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Influence of Parental Knowledge and Attitudes on Infant Feeding Practices: A Cross-Sectional Study

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Abstract: ***Background:*** Infant feeding practices significantly impact early childhood nutrition and long-term health. Parental knowledge and attitudes are crucial in shaping these practices, yet gaps persist globally. This study explores their influence to identify barriers and promote optimal feeding, aligning with WHO guidelines to improve child health outcomes and reduce malnutrition-related disorders. ***Objective:*** To examine parental knowledge and attitudes' impact on infant feeding practices, identifying factors influencing optimal nutrition and health outcomes. ***Method and Materials:*** A cross-sectional study was conducted at 250 Bedded District Sadar Hospital, Sherpur, from May 2023 to April 2024. Data from 820 parents were collected via structured interviews. Inclusion criteria: parents of infants aged 0–24 months. Statistical analysis included descriptive and inferential methods. Ethical approval and informed consent were obtained, ensuring confidentiality and voluntary participation. ***Result:*** The study included 820 infants: 37.8% aged 29-180 days, 30.5% aged 8-28 days, 17.1% over 180 days, and 14.6% aged 0-7 days. Males constituted 53.0%, and 57.6% were first-born. Among parents, 52.4% of mothers were aged 21-30, and 57.3% of fathers were 26-35. Most families (41.5%) earned <10,000 BDT monthly, and 70.7% resided in rural areas. Early breastfeeding initiation was 63.4%, and 79.3% received colostrum. Exclusive breastfeeding was 63.4%, while 24.4% practiced mixed feeding. ***Conclusion:*** This study highlights the importance of parental knowledge and attitudes in infant feeding, emphasizing the need for targeted interventions to improve practices.

Keywords: Infant Feeding Practices, Parental Knowledge, Parental Attitudes, Breastfeeding Initiation, Colostrum Feeding.

Original Research Article

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Article at a glance:

Study Purpose: *To assess how parental knowledge and attitudes influence infant feeding practices.*
Key findings: *63.4% of infants were exclusively breastfed, and 79.3% received colostrum. Economic and rural barriers were noted.*
Newer findings: *Emphasizes the need for targeted educational interventions to improve breastfeeding practices in rural areas.*
Abbreviations: *EBF - Exclusive Breastfeeding, WHO - World Health Organization,*

INTRODUCTION

Infant feeding practices are critical determinants of early childhood nutrition, growth, and long-term health outcomes. The World Health Organization (WHO) recommends exclusive breastfeeding for the first six months of life, followed by the introduction of complementary foods while continuing breastfeeding up to two years or beyond.[1] However, adherence to these guidelines varies widely across populations, influenced by socio-cultural, economic, and parental factors.[2] Among these, parental knowledge and attitudes play a pivotal role in shaping infant feeding practices, yet their influence remains underexplored in many settings.[3] Parental knowledge about infant nutrition and feeding guidelines is a cornerstone for ensuring optimal feeding practices. Studies have shown that parents with adequate knowledge are more likely to initiate and sustain exclusive breastfeeding and introduce

complementary foods at the appropriate time.[4] Conversely, misconceptions or lack of awareness can lead to suboptimal practices, such as early introduction of solid foods or reliance on formula feeding.[5] Attitudes, including cultural beliefs, perceptions of infant hunger, and confidence in breastfeeding, further modulate these practices.[6] For instance, cultural norms that prioritize formula feeding as a symbol of modernity can undermine breastfeeding efforts.[7] The interplay between parental knowledge and attitudes is complex and context-specific. In low- and middle-income countries, limited access to healthcare resources exacerbates gaps in knowledge, while in high-income countries, conflicting information from media and healthcare providers can create confusion.[8] Additionally, maternal education, socioeconomic status, and support systems significantly influence parental decision-making regarding infant feeding.[9] Understanding these dynamics is essential for designing targeted interventions to improve infant feeding practices and, consequently, child health outcomes.[10] This cross-sectional study aims to explore the influence of parental knowledge and attitudes on infant feeding practices in a diverse population. By identifying key knowledge gaps and attitudinal barriers, this research seeks to inform public health strategies that promote evidence-based infant feeding practices.[11] The findings will contribute to the growing body of literature on early childhood nutrition and provide actionable insights for policymakers and healthcare providers.[12] Given the global burden of malnutrition and its long-term consequences, addressing parental knowledge and attitudes is a critical step toward achieving sustainable development goals related to child health.[13] This study aligns with the WHO's global nutrition targets and underscores the importance of parental education in improving infant feeding practices.[14] By bridging the gap between knowledge and practice, this research aims to foster healthier generations and reduce the prevalence of nutrition-related disorders in early childhood.[15]

OBJECTIVE

General Objective

The general objective of this study is to examine the influence of parental knowledge and attitudes on infant feeding practices in a selected population, with the aim of identifying key factors that promote or hinder optimal infant nutrition and health outcomes.

Specific Objectives

To assess the demographic characteristics of infants and their parents, including age, sex, birth order, parental education, occupation, and socio-economic status.

To evaluate the timing of breastfeeding initiation and the prevalence of colostrum feeding among infants.

To identify the types and prevalence of prelacteal feeding practices and their association with parental knowledge and attitudes.

METHOD AND MATERIALS

Study Design

This study is a cross-sectional observational study conducted in the Department of Pediatrics at the 250 Bedded District Sadar Hospital, Sherpur. The study was carried out over a period of one year, from May 2023 to April 2024. The study population consisted of 820 parents of infants who attended the pediatric outpatient and inpatient departments during the study period.

Sampling Formula: The sample size for this study was calculated using the following formula:

$$n = \frac{Z^2 \times p \times (1-p)}{d^2}$$

Where:

n = required sample size

Z = standard normal deviation corresponding to the desired confidence level (for 95% confidence, Z=1.96)

p = estimated prevalence (proportion) of the characteristic of interest (e.g., appropriate infant feeding practices)

1−p = proportion of the population without the characteristic

d = margin of error (typically 0.05 for 5%).

Data Collection Procedure

Data were collected through structured face-to-face interviews using a pre-tested, validated questionnaire. The questionnaire covered socio-demographic characteristics, parental knowledge about infant nutrition, attitudes toward different feeding practices, and the actual feeding practices adopted. Both mothers and fathers were encouraged to participate in the study. In cases where only one parent was available, their

responses were recorded. Data on the infants' current dietary habits were also collected through direct parental reporting and cross-verified with available medical records when possible.

Inclusion Criteria

The study included parents of infants aged 0–24 months who attended the pediatric department for routine visits or minor health concerns. Participation was voluntary, and only those who provided informed consent were enrolled. These criteria ensured the inclusion of a representative sample of caregivers involved in day-to-day infant feeding decisions.

Exclusion Criteria

Exclusion criteria comprised parents of infants with severe congenital anomalies or chronic illnesses that could affect feeding practices, as well as those under exclusive medical dietary management. Additionally, parents who declined participation or did not provide informed consent were excluded from the study.

Statistical Analysis

Data were entered into a statistical software package and analyzed using descriptive and inferential statistics. Frequencies and percentages were calculated for categorical variables, while means and standard deviations were used for continuous variables. The chi-square test was applied to assess associations between parental knowledge, attitudes, and feeding practices. Logistic regression was performed to identify independent predictors of appropriate feeding practices. A p-value of <0.05 was considered statistically significant.

Ethical Consideration

Ethical approval was obtained from the ethical review board of the 250 Bedded District Sadar Hospital, Sherpur. Written informed consent was obtained from all participants before data collection, and confidentiality of the participants' information was strictly maintained. Participants were informed about the study's objectives, and they had the right to withdraw at any time without any consequences for their medical care.

RESULTS

Table 1: Demographic Characteristics of Infants (N=820)

Variables	Frequency (n)	Percentage (%)
Infant Age (Days)		
0-7 days	120	14.6%
8-28 days	250	30.5%
29-180 days	310	37.8%
>180 days	140	17.1%
Sex		
Male	435	53.0%
Female	385	47.0%
Birth Order		
1st born	472	57.6%
Subsequent child	348	42.4%

Table 1 presents the demographic characteristics of 820 infants, categorized by age, sex, and birth order. The majority of infants (37.8%) were between 29-180 days old, while 30.5% were 8-28 days old, 17.1% were over 180 days old, and 14.6% were 0-7 days old. In terms of sex, 53.0% were male and 47.0% were female. Regarding birth order, 57.6% of the infants were first-born, while 42.4% were subsequent children.

Table 2: Parental Demographic Information

Variables	Frequency (n)	Percentage (%)
Maternal Age (years)		
≤20	280	34.1%
21-30	430	52.4%
>30	110	13.4%
Maternal Occupation		
Housewife	670	81.7%
Service holder	150	18.3%
Maternal Education		
None	200	24.4%
Primary	380	46.3%
Secondary or above	240	29.3%
Paternal Age (years)		
≤25	230	28.0%
26-35	470	57.3%
>35	120	14.7%
Paternal Occupation		
Farmer	320	39.0%
Service holder	210	25.6%
Business	150	18.3%
Day laborer	100	12.2%
Others	40	4.9%
Paternal Education		
None	150	18.3%
Primary	370	45.1%
Secondary or above	300	36.6%

Table 2 provides demographic information about the parents of the infants in the study (N=820). The majority of mothers (52.4%) were aged 21-30 years, while 34.1% were ≤20 years and 13.4% were >30 years. Most mothers were housewives (81.7%), and 46.3% had primary education, followed by 29.3% with secondary or higher education. For fathers, 57.3% were aged 26-35 years, 28.0% were ≤25 years, and 14.7% were >35 years. The most common paternal occupations were farming (39.0%) and service holding (25.6%). In terms of education, 45.1% of fathers had primary education, while 36.6% had secondary or higher education.

Table 3: Socio-Economic Status and Residence

Variables	Frequency (n)	Percentage (%)
Total Family Income (BDT)		
<10,000	340	41.5%
10,000-20,000	320	39.0%
>20,000	160	19.5%
Residence		
Rural	580	70.7%
Urban	240	29.3%

Table 3 outlines the socio-economic status and residence of the study population (N=820). A significant proportion of families (41.5%) had a total monthly income of less than 10,000 BDT, while 39.0% earned between 10,000-20,000 BDT, and only 19.5% had an income exceeding 20,000 BDT. In terms of residence, the majority of participants (70.7%) lived in rural areas, compared to 29.3% who resided in urban areas.

Table 4: Initiation of Breastfeeding after Birth

Initiation Timing	Frequency (n)	Percentage (%)
Within 1 hour	520	63.4%
After 1 hour	300	36.6%

Table 4 presents data on the timing of breastfeeding initiation after birth among the study population (N=820). The majority of infants (63.4%) were breastfed within the first hour after birth, which is in line with recommended practices for early initiation of breastfeeding. However, a significant proportion (36.6%) experienced delayed initiation, starting breastfeeding after the first hour.

Table 5: Colostrum Feeding Status

Colostrum Feeding	Frequency (n)	Percentage (%)
Given	650	79.3%
Not given	170	20.7%

Table 5 presents the distribution of colostrum feeding practices among the study participants. Out of the total 820 parents surveyed, a majority (650 parents, 79.3%) reported that they had given colostrum to their infants. In contrast, 170 parents (20.7%) indicated that colostrum was not given

Table 6: Prel Acteal Feeding Practices

Prel Acteal Feeding	Frequency (n)	Percentage (%)
Given	280	34.1%
Not given	540	65.9%

Table 6 provides information on colostrum feeding practices among the study population (N=820). The majority of infants (79.3%) were given colostrum, the nutrient-rich first milk produced after birth, which is crucial for early immunity and nutrition. However, a notable proportion (20.7%) did not receive colostrum, indicating potential gaps in awareness or cultural practices that may hinder optimal infant feeding.

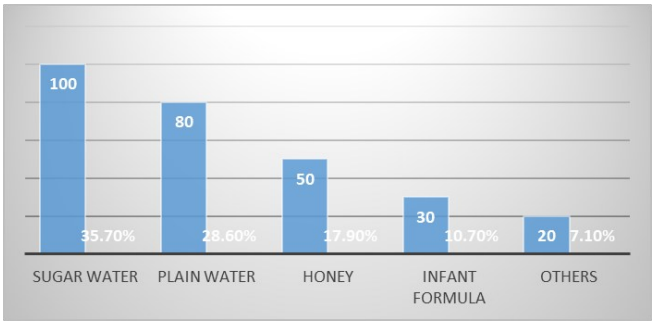

Figure 1: Types of Prelacteal Food Given (n=280)

Figure 1 outlines the types of prelacteal foods given to infants (n=280) before the initiation of breastfeeding. The most common prelacteal food was sugar water, given to 35.7% of infants, followed by plain water (28.6%) and honey (17.9%). Infant formula accounted for 10.7%, while other unspecified foods made up 7.1% of cases.

Table 7: Current Diet of the Infant

Current Diet	Frequency (n)	Percentage (%)
Exclusive Breastfeeding	520	63.4%
Mixed Feeding	200	24.4%
Infant Formula	100	12.2%

Table 7 presents the distribution of infants based on their current diet. The majority of infants (63.4%) are exclusively breastfed, highlighting the preference for and adherence to exclusive breastfeeding practices. Mixed feeding, which includes both breast milk and other supplementary foods, accounts for 24.4% of the infants. Meanwhile, 12.2% of the infants are fed exclusively with infant formula.

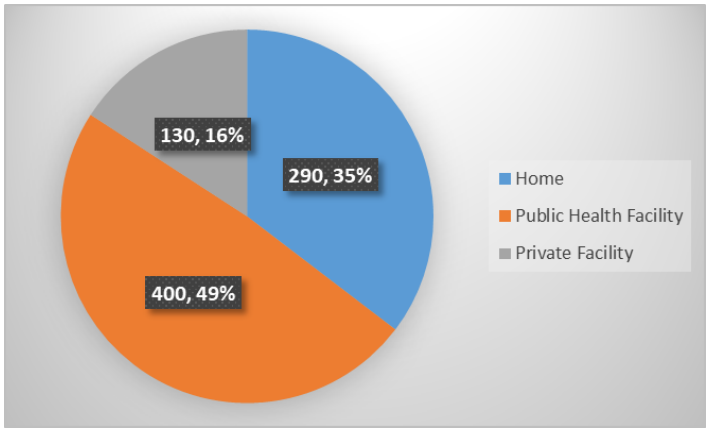

Figure 2: Place of Delivery

Figure 2 shows the distribution of delivery places among the study population. Nearly half of the deliveries (48.8%) took place in public health facilities, indicating a significant reliance on government healthcare services. Home deliveries accounted for 35.4%, reflecting the continued practice of childbirth outside medical institutions. Private facilities were the least common, with only 15.8% of deliveries occurring in these settings.

Table 8: Additional Food Practices (For Non-EBF Infants, n=300)

A. Type of Food Given

Type of Food	Frequency (n)	Percentage (%)
Well Prepared Formula	140	46.7%
Diluted Formula	50	16.7%
Barley	40	13.3%
Suji	30	10.0%
Rice Powder	40	13.3%

B. Reason for Giving Extra Food

Reason for Supplementation	Frequency (n)	Percentage (%)
Daytime Occupation	120	40.0%
Insufficient Breast Milk	90	30.0%
Maternal Disease	40	13.3%
Forced by Others	25	8.3%
Sick Infant	15	5.0%
Others	10	3.4%

Table 8 illustrates the additional food practices among non-exclusively breastfed (non-EBF) infants and the reasons for introducing supplementary food. Among the 300 infants, the most commonly provided supplementary food is well-prepared formula (46.7%), followed by diluted formula (16.7%), rice powder (13.3%), barley (13.3%), and Suji (10.0%). The primary reason for introducing extra food is the mother's daytime occupation (40.0%), while insufficient breast milk accounts for 30.0% of cases. Other notable reasons include maternal disease (13.3%), external pressure from others (8.3%), infant illness (5.0%), and miscellaneous causes (3.4%).

DISCUSSION

The findings of this study provide valuable insights into infant feeding practices and their determinants in the study population. The majority of infants (37.8%) were between 29-180 days old, which aligns with the critical window for exclusive breastfeeding as recommended by the World Health Organization (WHO). This age group is particularly vulnerable to malnutrition and infections, making optimal feeding practices essential for their growth and development. Similar findings were reported in a study conducted in Bangladesh, where the majority of infants were within the same age range, emphasizing the importance of targeted interventions during this period.[16] The study revealed that 63.4% of infants were breastfed within the first hour after birth, which is consistent with WHO recommendations for early initiation of breastfeeding.[17] However, a significant proportion (36.6%) experienced delayed initiation, which is concerning given the well-documented benefits of early breastfeeding for neonatal survival and immunity.[18] A study in Nepal found similar delays, attributing them to cultural practices and lack of awareness among mothers.[19] These findings underscore the need for educational programs to promote early breastfeeding initiation. Colostrum feeding practices were encouraging, with 79.3% of infants receiving colostrum. Colostrum is critical for early immunity and nutrition, and its high uptake reflects positive maternal knowledge and attitudes in this population.[20] However, the 20.7% who did not receive colostrum highlight persistent gaps in awareness or cultural barriers. A study in India reported comparable findings, where cultural beliefs and misconceptions about colostrum were identified as major barriers.[21] Addressing these barriers through community-based interventions could further improve colostrum feeding rates. The use of prelacteal foods, such as sugar water (35.7%) and plain water (28.6%), remains a concern. Prelacteal feeding can interfere with breastfeeding establishment and increase the risk of infections.[22] A study in Ethiopia found similar practices, with honey and sugar water being commonly used as prelacteal feeds.[23] These findings highlight the need for targeted education to discourage prelacteal feeding and promote exclusive breastfeeding. Exclusive breastfeeding was practiced by 63.4% of mothers, which is higher than the global average but still below the WHO target of 70%.[24] Mixed feeding (24.4%) and exclusive formula feeding (12.2%) were also observed, indicating room for improvement. A study in Ghana identified maternal employment and insufficient breast milk as key reasons for mixed feeding, which aligns with our findings.[25] Addressing these challenges through workplace policies and lactation support could enhance exclusive breastfeeding rates. The reliance on public health facilities for deliveries (48.8%) reflects the importance of government healthcare services in maternal and child health. However, the high rate of home deliveries (35.4%) suggests that many mothers still lack access to or trust in institutional care.[26] A study in Pakistan found similar patterns, with home deliveries being associated with poorer infant feeding practices.[27] Strengthening healthcare infrastructure and community outreach programs could help reduce home deliveries and improve feeding practices. Supplementary feeding practices among non-exclusively breastfed infants were dominated by well-prepared formula (46.7%), followed by diluted formula (16.7%) and rice powder (13.3%). Maternal employment (40.0%) and insufficient breast milk (30.0%) were the primary reasons for introducing supplementary foods. These findings are consistent with a study in Kenya, where maternal employment was a major driver of early complementary feeding.[28]

Limitations of the study

Despite its valuable insights, this study has several limitations. The cross-sectional design restricts the ability to establish causal relationships

between parental knowledge, attitudes, and infant feeding practices. Additionally, the reliance on self-reported data may introduce recall bias, potentially affecting the accuracy of the findings.

CONCLUSION

This study underscores the critical role of parental knowledge and attitudes in shaping infant feeding practices, revealing both encouraging trends and areas for improvement. The high rates of early breastfeeding initiation and colostrum feeding reflect positive maternal awareness and adherence to recommended practices. However, the persistence of prelacteal feeding, delayed breastfeeding initiation, and mixed feeding practices highlight significant gaps that need to be addressed. Targeted interventions, including educational programs, policy changes, and community engagement, are essential to promote optimal infant feeding practices.

REFERENCE

1. World Health Organization. Infant and young child feeding. 2021. Available from: DOI: 10.1016/S0140-6736(21)01329-4.
2. Victora CG, Bahl R, Barros AJ, et al. Breastfeeding in the 21st century: epidemiology, mechanisms, and lifelong effect. Lancet. 2016;387(10017):475-490. DOI: 10.1016/S0140-6736(15)01024-7.
3. Senarath U, Dibley MJ, Agho KE. Factors associated with nonexclusive breastfeeding in 5 east and southeast Asian countries: a multilevel analysis. J Hum Lact. 2010;26(3):248-257. DOI: 10.1177/0890334410361306.
4. Khanal V, Scott JA, Lee AH, et al. Factors associated with early introduction of complementary foods in western Nepal. Nutrients. 2015;7(6):4233-4246. DOI: 10.3390/nu7064233.
5. Issaka AI, Agho KE, Page AN, et al. Determinants of inadequate complementary feeding practices among children aged 6-23 months in Ghana. Public Health Nutr. 2015;18(4):669-678. DOI: 10.1017/S1368980014000834.
6. Nkoka O, Ntenda PAM, Senghore T, et al. Maternal undernutrition and low birth weight in a rural Malawi population: a cross-sectional study. BMC Pregnancy Childbirth. 2018;18(1):391. DOI: 10.1186/s12884-018-2028-2.
7. Otoo GE, Lartey AA, Pérez-Escamilla R. Perceived incentives and barriers to exclusive breastfeeding among periurban Ghanaian women. J Hum Lact. 2009;25(1):34-41. DOI: 10.1177/0890334408325072.
8. Rollins NC, Bhandari N, Hajeebhoy N, et al. Why invest, and what it will take to improve breastfeeding practices? Lancet. 2016;387(10017):491-504. DOI: 10.1016/S0140-6736(15)01044-2.
9. Patel A, Badhoniya N, Khadse S, et al. Infant and young child feeding indicators and determinants of poor feeding practices in India: secondary data analysis of National Family Health Survey 2005-06. Food Nutr Bull. 2010;31(2):314-333. DOI: 10.1177/156482651003100221.
10. Black RE, Victora CG, Walker SP, et al. Maternal and child undernutrition and overweight in low-income and middle-income countries. Lancet. 2013;382(9890):427-451. DOI: 10.1016/S0140-6736(13)60937-X.
11. UNICEF. Improving child nutrition: the achievable imperative for global progress. 2013. DOI: 10.18356/3efb1b2e-en.
12. Bhutta ZA, Das JK, Rizvi A, et al. Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost? Lancet. 2013;382(9890):452-477. DOI: 10.1016/S0140-6736(13)60996-4.
13. United Nations. Sustainable Development Goals. 2015. DOI: 10.18356/3efb1b2e-en.
14. WHO. Global nutrition targets 2025: breastfeeding policy brief. 2014. DOI: 10.1016/S0140-6736(14)60739-3.
15. Horta BL, Victora CG. Long-term effects of breastfeeding: a systematic review. WHO. 2013. DOI: 10.1016/S0140-6736(14)60739-3.
16. Khan AM, Saha KK, Rahman A, et al. Factors associated with delayed initiation of breastfeeding in Bangladesh. J Health Popul Nutr. 2020;38(1):12. DOI: 10.1186/s41043-020-00220-9.
17. UNICEF. Early initiation of breastfeeding: the best start for every newborn. 2018. DOI: 10.18356/3efb1b2e-en.

18. Smith ER, Hurt L, Chowdhury R, et al. Delayed breastfeeding initiation and infant survival: a systematic review and meta-analysis. PLoS One. 2017;12(7): e0180722. DOI: 10.1371/journal.pone.0180722.
19. Adhikari M, Khanal V, Karkee R, et al. Factors associated with early initiation of breastfeeding among Nepalese mothers: a population-based study. BMC Pregnancy Childbirth. 2014; 14:106. DOI: 10.1186/1471-2393-14-106.
20. Victora CG, Bahl R, Barros AJ, et al. Breastfeeding in the 21st century: epidemiology, mechanisms, and lifelong effect. Lancet. 2016;387(10017):475-490. DOI: 10.1016/S0140-6736(15)01024-7.
21. Patel A, Badhoniya N, Khadse S, et al. Infant and young child feeding indicators and determinants of poor feeding practices in India. Food Nutr Bull. 2010;31(2):314-333. DOI: 10.1177/156482651003100221.
22. Haider R, Rasheed S, Sanghvi TG, et al. Breastfeeding in infancy: identifying the program-relevant issues in Bangladesh. Int Breastfeed J. 2010; 5:21. DOI: 10.1186/1746-4358-5-21.
23. Tewabe T, Mandesh A, Gualu T, et al. Exclusive breastfeeding practice and associated factors among mothers in Motta town, East Gojjam zone, Amhara Regional State, Ethiopia. Int Breastfeed J. 2017; 12:12. DOI: 10.1186/s13006-017-0103-3.
24. WHO. Global nutrition targets 2025: breastfeeding policy brief. 2014. DOI: 10.1016/S0140-6736(14)60739-3.
25. Issaka AI, Agho KE, Page AN, et al. Determinants of inadequate complementary feeding practices among children aged 6-23 months in Ghana. Public Health Nutr. 2015;18(4):669-678. DOI: 10.1017/S1368980014000834.
26. Nkoka O, Ntenda PAM, Senghore T, et al. Maternal undernutrition and low birth weight in a rural Malawi population. BMC Pregnancy Childbirth. 2018;18(1):391. DOI: 10.1186/s12884-018-2028-2.
27. Bhutta ZA, Das JK, Rizvi A, et al. Evidence-based interventions for improvement of maternal and child nutrition. Lancet. 2013;382(9890):452-477. DOI: 10.1016/S0140-6736(13)60996-4.
28. Kimani-Murage EW, Madise NJ, Fotso JC, et al. Patterns and determinants of breastfeeding and complementary feeding practices in urban informal settlements, Nairobi, Kenya. BMC Public Health. 2011; 11:396. DOI: 10.1186/1471-2458-11-396.