        | %    | N      | %    |
| Improved | 4213         | 73.8 | 2547     | 37.5 | 1861     | 44.4 | 4322  | 61.5 | 2472 | 65.0 | 3253  | 66.0 | 6615    | 56.5 | 581      | 18.7 | 475    | 16.3 |

**<sup>1</sup>Source of drinking water:** 'Improved' source of drinking water included residences where water was piped into the dwelling/yard or plot; access to a public tap/standpipe; a tube well or borehole; protected well; protected spring; rainwater and/or bottled water. 'Not improved' water comprised access to an unprotected well; unprotected or spring; tanker truck/cart with drum; surface water; sachet water and/or other source.

**<sup>2</sup>Type of toilet:** 'Improved' type of toilet included toilets such as flush or pour flush toilets or piped to the sewer system, septic tank, pit latrine; flush/pour flush to septic tank; flush/pour flush to pit latrine; ventilated improved pit (VIP) latrine; pit latrine with slab and/or composting toilet. 'Not improved' or shared toilets comprised flush/pour flush not piped to sewer, /septic tank, or /pit latrine; pit latrine without slab/open pit; bucket or hanging toilet/hanging latrine and no facility/bush/field.

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spring, unprotected dug well, cart with small tank/drum, tanker-truck, surface water or bottled water. 'Improved' sanitation facility included a flush toilet, piped sewer system, septic tank, flush/pour flush to pit latrine, ventilated improved pit latrine (VIP), pit latrine with slab, composting toilet, and a special case (i.e., flush/pour flush of excreta to a place unknown the respondent place). 'Unimproved' sanitation facility was defined as a flush/pour flush to elsewhere (such as street, yard/plot, open sewer or a ditch), pit latrine without slab, bucket, hanging toilet or hanging latrine, shared sanitation, no facilities, bush or field.

## Statistical analysis

Initial analyses involved a series of frequency tabulations to describe frequencies (and corresponding percentages) for each of the confounding factors (i.e., socioeconomic, health service, individual and household factors) considered in the study. For the pooled analyses, the selected DHS data were combined, and a single model was used to estimate prevalence and standard errors (for calculation of 95% confidence intervals) of infant feeding indicators associated with diarrhoea using the "svy" command to adjust for sampling weights and the cluster sampling employed in the DHS.

Multilevel logistic regression models that adjusted for socio-economic, health service, individual and household factors as common causes (confounders) were used to assess the association between infant feeding practices (i.e., early initiation of breastfeeding, exclusive breastfeeding, predominant breastfeeding, continued breastfeeding at one year, introduction soli, semi-solid and soft food) and diarrhoea in the selected sub-Saharan African countries using "xlogit" command to estimate the relative risks. The modifying effect of the type of sanitation and drinking water sources on the association between infants feeding indicators and diarrhoea was also examined to determine the interaction between the type of toilet use and drinking water sources, and a given infant feeding indicator based on previous reports [31, 32]. These models were restricted to the youngest living child aged less than 24 months living with the respondent (woman aged 15–49 years) to minimise recall bias [31, 40]. All statistical analyses were conducted in STATA version 13.0 (Stata Corporation, College Station, TX, USA).

## Ethics

The DHS project obtained the required ethical approvals from the relevant research ethics committee in each country before the surveys were conducted. The ethical institutions included: Burkina Faso (Burkina Faso National Ethical Committee); Demographic Republic of Congo (Ethics Committee of the Demographic Republic of Congo Ministry of Planning); Ethiopia (National Ethics Review Committee of the Ethiopia Science and Technology Commission); Kenya (Scientific and Ethical review committee of the Kenya Medical and Research Institute); Mali (Ethical Committee of the Faculty of Medicine, Pharmacy and Odonto-stomatology, University of Bamako); Niger (National Consultative Ethics Committee of the Niger Ministry of Health); Nigeria (National Health Research Ethic Committee); Tanzania (National Health Research Ethical Committee); and Uganda (Research and Ethics Committee, Uganda National Council for Science and Technology in Uganda). Participants were informed of the rationale for the surveys, confidentiality of their responses, and that respondents did not need to answer the questions if they do not feel comfortable doing so. Written informed consents were obtained from participants before being allowed in the surveys; and data used in this study were anonymous and are available to apply for online. Measure DHS/ ICF International approved the usage of the data for this study.

## Results

From the analyses, children aged 0–23 months whose mothers engaged in early initiation of breastfeeding and exclusive breastfeeding practices had a lower prevalence of diarrhoea compared to children whose mothers did not engage in early initiation of breastfeeding and exclusive breastfeeding practices, respectively (Table 2). A similar finding was observed in children whose mothers engaged in predominant breastfeeding behaviour. In contrast, children who continued breastfeeding at the age of one year had a high prevalence of diarrhoea compared to children who had stopped breastfeeding. Among infants aged 6–8 months who were introduced to solid, semi-solid and soft foods, a higher proportion experienced diarrhoea compared to their counterparts.

**Table 2. Prevalence of infant and young child feeding (IYCF) indicators and diarrhoea among children aged 0–23 months in sub-Saharan African countries (N = 83,100).**

|  | N*     | Prevalence of IYCF indicators in sub-Saharan African countries | Prevalence of diarrhoea in sub-Saharan African countries |
|--|--------|--|--|
|  |        | % (95%LCI-UCI) (a)   | % (95%LCI-UCI) (b)                                       |
| <b>Early initiation of breast feeding</b>          |        |  |  |
| Yes  | 22,171 | 44.2 (43.3–45.1)   | 19.0 (18.2–19.8)   |
| No   | 28,023 | 55.8 (54.9–56.7)   | 20.7 (20.0–21.5)   |
| <b>Exclusive breast feeding</b>                    |        |  |  |
| Yes  | 4,577  | 29.2 (33.0–35.6)   | 7.7 (6.6–8.9)  |
| No   | 11,127 | 70.8 (69.7–72.0)   | 13.3 (12.4–14.1)   |
| <b>Predominant breast feeding</b>                  |        |  |  |
| Yes  | 4,891  | 31.1 (30.0–32.3)   | 9.6 (8.6–10.73)  |
| No   | 10,814 | 68.9 (67.7–70.0)   | 12.6(11.7,13.5)  |
| <b>Continued breast feeding at one year</b>        |        |  |  |
| Yes  | 7,583  | 83.3 (82.2–84.4)   | 25.4(24.1–26.8)  |
| No   | 1,520  | 16.7 (15.6–17.8)   | 23.2 (20.5–26.1)   |
| <b>Bottle feeding</b>                              |        |  |  |
| Yes  | 4,268  | 8.5 (8.1–9.0)  | 21.7 (20.0–23.5)   |
| No   | 45,926 | 91.5 (91.0–91.9)   | 19.78 (19.2–20.4)  |
| <b>Introduction of solid, semi-solid and softs</b> |        |  |  |
| Yes  | 4,025  | 57.6 (55.9–59.2)   | 25.1 (23.4–27.0)   |
| No   | 2,970  | 42.5 (40.8–44.1)   | 19.5 (17.7–21.4)   |

N\* = weighted total number of children within each IYCF indicators.

(a) Prevalence represents the overall weighted proportion of children for each level ('Yes', 'No') of infant and young child feeding indicators. (b) Prevalence represents the overall weighted proportion of children with diarrhoea for each level ('Yes', 'No') of infant and young child feeding indicators.

**Early initiation of breast feeding:** Children 0–23 months of age who were put to the breast within one hour of birth.

**Exclusive Breast feeding:** Infants 0–5 months of age who received breast milk as the only source of nourishment (but allows oral rehydration solution, drops or syrups of vitamins and medicines).

**Predominant breast feeding:** Infants 0–5 months of age who received breast milk as the predominant source of nourishment (but which allows water and water-based drinks fruit juice, ritual fluids, oral rehydration solution, syrups or drops of vitamins).

**Continued breast feeding at one year:** Children 12–15 months of age who were fed breast milk—this indicator includes breast feeding by a wet nurse and feeding expressed breast milk.

**Bottle feeding:** Infants 0–23 months of age who received any liquid (including breast milk) or semi-solid food from a bottle with nipple/teat.

**Introduction of solid, semi-solid and softs:** Infants 6–8 months of age who received solid, semi-solid or soft foods.

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**Table 3. Association between infant and young child feeding (IYCF) indicators and diarrhoea in sub-Saharan African countries, with high burden of diarrhoea mortality.**

| IYCF indicators                                    | Unadjusted<br>OR 95%(LCI-UCI) | P<br>value | ‡Adjusted<br>OR 95%(LCI-UCI) | P<br>value |
|--|-------------------------------|------------|------------------------------|------------|
| <b>Early initiation of breast feeding</b>          |                               |            |                              |            |
| No   | 1.00                          |            | 1.00                         |            |
| Yes  | 0.83 (0.79–0.87)              | <0.001     | 0.81 (0.77–0.85)             | <0.001     |
| <b>Exclusive breast feeding</b>                    |                               |            |                              |            |
| No   | 1.00                          |            | 1.00                         |            |
| Yes  | 0.51 (0.45–0.59)              | <0.001     | 0.50 (0.43–0.57)             | <0.001     |
| <b>Predominant breast feeding</b>                  |                               |            |                              |            |
| No   | 1.00                          |            | 1.00                         |            |
| Yes  | 1.04 (0.91–1.20)              | 0.548      | 1.05 (0.92–1.21)             | 0.476      |
| <b>Continued breast feeding at one year</b>        |                               |            |                              |            |
| No   | 1.00                          |            | 1.00                         |            |
| Yes  | 1.25 (1.05–1.50)              | 0.013      | 1.27 (1.05–1.55)             | 0.012      |
| <b>Bottle feeding</b>                              |                               |            |                              |            |
| No   | 1.00                          |            | 1.00                         |            |
| Yes  | 1.06 (0.98–1.15)              | 0.151      | 1.05 (0.97–1.15)             | 0.223      |
| <b>Introduction of solid, semi-solid and softs</b> |                               |            |                              |            |
| No   | 1.00                          |            | 1.00                         |            |
| Yes  | 1.27 (1.12–1.44)              | <0.001     | 1.31 (1.14–1.50)             | <0.001     |

‡Models adjusted for socio-economic factors (maternal education, household wealth and maternal employment); health service factors (antenatal care visit and place of birth); individual factors (maternal age, child's age and gender) and household factors (household location, source of drinking water and type of toilet).

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In the current study, infants who received breast milk within the first hour of birth were significantly less likely to experience diarrhoea in the selected sub-Saharan African countries compared to those who did not receive breast milk within one of life (Table 3). Similarly, infants aged 0–5 months who received breast milk as the only source of nourishment, but also received oral rehydration solution, drops or syrups of vitamins and medicines were significantly less likely to experience diarrhoea compared to their counterparts. Children aged 12–15 months whose mothers continued breastfeeding were significantly more likely to experience diarrhoea compared to those whose mothers had stopped breastfeeding. Additionally, infants aged 6–8 months whose mothers introduced solid, semi-solid and soft foods were significantly more likely to experience diarrhoea compared to their counterparts. A stratified analysis of the association between infants feeding practices and diarrhoea by each country varied in the analysis (S1 Files).

The analyses testing the modifying effect of sanitation (type of toilet) on the association between infant feeding practices and diarrhoea found that the impact (in terms of effect sizes) of early initiation of breastfeeding and exclusive breastfeeding on diarrhoea prevention were stronger in infants whose households had improved sanitation (Table 4). The analysis also showed that children who continued breastfeeding at one year with unimproved sanitation were more likely to experience diarrhoea compared to their counterparts. A comparable stratified analysis testing the modifying effect of drinking water sources on the association between infant feeding practices and diarrhoea found similar results, where for example, the protective effects (in terms of effect size) of early initiation of breastfeeding and exclusive breastfeeding

**Table 4. Prevalence and modifying effect of sanitation on infant and young child feeding indicators associated with diarrhoea in sub-Saharan African countries, with high burden of diarrhoea mortality.**

| IYCF indicators   | Improved Sanitation |                  |                  |         | Unimproved sanitation |                  |                  |         | P for Interaction |
|---|---------------------|------------------|------------------|---------|-----------------------|------------------|------------------|---------|-------------------|
|   | N*                  | (%) <sup>S</sup> | OR 95% (LCI-UCI) | P value | N*                    | (%) <sup>‡</sup> | OR 95% (LCI-UCI) | P value |                   |
| <b>Early initiation of breast feeding</b>               |                     |                  |                  |         |                       |                  |                  |         |                   |
| No  | 9583                | 54.5             | 1.00             |         | 18107                 | 56.7             | 1.00             |         | 0.026             |
| Yes   | 8016                | 45.6             | 0.76 (0.69–0.83) | <0.001  | 13826                 | 43.3             | 0.84 (0.79–0.89) | <0.001  |                   |
| <b>Exclusive breast feeding</b>                         |                     |                  |                  |         |                       |                  |                  |         |                   |
| No  | 3821                | 71.8             | 1.00             |         | 7198                  | 70.6             | 1.00             |         | 0.304             |
| Yes   | 1504                | 28.2             | 0.45 (0.35–0.58) | <0.001  | 2996                  | 29.4             | 0.52 (0.44–0.63) | <0.001  |                   |
| <b>Predominant breast feeding</b>                       |                     |                  |                  |         |                       |                  |                  |         |                   |
| No  | 3849                | 72.3             | 1.00             |         | 6807                  | 66.8             | 1.00             |         | <0.001            |
| Yes   | 1475                | 27.7             | 1.13 (0.88–1.45) | 0.344   | 3387                  | 33.2             | 1.02 (0.87–1.21) | 0.790   |                   |
| <b>Continued breast feeding at 1 year</b>               |                     |                  |                  |         |                       |                  |                  |         |                   |
| No  | 717                 | 22.1             | 1.00             |         | 781                   | 13.6             | 1.00             |         | 0.157             |
| Yes   | 2524                | 77.9             | 1.15 (0.86–1.53) | 0.338   | 4954                  | 86.4             | 1.32 (1.02–1.70) | 0.034   |                   |
| <b>Bottle feeding</b>                                   |                     |                  |                  |         |                       |                  |                  |         |                   |
| No  | 15369               | 87.3             | 1.00             |         | 29999                 | 93.9             | 1.00             |         | <0.001            |
| Yes   | 2230                | 12.7             | 1.03 (0.91–1.18) | 0.563   | 1935                  | 96.1             | 1.08 (0.96–1.21) | 0.205   |                   |
| <b>Introduction of solid, semi-solid and soft foods</b> |                     |                  |                  |         |                       |                  |                  |         |                   |
| No  | 1071                | 42.6             | 1.00             |         | 1883                  | 43.0             | 1.00             |         | <0.001            |
| Yes   | 1446                | 57.5             | 1.41(1.13–1.78)  | 0.003   | 2502                  | 57.1             | 1.24 (1.04–1.47) | 0.014   |                   |

N\* = total number of children aged 0–23 months with improved and unimproved sanitation.

%<sup>S</sup> = proportion of children who engaged in each feeding indicators, but also had improved sanitation.

%<sup>‡</sup> = proportion of children who engaged in each feeding indicators, but also had unimproved sanitation.

Models adjusted for socio-economic factors (maternal education, father’s education, household wealth and maternal employment); health service factors (antenatal care visit); individual factors (maternal age, child’s age and gender) and household factors (household location and source of drinking).

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on diarrhoea were stronger in infants with improved water sources compared to those with unimproved drinking water sources.

## Discussion

This study found that diarrhoea prevalence was lower among children whose mothers practiced early initiation of breastfeeding, exclusive and predominant breastfeeding. Infants who were introduced to solid, semi-solid and soft foods and those who continued breastfeeding at one year had a higher prevalence of diarrhoea compared to their counterparts. Early initiation of breastfeeding and exclusive breastfeeding were protective against diarrhoea in the selected sub-Saharan African countries, while introduction solid, semi-solid and soft foods and continued breastfeeding were risk factors for diarrhoea. In households with improved sanitary conditions, the protective effect of early initiation of breastfeeding and exclusive breastfeeding against diarrhoea were stronger.

Across various levels of development worldwide, the issue of diarrhoea is most common in the poor and less developed countries, indicating that the problem of diarrhoea is a function of many factors. These factors include: socio-economic status, culture, level of health services or capacity of the primary health care [41], a lack of appropriate health information for diarrhoea prevention, environmental conditions, and basic social amenities such as housing and potable

drinking water [42, 43]. Shortages of basic social amenities and dysfunctional health services in many communities in sub-Saharan Africa are the main drivers of diarrhoea-related morbidity and mortality. Changes in health service productivity (including appropriate IYCF messages to mothers), housing availability and affordability, and good drinking water sources, galvanised with strong political support, could substantially reduce the burden of diarrhoea in many sub-Saharan African communities. By improving opportunities for appropriate IYCF behaviours, changes in early initiation of breastfeeding, exclusive breastfeeding and introduction of safe and nutritionally adequate complementary foods can also reduce the burden of diarrhoea in sub-Saharan Africa.

The mechanisms of optimal infant feeding practices in reducing diarrhoea are well-documented [6, 13, 16]. Consistent with prior studies [31, 32, 38, 44], this study demonstrated that early initiation of breastfeeding and exclusive breastfeeding were protective against diarrhoea in sub-Saharan African countries with high diarrhoea mortality. Additionally, a lower likelihood of developing diarrhoea was also found among children who were optimally breastfed (that is, exclusively breastfed from the first hour of birth to six months) in improved sanitary environment and those whose households received improved drinking water. These findings have important operational implications for efforts to reduce diarrhoea mortality in sub-Saharan Africa. Changes in diarrhoea mortality at the population level in Africa would require initiatives in the health, environment and social sectors. In the era of the United Nations millennium development goals (MDGs), significant improvements were made in providing improved drinking water and sanitation to many communities [39]; however, less attention was given to promotion of infant feeding practices [33]. Current interventions such as the sustainable development goals (SDG 3 and 4), advocating for improved nutrition and healthy lives for all [45], and Global Nutrition Target by 2025 (for example, global target 5 –increasing the rate of exclusive breastfeeding in the first 6 months up to at least 50% by the year 2025) [46] are initiatives needed on a large scale to reduce diarrhoea mortality in resource constraint settings; but these initiatives must be streamlined with available in-country resources to maximise positive results.

Despite international commitments (i.e., the International Code of Marketing of Breast milk Substitutes–The Code, the baby friendly hospital initiative–BFHI, and the Global Strategy for Infant and Young Child Feeding) to improve infant feeding practices [17]; improvement in exclusive breastfeeding has been minimal globally (from 33% in 1995 to 37% in 2014) [47]. Poor implementation and monitoring as well as violation of The Code have been reported in many countries [48–51]. Probable reasons for these practices include: a non-legal binding nature of The Code; non-enforcement of The Code under various national laws, except amended [25]; innovative marketing strategies such as the use of internet channels, including social media [51]; and a lack of training for enforcement officers [52]. These measures have engendered the growth of infant formula marketing worldwide, with subsequent impacts on optimal infant feeding practices [53, 54]. Nonetheless, some authors have argued that rapidly increasing birth rate in developing countries is a major driver for the notable use of infant formula worldwide [55]. In countries (such as Brazil, Bangladesh and Philippines) with stricter regulatory policy framework that limit marketing of infant formula, minimal sales in infant formula have been recorded, indicating that effective regulatory measures can prevent infant formula marketing and improve infant feeding practices in developing countries [56]. Attempts to improve infant feeding practices in sub-Saharan African countries must consider the benefits of effective implementation and monitoring of The Code in the local context.

Existing evidence-based initiatives and policy responses have proven effective in improving infant feeding practices in many developing contexts [57, 58]. Facility-based interventions (such as the BFHI) have also proven to be successful in improving infant feeding practices in

many communities, with subsequent impact on diarrhoea mortality [59, 60]. These initiatives, however, have made less impact in many countries in sub-Saharan Africa region compared to developed countries for a number of reasons. These include notable home birthing [61]; myths and beliefs held for infant feeding practices; influence of grandmothers on new mothers whose infant feeding experiences are often based on traditional belief systems [24]; low socio-economic status; and a lack of appropriate health promotion messages and support for nursing mothers [20, 23]. Interventions to improve optimal infant feeding practices with subsequent impact on diarrhoea-mortality in sub-Saharan Africa should be context-specific to maximise outcomes. These strategies will also reduce the impacts of sub-optimal infant feeding practices on other adverse health outcomes for the mother-infant pairs [62].

The study found no association between predominant breastfeeding and diarrhoea in the pooled analysis, but the association varied in each country studied. Previous studies have revealed that predominant breastfeeding (i.e., infants who received breast milk as the main source of nourishment, but received water-based foods) was protective against diarrhoea, and was associated with higher intelligence [63], educational achievement [63, 64], and better income in later life [64]. In addition, empirical evidence that substantially supports exclusive breastfeeding over predominant breastfeeding is limited [65]. Some reports have argued that predominant breastfeeding is a risk factor for diarrhoea, particularly in developing countries [32, 66]. The consumption of contaminated water-based foods in addition to breast milk increases the likelihood of developing diarrhoea in communities where access to potable water and clean sanitary environment is often inadequate [67]. Putting the achievements of the MDGs in context, in relation to provision of drinking water and sanitation in Africa [39]; our study suggests that the association between predominant breastfeeding and diarrhoea vary in sub-Saharan countries, suggesting that interventions to promote infant feeding behaviours must be context-specific, and should consider the socio-economic aspects of the population.

The introduction of solid, semi-solid and soft foods (complementary foods) to infants around the age of six months is recommended because breast milk alone is no longer sufficient to meet the nutritional requirements of the infant; and continued breastfeeding until the child is two years and beyond. Our analysis showed that introduction of complementary foods and continued breastfeeding at one year were associated with higher likelihood of the child experiencing diarrhoea, consistent with previous studies [31, 32]. Evidence suggests that the incidence of diarrhoea among infants in developing countries is highest during the weaning period—a time when complementary foods are introduced to infants [68, 69]. The choice of complementary foods is usually based on the household socio-economic status, culture and infant feeding belief systems [70], presence of a key family member (grandmother) [24], and availability and affordability of local complementary foods [71–73]. Each or a combination of these factors is likely to play a significant role in contributing to onset of diarrhoea in sub-Saharan Africa. For example, a study from Nigeria found that storage, poor preparation and handling of complementary foods, and the addition of locally-sourced condiments significantly contributed to the contamination of complementary foods [74], a major source of childhood diarrhoea in developing countries [69]. Training of health professionals and non-health professionals (traditional birth attendants) on evidence-based initiatives for educating mothers and their families on appropriate infant feeding practices (e.g., complementary foods preparation and handling, and storage) is vital to reducing diarrhoea-related morbidity and mortality in sub-Saharan Africa. Such initiatives (including health promotion messages) should be selected based on the accessibility, availability and affordability of local complementary foods, and should also consider the specific socio-economic environment in which mothers raise their children to ensure sustainability.

Potential limitations of the study should be considered when interpreting the findings. We used self-reported outcome measures, a source of measurement bias. The analyses were based on cross-sectional data, which could make the establishment of a causal relationship between the exposures (infant feeding outcomes) and diarrhoea challenging. Seasonal variations has been reported to influence the incidence of diarrhoea in sub-Saharan Africa [75], and may affect the observed findings given that the NDHS data (employed in this study) were collected at different time points, geographical areas and climatic conditions. Information on the duration and severity of diarrhoea was unavailable in the NDHS dataset. This data would have provided additional information on the level of protection derived from each infant feeding practice.

The study has a number of strengths. The analyses were based on in-country nationally representative samples to ensure adequate generalisability of the study findings, and selection bias is unlikely to influence the observed results given the high response rates (96–99%). The data employed were collected using consistent standardised questionnaires, which provide an important source of information on infant feeding practices and diarrhoea in Africa. [76] This study also provides evidence on the relationship between infant feeding behaviours and diarrhoea in sub-Saharan African countries with the highest diarrhoea mortality in the region to inform context-specific initiatives.

## Conclusion

This study showed that early initiation of breastfeeding and exclusive breastfeeding were protective against diarrhoea, while introduction of solid, semi-solid and soft foods and continued breastfeeding at one year were risk factors for diarrhoea in sub-Saharan African countries with high diarrhoea mortality. There is need for an integrated, multi-agency strategic partnership at all levels within each country to ensure improvement in optimal infant feeding practices, with resultant impact on diarrhoea-related morbidity and mortality as well as achievement of the SDGs.

## Supporting information

**S1 Files.**  
(DOCX)

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## References

1. The World Bank. Disease and mortality in sub-Saharan Africa. Jamison DT, Richard GF, Malegapuru WM, Eduard RB, Florence KB, Karen JH, et al., editors. Washington, DC, USA: World Bank Publications; 2006.
2. Centers for Disease Control and Prevention. Diarrhea: Common Illness, Global Killer Online: Centers for Disease Control and Prevention; 2016 [cited 2016 September 7]. Available from: <http://www.cdc.gov/healthywater/global/diarrhea-burden.html>.
3. UNICEF, WHO. Pneumonia and diarrhoea: Tackling the deadliest diseases for the world's poorest children. New York, USA: UNICEF, 2012.
4. UNICEF/WHO. Diarrhoea: why children are still dying and what can be done. New York, USA: UNICEF/WHO, 2010.
5. Ahs JW, Tao W., Löfgren J, Forsberg Birger C. Diarrheal diseases in low-and middle-income countries: incidence, prevention and management. *Open Infectious Diseases Journal*. 2010; 4(1):113–24.
6. Victora CG, Bahl R, Barros AJ, França GV, Horton S, Krasevec J, et al. Breastfeeding in the 21st century: epidemiology, mechanisms, and lifelong effect. *The Lancet*. 2016; 387(10017):475–90.
7. Black R, Allan LH, Bhutta ZA, Caulfield LE, de Onis M, Ezzati M, et al. The Maternal and Child Undernutrition Study Group: Maternal and child undernutrition: global and regional exposures and health consequences. *Lancet* 2008; 371:243–60. doi: [10.1016/S0140-6736\(07\)61690-0](https://doi.org/10.1016/S0140-6736(07)61690-0) PMID: [18207566](https://pubmed.ncbi.nlm.nih.gov/18207566/)
8. Edmond KM, Zandoh C., Quigley M. A., Amenga-Etego S., Owusu-Agyei S., Kirkwood BR. Delayed breastfeeding initiation increases risk of neonatal mortality. *Pediatrics*. 2006; 117(3):380–6.
9. Lamberti LM, Walker C, Fischer L, Noiman A, Victora C, Black RE. Breastfeeding and the risk for diarrhea morbidity and mortality. *BMC public health*. 2011; 11(Suppl 3):S15.
10. Sankar MJ, Sinha B, Chowdhury R, Bhandari N, Taneja S, Martines J, et al. Optimal breastfeeding practices and infant and child mortality: a systematic review and meta-analysis. *Acta paediatrica*. 2015; 104(S467):3–13.
11. World Health Organisation. Short-term effects of breastfeeding: a systematic review of the benefits of breastfeeding on diarrhoea and pneumonia mortality Geneva, Switzerland: WHO, 2013.
12. Horta B, Bahl R, Martines JC, Victora CG. Evidence on the long-term effects of breastfeeding: systematic review and meta-analysis. *World Health Organisation* 2013:1–57.
13. Mickleson K, Moriarty K. Immunoglobulin levels in human colostrum and milk. *Journal of pediatric gastroenterology and nutrition*. 1982; 1(3):381–4. PMID: [7186050](https://pubmed.ncbi.nlm.nih.gov/7186050/)
14. Yatsunenkov T, Rey FE, Manary MJ, Trehan I, Dominguez-Bello MG, Contreras M, et al. Human gut microbiome viewed across age and geography. *Nature*. 2012; 486(7402):222–7. doi: [10.1038/nature11053](https://doi.org/10.1038/nature11053) PMID: [22699611](https://pubmed.ncbi.nlm.nih.gov/22699611/)
15. Azad MB, Konya T, Maughan H, Guttman DS, Field CJ, Chari RS, et al. Gut microbiota of healthy Canadian infants: profiles by mode of delivery and infant diet at 4 months. *Canadian Medical Association Journal*. 2013; 185(5):385–94. doi: [10.1503/cmaj.121189](https://doi.org/10.1503/cmaj.121189) PMID: [23401405](https://pubmed.ncbi.nlm.nih.gov/23401405/)
16. Verduci E, Banderali G, Barberi S, Radaelli G, Lops A, Betti F, et al. Epigenetic effects of human breast milk. *Nutrients*. 2014; 6(4):1711–24. doi: [10.3390/nu6041711](https://doi.org/10.3390/nu6041711) PMID: [24763114](https://pubmed.ncbi.nlm.nih.gov/24763114/)
17. World Health Organisation. The Global Strategy for Infant and Young Child Feeding. Geneva: WHO, 2003.

18. Cai X, Wardlaw T, Brown DW. Global trends in exclusive breastfeeding. *International breastfeeding journal*. 2012; 7(12):1–5.
19. Ogbo FA, Page A, Idoko J, Claudio F, Agho KE. Trends in complementary feeding indicators in Nigeria, 2003–2013. *BMJ Open*. 2015; 5(10):e008467. doi: [10.1136/bmjopen-2015-008467](https://doi.org/10.1136/bmjopen-2015-008467) PMID: [26443657](https://pubmed.ncbi.nlm.nih.gov/26443657/)
20. Ogbo FA, Page A, Agho KE, Claudio F. Determinants of trends in breast-feeding indicators in Nigeria, 1999–2013. *Public Health Nutrition*. 2015; 18:3287–99. doi: [10.1017/S136898001500052X](https://doi.org/10.1017/S136898001500052X) PMID: [25784191](https://pubmed.ncbi.nlm.nih.gov/25784191/)
21. Issaka AI, Agho KE, Page AN, L Burns P, Stevens GJ, Dibley MJ. Determinants of suboptimal complementary feeding practices among children aged 6–23 months in seven francophone West African countries. *Maternal & child nutrition*. 2015; 11(S1):31–52.
22. Ogbo FA, Agho KE, Page A. Determinants of suboptimal breastfeeding practices in Nigeria: evidence from the 2008 demographic and health survey. *BMC Public Health*. 2015; 15:259. doi: [10.1186/s12889-015-1595-7](https://doi.org/10.1186/s12889-015-1595-7) PMID: [25849731](https://pubmed.ncbi.nlm.nih.gov/25849731/)
23. Victor R, Baines SK, Agho KE, Dibley MJ. Determinants of breastfeeding indicators among children less than 24 months of age in Tanzania: a secondary analysis of the 2010 Tanzania Demographic and Health Survey. *BMJ Open* 2013; 3(1):e001529. doi: [10.1136/bmjopen-2012-001529](https://doi.org/10.1136/bmjopen-2012-001529) PMID: [23299109](https://pubmed.ncbi.nlm.nih.gov/23299109/)
24. Bezner KR, Laifolo D, Shumba Lizzie, Msachi Rodgers, Chirwa M. “We grandmothers know plenty”: breastfeeding, complementary feeding and the multifaceted role of grandmothers in Malawi. *Social Science & Medicine*. 2008; 66(5):1095–105.
25. World Health Organization. Country implementation of the international code of marketing of breast-milk substitutes: status report 2011. Geneva: WHO, 2013 (revised) 9241505982.
26. Arifeen S, Black RE, Antelman G, Baqui A, Caulfield L, Becker S. Exclusive breastfeeding reduces acute respiratory infection and diarrhea deaths among infants in Dhaka slums. *Pediatrics*. 2001; 108(4):e67–e. PMID: [11581475](https://pubmed.ncbi.nlm.nih.gov/11581475/)
27. Lamberti LM, Walker CLF, Noiman A, Victora C, Black RE. Breastfeeding and the risk for diarrhea morbidity and mortality. *BMC public health*. 2011; 11(3):1.
28. Oni G. Infant feeding practices, socio-economic conditions and diarrhoeal disease in a traditional area of urban Ilorin, Nigeria. *East African medical journal*. 1996; 73(5):283–8. PMID: [8756027](https://pubmed.ncbi.nlm.nih.gov/8756027/)
29. Bahl R, Frost C, Kirkwood BR, Edmond K, Martines J, Bhandari N, et al. Infant feeding patterns and risks of death and hospitalization in the first half of infancy: multicentre cohort study. *Bulletin of the World Health Organization*. 2005; 83(6):418–26. PMID: [15976892](https://pubmed.ncbi.nlm.nih.gov/15976892/)
30. Mhrshahi S, Oddy WH, Peat JK, Kabir I. Association between infant feeding patterns and diarrhoeal and respiratory illness: a cohort study in Chittagong, Bangladesh. *International breastfeeding journal*. 2008; 3(1):1.
31. Ogbo FA, Page A, Idoko J, Claudio F, Agho KE. Diarrhoea and Suboptimal Feeding Practices in Nigeria: Evidence from the National Household Surveys. *Paediatric and Perinatal Epidemiology*. 2016; 30:346–55. doi: [10.1111/ppe.12293](https://doi.org/10.1111/ppe.12293) PMID: [27009844](https://pubmed.ncbi.nlm.nih.gov/27009844/)
32. Hajeebhoy N, Nguyen H, Mannava P, Nguyen TT, Tran ML. Suboptimal breastfeeding practices are associated with infant illness in Vietnam. *Int Breastfeed J*. 2014; 9:12. doi: [10.1186/1746-4358-9-12](https://doi.org/10.1186/1746-4358-9-12) PMID: [25097662](https://pubmed.ncbi.nlm.nih.gov/25097662/)
33. Institute for Health Metrics and Evaluation. Financing Global Health 2015: Development assistance steady on the path to new Global Goals. Seattle, WA: USA: Institute for Health Metrics and Evaluation (IHME). 2016.
34. World Health Organization. The Abuja Declaration: ten years on. Geneva, Switzerland: WHO, 2011.
35. Boschi-Pinto C, Velebit L, Shibuya K. Estimating child mortality due to diarrhoea in developing countries. *Bulletin of the World Health Organization*. 2008; 86(9):710–7. doi: [10.2471/BLT.07.050054](https://doi.org/10.2471/BLT.07.050054) PMID: [18797647](https://pubmed.ncbi.nlm.nih.gov/18797647/)
36. WHO., UNICEF, USAID., FANTA., AED., UC., et al. Indicators for assessing infant and young child feeding practices I. Geneva, Switzerland: World Health Organization, 2008.
37. The Demographic and Health Survey Program. Publications by country Online2016. Available from: <https://dhsprogram.com/Publications/Publications-by-Country.cfm>.
38. Mhrshahi S, Oddy Wendy H., Peat Jennifer K, Kabir I. Association between infant feeding patterns and diarrhoeal and respiratory illness: a cohort study in Chittagong, Bangladesh. *Int Breastfeed J*. 2008; 3(1):23–8.
39. Unicef, World Health Organization. Progress on sanitation and drinking water—2015 update and MDG assessment. Geneva, Switzerland: World Health Organization, 2015 9241507241.
40. Agho K, Dibley M, Odiase J, Ogbonmwan S. Determinants of exclusive breastfeeding in Nigeria. *BMC pregnancy and childbirth*. 2011; 11(1):2.

41. Ziyane IS. The relationship between infant feeding practices and diarrhoeal infections. *Journal of advanced nursing*. 1999; 29(3):721–6. PMID: [10210471](#)
42. Tambe AB, Nzefa LD, Nicoline NA. Childhood Diarrhea Determinants in Sub-Saharan Africa: A Cross Sectional Study of Tiko-Cameroon. *Challenges*. 2015; 6(2):229–43.
43. Godana W, Mengistie B. Determinants of acute diarrhoea among children under five years of age in Derashe District, Southern Ethiopia. *Rural Remote Health*. 2013; 13(2329):10.
44. Arifeen S, Black Robert E., Antelman Gretchen, Baqui Abdullah, Caulfield Laura, Becker S. Exclusive breastfeeding reduces acute respiratory infection and diarrhea deaths among infants in Dhaka slums. *Pediatrics*. 2001; 108(4):e67–e. PMID: [11581475](#)
45. United Nations. Sustainable development goals: United Nations; 2016 [cited 2016 15 March]. Available from: <http://www.un.org/sustainabledevelopment/sustainable-development-goals/>.
46. World Health Organisation. Global nutrition targets 2025: policy brief series (WHO/NMH/NHD/14.2). Geneva: World Health Organisation, 2014.
47. World Health Organization. World Health Statistics—2014. Geneva World Health Organization 2014.
48. Taylor A. Violations of the international code of marketing of breast milk substitutes: prevalence in four countries. *BMJ*. 1998; 316(7138):1117–22. PMID: [9552947](#)
49. Aguayo VM, Ross JS, Kanon S, Ouedraogo AN. Monitoring compliance with the International Code of Marketing of Breastmilk Substitutes in west Africa: multisite cross sectional survey in Togo and Burkina Faso. *BMJ*. 2003; 326(7381):127. PMID: [12531842](#)
50. Liu A, Dai Y, Xie X, Chen L. Implementation of International Code of Marketing Breast-Milk Substitutes in China. *Breastfeeding Medicine*. 2014; 9(9):467–72. doi: [10.1089/bfm.2014.0053](#) PMID: [25026262](#)
51. Abrahams SW. Milk and social media online communities and the International Code of Marketing of Breast-milk Substitutes. *Journal of Human Lactation*. 2012; 28(3):400–6. doi: [10.1177/0890334412447080](#) PMID: [22674963](#)
52. Federal Ministry of Health—Nigeria. The World Breastfeeding Trends Initiative (WBTi)—Nigeria Abuja, Nigeria: Federal Ministry of Health, 2015.
53. Baker P, Smith J, Salmon L, Friel S, Kent G, Iellamo A, et al. Global trends and patterns of commercial milk-based formula sales: is an unprecedented infant and young child feeding transition underway? *Public health nutrition*. 2016:1–11.
54. Kent G. Global infant formula: monitoring and regulating the impacts to protect human health. *International breastfeeding journal*. 2015; 10(1):1.
55. Future Market Insights. Infant Formula Market—Rapidly Increasing Birth Rate in Developing Countries is a Key Factor Driving Revenue Growth: Global Industry Analysis and Opportunity Assessment, 2016–2026 Online: Future Market Insights; 2016 [cited 2016 19 October]. Available from: <http://www.futuremarketinsights.com/reports/infant-formula-market>.
56. Save the Children. Breastfeeding: Policy Matters. Identifying Strategies to Effectively Influence Political Commitment to Breastfeeding: A Review of Six Country Case Studies. London, UK: Save the Children 2015.
57. Quinn VJ, Guyon AB, Schubert JW, Stone-Jiménez M, Hainsworth MD, Martin LH. Improving breastfeeding practices on a broad scale at the community level: success stories from Africa and Latin America. *Journal of human lactation*. 2005; 21(3):345–54. doi: [10.1177/0890334405278383](#) PMID: [16113023](#)
58. UNICEF. Consolidated report of six-country review of breastfeeding programmes. New York: UNICEF. 2010.
59. Philipp BL, Merewood A, Miller LW, Chawla N, Murphy-Smith MM, Gomes JS, et al. Baby-friendly hospital initiative improves breastfeeding initiation rates in a US hospital setting. *Pediatrics*. 2001; 108(3):677–81. PMID: [11533335](#)
60. Abrahams SW, Labbok MH. Exploring the impact of the Baby-Friendly Hospital Initiative on trends in exclusive breastfeeding. *International Breastfeeding Journal*. 2009; 4(1):1.
61. Moyer CA, Mustafa A. Drivers and deterrents of facility delivery in sub-Saharan Africa: a systematic review. *Reproductive health*. 2013; 10(1):1.
62. Horta BL, Loret de Mola C, Victora CG. Long-term consequences of breastfeeding on cholesterol, obesity, systolic blood pressure and type 2 diabetes: a systematic review and meta-analysis. *Acta Paediatrica*. 2015; 104(S467):30–7.
63. Victora CG, Barros FC, Horta BL, Lima RC. Breastfeeding and school achievement in Brazilian adolescents. *Acta Paediatrica*. 2005; 94(11):1656–60. doi: [10.1080/08035250500252658](#) PMID: [16303706](#)
64. Victora CG, Horta BL, de Mola CL, Quevedo L, Pinheiro RT, Gigante DP, et al. Association between breastfeeding and intelligence, educational attainment, and income at 30 years of age: a prospective



- birth cohort study from Brazil. *The Lancet Global Health*. 2015; 3(4):e199–e205. doi: [10.1016/S2214-109X\(15\)70002-1](https://doi.org/10.1016/S2214-109X(15)70002-1) PMID: [25794674](https://pubmed.ncbi.nlm.nih.gov/25794674/)
65. Rajiv B, Frost Chris, Kirkwood Betty R., Edmon, Karen, Martines Jose, Bhandari Nita, Arthur P. Infant feeding patterns and risks of death and hospitalization in the first half of infancy: multicentre cohort study. *Bulletin of the World Health Organization*. 2005; 83(6):418–26. PMID: [15976892](https://pubmed.ncbi.nlm.nih.gov/15976892/)
  66. World Health Organization. *Indicators for Assessing Breastfeeding Practices*. Geneva: World Health Organization, 1991.
  67. Fuller JA, Westphal JA, Kenney B, Eisenberg JN. The joint effects of water and sanitation on diarrhoeal disease: a multicountry analysis of the Demographic and Health Surveys. *Tropical Medicine & International Health*. 2015; 20(3):284–92.
  68. Sheth M, Dwivedi R. Complementary foods associated diarrhea. *The Indian Journal of Pediatrics*. 2006; 73(1):61–4. PMID: [16444063](https://pubmed.ncbi.nlm.nih.gov/16444063/)
  69. Käferstein F. Food safety: the fourth pillar in the strategy to prevent infant diarrhoea. *Bulletin of the World Health Organization*. 2003; 81(11):842–3. PMID: [14758413](https://pubmed.ncbi.nlm.nih.gov/14758413/)
  70. Agunbiade OM, Ogunleye OV. Constraints to exclusive breastfeeding practice among breastfeeding mothers in Southwest Nigeria: implications for scaling up. *International Breastfeeding Journal*. 2012; 7:5. doi: [10.1186/1746-4358-7-5](https://doi.org/10.1186/1746-4358-7-5) PMID: [22524566](https://pubmed.ncbi.nlm.nih.gov/22524566/)
  71. Anigo KM, Ameh D. A., Ibrahim S, Danbauchi S. Nutrient composition of commonly used complementary foods in North western Nigeria. *African Journal of Biotechnology*. 2009; 8(17).
  72. Gibson R, Ferguson E, Lehrfeld J. Complementary foods for infant feeding in developing countries: their nutrient adequacy and improvement. *European Journal of Clinical Nutrition*. 1998; 52(10):764–70. PMID: [9805226](https://pubmed.ncbi.nlm.nih.gov/9805226/)
  73. Onofiok N, Nnanyelugo D. Weaning foods in West Africa: Nutritional problems and possible solutions. *Food and Nutrition Bulletin*. 1998; 19(1):27–33.
  74. Ehiri JE, Azubuike MC, Ubbaonu CN, Anyanwu EC, Ibe KM, Ogbonna MO. Critical control points of complementary food preparation and handling in eastern Nigeria. *Bulletin of the World Health Organization*. 2001; 79(5):423–33. PMID: [11417038](https://pubmed.ncbi.nlm.nih.gov/11417038/)
  75. Bandyopadhyay S, Kanji Shireen, Wang L. The impact of rainfall and temperature variation on diarrheal prevalence in Sub-Saharan Africa. *Applied Geography*. 2012; 33:63–72.
  76. WHO, UNICEF, USAID, FANTA, AED, UC, et al. *Indicators for assessing infant and young child feeding practices part 2*. Geneva, Switzerland: World Health Organization, 2008.