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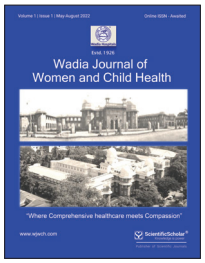
Wadia Journal of Women and Child Health



Original Article

Feeding modes and persistent diarrhea: A comparative case–control study in infants in Hodeida, Yemen

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Received: 28 October 2023
Accepted: 11 January 2024
Published: 04 June 2024

DOI
10.25259/WJWCH_43_2023

ABSTRACT

Objectives: Diarrhea is a major cause of morbidity and mortality among infants globally. Infant feeding practices influence diarrhea risk, but its relationship requires further investigation, especially in Yemen. This study aims to identify associations between feeding modes (breastfeeding, mixed feeding, formula, and goat milk) and persistent diarrhea in Yemeni infants.

Material and Methods: A hospital-based case–control study was conducted from January to June 2020 in Hodeidah, Yemen. The cases were 240 infants aged 2–24 months with persistent diarrhea. Controls were 120 age-matched healthy infants. Caregiver interviews collected data on feeding practices. Odds ratios (OR) estimate relationships between exposures and persistent diarrhea.

Results: We observed a protective effect of breastfeeding against persistent diarrhea, with breastfed infants having a significantly lower risk of developing persistent diarrhea compared to non-breastfed infants (OR: 0.43, 95% confidence interval [CI]: 0.27–0.68, $P = 0.037$). In addition, we found a significant association between goat milk consumption and persistent diarrhea, with infants who consumed goat milk having a higher risk of persistent diarrhea (OR: 4.67, 95% CI: 1.15–19.01, $P = 0.009$). While mixed feeding showed a potential increased risk of persistent diarrhea compared to exclusive breastfeeding, the wide CI indicated that this association was not statistically significant and required further research (OR: 1.86, 95% CI: 1.09–3.18). In contrast, the association between formula feeding and persistent diarrhea was inconclusive and not statistically significant ($P = 0.938$; OR: 0.867, 95% CI: 0.353–2.128), suggesting no significant relationship. These results highlight the protective effect of breastfeeding and the potential risks of goat milk consumption, while relationships between mixed/formula feeding and persistent diarrhea require more evidence.

Conclusion: Certain feeding practices increase the risk of persistent diarrhoea in Yemeni infants. Promoting exclusive breastfeeding and complementary feeding guidance alongside tailored behavior change strategies, especially in rural communities can help address these modifiable risk factors.

Keywords: Infant feeding modes, Exclusive breastfeeding, Goat milk feeding, Mixed feeding of breastfeeding with milk formula, Exclusive milk formula, Diarrhea risk

INTRODUCTION

Diarrhea is a common health concern among infants and young children worldwide, contributing to significant morbidity and mortality. Various factors, including infant feeding modes have been associated with the occurrence of diarrhea. It is estimated that diarrhea accounts for 9%

How to cite this article: Alselwi KA, Suhail MA. Feeding modes and persistent diarrhea: A comparative case–control study in infants in Hodeida, Yemen. Wadia J Women Child Health. 2024;3(1):4-8. doi: 10.25259/WJWCH_43_2023

of all deaths among children under 5 years of age, most of which occur in low- and middle-income countries, including Yemen.[1] Understanding the relationship between different feeding modes and the prevalence of diarrhea is crucial for developing interventions to reduce its incidence.

Breastfeeding is widely recognized as the optimal feeding mode for infants, providing numerous health benefits and protection against various diseases, including diarrhea. Exclusive breastfeeding has been shown to have a significant protective effect against diarrhea.[1] Several studies have shown that longer duration of breastfeeding and higher proportion of breast milk in the infant's diet are associated with a lower risk of developing diarrhea.[2,3] Breast milk contains essential nutrients, antibodies, and enzymes that enhance the infant's immune system and provide protection against diarrheal pathogens.[4]

However, there is limited research examining the relationship between other feeding modes, such as mixed feeding, formula feeding, and the consumption of animal milk such as goat milk and diarrhea prevalence in infants. Mixed feeding, which involves the combination of breast milk and other milk or food sources, may alter the protective effect of breastfeeding against diarrhea.[5] The introduction of formula feeding, which does not have the same immunological properties as breast milk may increase the risk of diarrhea.[6] In addition, the consumption of animal milk such as goat milk by infants is a common practice in certain cultural contexts. However, the impact of goat milk feeding on diarrhea prevalence remains unclear and requires further investigation.[7] This study aims to examine the associations between various feeding modes, including breastfeeding, mixed feeding, formula feeding, and the consumption of goat milk, and the prevalence of persistent diarrhea among Yemeni infants aged 2–24 months. The findings of this research will provide crucial insights for informing public health efforts in reducing the burden of diarrhea.

MATERIAL AND METHODS

Study design and participants

This hospital-based case–control study was conducted from January to June 2020 across six health facilities located in both urban and rural areas of Hodeidah, Yemen. The overarching aim of the research was to explore the association between various infant feeding practices and the prevalence of persistent diarrhea among young children in this region. As the first investigation of its kind in Hodeidah, this study sought to generate valuable local data to inform public health interventions. A total of 240 caregivers of infants with persistent diarrhea (meeting the case definition) were recruited, along with 120 age-matched healthy controls. Study participants were identified from three urban and three rural study sites.

Case definition

Persistent diarrhea was defined according to the World Health Organization (WHO) guidelines as cases of diarrhea persisting for 3 weeks or more.

Interview

To obtain comprehensive feeding histories, we worked closely to design a personalized interview guide. Through respectful, in-depth discussions with each caregiver, we compiled a detailed record of each child's feeding experiences from birth. This nuanced approach helped establish trust while also capturing a full picture of feeding modes and routines.

Data collection

Data was gathered systematically using a structured questionnaire. The survey specifically asked caregivers to describe various feeding modes over time, including exclusive breastfeeding, goat milk, breastfeeding with milk formula and exclusive milk formula. Participants were also asked about the timing and duration of any diarrhea episodes according to the case definition.

Data analysis

The proportions of participants employing each feeding mode were calculated. Two-by-two contingency tables were developed to assess associations between feeding modes (e.g., breastfeeding) and diarrhea status. Chi-square tests were performed using the Statistical Package for the Social Sciences (SPSS) version 23 to determine odds ratios (ORs) and estimate the likelihood of persistent diarrhea.

RESULTS

A total of 240 infant cases and 120 controls were enrolled. Table 1 shows the effects of breastfeeding on diarrhea risk. Among cases, 161 (67%) were breastfed, while in controls, 94 (78.3%) were breastfed. Breastfeeding was associated with 43% reduced odds of persistent diarrhea (OR: 0.43, 95% confidence interval [CI]: 0.27–0.68, $P = 0.037$), indicating those who were breastfed had 57% lower odds of persistent diarrhea compared to non-breastfed infants. This association was statistically significant. Table 2 presents the effects of mixed feeding. Of the cases, 36 (15%) practiced mixed feeding versus 204 (85%) who did not. Among controls, 15 (12.5%) were on mixed feeding and 115 (87.5%) were not. Mixed feeding showed a potentially increased risk of persistent diarrhea compared to exclusive breastfeeding, but this association was not statistically significant (OR: 1.86, 95% CI: 1.09–3.18). Table 3 shows the relationship between formula feeding and diarrhea. Of the cases, 14 (5.8%) received formula feeds while in controls, 8 (6.7%) were formula-fed. Although more number

Table 1: The effect of exclusive breast feeding.

Category	Exposed	Not exposed	Total
Cases	161	79	240
Control	94	26	120
Total	255	105	360

Table 2: The effect of mixed feeding.

Category	Mixed feeding	No mix feeding	Total
Cases	36	204	240
Control	15	115	120
Total	255	105	360

Table 3: The effect of formula milk feeding.

Category	Formula	No formula	Total
Cases	14	226	240
Control	8	112	120
Total	22	338	360

Table 4: The effect of goat milk feeding.

Category	Exposed	Not exposed	Total
Cases	27	213	240
Control	3	117	120
Total	30	330	360

of cases with persistent diarrhea were on formula feeding, the association between formula feeding and persistent diarrhea was inconclusive ($P = 0.938$; OR: 0.867, 95% CI: 0.353–2.128), suggesting no statistically significant relationship. Table 4 examines the effects of goat milk consumption. Among cases, 27 (11.3%) consumed goat milk compared to 3 (2.5%) in the control group. A significant association between goat milk consumption and increased risk of persistent diarrhea was found in infants who consumed goat milk having a statistically significant higher risk of persistent diarrhea (OR: 4.67, 95% CI: 1.15–19.01, $P = 0.009$).

DISCUSSION

This study indicates that breastfeeding has a protective effect against persistent diarrhea in infants. Breast milk contains antibodies and is easily digestible, which likely confer this advantage.[8-11] Mixed feeding was also associated with a higher diarrhea risk, possibly due to contamination of other foods or liquids or immature gut immunity. Caregivers require guidance on appropriate complementary feeding practices to be initiated after six months of age.[12] While formula feeding showed a higher odds ratio, the relationship was inconclusive due to wide confidence intervals (CIs) due to small numbers. More research is needed in this population to understand the role of formula feeding. Previous studies have highlighted various health benefits associated with goat milk consumption. However, results from the current study indicate it as a risk factor for persistent diarrhea. While this association was observed, the confidence interval was large, suggesting the findings need to be validated in future research with larger sample sizes.[13,14] Rural settings showed higher exposures to identified risk factors potentially related to lack of awareness. Tailored behavior change interventions for these communities may help address modifiable risks.[15] This study provides valuable insights into the associations between different feeding methods and risk of persistent diarrhoea. Exclusive breast milk feeding is protective and goat milk feeding appear to have significant increase in risk of persistent diarrhea while mixed feeding and formula feeding do not demonstrate strong associations. However, the wide CIs indicate the need for further research to understand these relationships better and obtain more precise estimates of the effects.

Comparison to previous studies

In several other countries, studies have reported protective effects of breastfeeding against diarrhea similar to our findings. A Bangladesh study found over 50% reduced risk of persistent diarrhea with exclusive breastfeeding until 6 months.[16] A meta-analysis in sub-Saharan Africa also demonstrated strong protection by exclusive breastfeeding.[17] Mixed feeding as a risk factor for diarrhea is consistent with studies from Ghana and Pakistan.[18,19] The timely introduction of appropriate complementary foods while continuing breastfeeding is critical. Few studies from Yemen, the Middle East, and Africa have specifically examined the role of goat milk. Our study found a novel and surprising result regarding the possible negative effect of goat milk, where goat milk showed higher odds of diarrhea (OR: 4.67, 95% CI: 1.15–19.01) despite the good and beneficial effects of goat milk in other studies.[20,21] Overall, our results align with previous evidence on the impact of modifiable infant and young child feeding practices on diarrhea morbidity. Larger multi-national studies are required for some of these under-researched factors.[22]

Large-scale behavior change interventions are needed targeting caregivers in both urban and rural areas. Interventions should promote exclusive breastfeeding for the first 6 months, followed by timely introduction of appropriate complementary food while continuing breastfeeding. Caregivers should be educated on avoiding contamination risks and proper hygiene during feeding. Community-based programs tailored for rural contexts could effectively raise awareness of best infant feeding practices. Interventions

must also address cultural sensitivities and local beliefs through respectful, culturally-sensitive education. Further research is needed to validate relationships between understudied factors and diarrhea, inform context-specific recommendations, integrate feeding recommendations into health policies, reduce diarrhea morbidity and mortality, strengthen primary healthcare systems, support caregivers, manage diarrhea cases, consider food fortification programs and nutritional supplementation, and target vulnerable groups practicing risky feeding behaviors.

Limitations

In this study design, various confounding factors for persistent diarrhea like preexisting malnutrition, HIV status, the causative organism and specific etiology of diarrhea were unevenly distributed between the exclusively breastfed and non-exclusively breastfed groups. Hence, highlighting these limitations provides important context for interpreting the present findings and provides future research directions.

CONCLUSION

This study highlights the significant protective effect of breastfeeding against persistent diarrhea among Yemeni infants. Exclusive breastfeeding, with its unique immunological and nutritional properties serves as a potent defense against diarrheal pathogens. On the other hand, the introduction of mixed feeding, formula feeding, and goat milk consumption did not demonstrate a similar protective effect. These findings provide valuable insights for public health interventions aimed at reducing the burden of persistent diarrhea among infants. Promoting and supporting exclusive breastfeeding should continue to be a priority to reduce the burden of persistent diarrhea in Yemeni infants. Further research is needed to explore the potential impact of other feeding modes and confounding factors on the prevalence of persistent diarrhea.

Ethical approval

Ethical approval was issued from the Health Ethical Research Committee (HERC) at Hodeidah Faculty of Medicine. The approval decision was taken with no need for submitting Ethical application because the study is not harmful, not experimental, and no laboratory animals were involved. In addition, the study was carried out according to the Helsinki Protocol.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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