IMPLICATIONS OF FORMULA FEEDING TO REDUCE HIV TRANSMISSION

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Background. The risk of vertical transmission of HIV during breast-feeding has prompted renewed interest in the role of supplementary feeding during childhood. However, it is also known that supplementary feeding is an important vector of disease transmission. The aim of this study was to investigate the level of microbial contamination present in bottle feeds given to infants living in Mangaung, South Africa.

Methods. The study followed a cross-sectional design. Two hundred randomly selected households were visited and caregivers of bottle-feeding infants in the selected area were requested to provide a sample of the infants' bottle feed. Nutritional and microbial content of each bottle feed were measured. Bottle feeds were classified as unfit for human consumption if they had a standard plate count greater than 50 000 organisms per millilitre feed, or a total coliform count greater than 10 coliform organisms per millilitre.

Findings. A total of 84.5% of all the bottle feeds were classified as unfit for human consumption. There was no major difference in nutritional quality of the fit and unfit feeds. The infants receiving unfit bottle feeds were younger than those receiving fit bottle feeds (11.1 ± 6.9 months compared with 14.0 ± 7.6 months, respectively; $p = 0.010$) and also weighed less.

Interpretation. This finding underlines the need to address the content of feeding literacy programmes. Bottle-feeding in Mangaung is currently not a safe alternative to breast-feeding and should therefore not be promoted.

The global HIV epidemic has a major impact on the health and survival of infants in sub-Saharan Africa.[1] Recent advances in reducing HIV transmission from mother to child during the intrapartum period have been made by studies such as the 076 Study, the Thai Study, Petra, and the HIVNET012 Study. However, the postpartum risk of HIV transmission through breast-feeding remains a challenge in resource-constrained settings. Breast-feeding is believed to bring multiple benefits to infants and to improve the health of mothers.[2] (Coutsoudis *et al.*, 2001). The most serious threat to breast-feeding in modern times has been promotion of the use of artificial milks, particularly, but not only, in developing countries. More recently realisation that breast-feeding can transmit HIV-1 to the infant has resulted in HIV-infected women in the industrialised world choosing to avoid this feeding method.[2] It is believed that the rate of HIV transmission via breast-milk ranges from 12% to 26%.[1,3]

The risk of transmission of HIV to the infant associated with exclusive bottle-feeding is, in theory, negligible. However, bottle-feeding and weaning have been associated with increased infant and child mortality and morbidity even in the absence of HIV.[4-7] Furthermore, mortality among children who are not breast-fed or are weaned because of preceding morbidity in mother or infant is higher than mortality among children who are not breast-fed or are weaned as a result of maternal choice.[1]

The most prevalent infections among children are respiratory and diarrhoeal infections, and children become most susceptible to them when weaning foods or liquids complement or replace breast-milk. Diarrhoea is believed to be the most common cause of child morbidity and mortality in developing countries. It is estimated that across the world, excluding China, 1 400 million episodes of diarrhoea occur annually in children under the age of 5 years. In 1990 over 3 million children died worldwide as a result of diarrhoea. It is also suspected that almost 70% of these diarrhoeal episodes could be caused by pathogens transmitted through food.

The total number of deaths in South Africa's Free State province for 1999 was approximately 6 870. Deaths of infants in the age group 0 - 5 years comprise 15.6% of this

total. The contribution of food-borne pathogens to this figure is unknown.

The aim of this study was to investigate the level of microbial contamination present in a representative sample of bottle feeds given to infants in the Mangaung region of Bloemfontein. Social, environmental and economic factors believed to affect the preparation of bottle feeds were also examined. Information from this study will assist in planning intervention methods to improve the standard of health education among caregivers, and ultimately contribute to a decrease in mortality and morbidity associated with poorly prepared bottle feeds.

MATERIALS AND METHODS

STUDY DESIGN

A cross-sectional design was used. The Ethics Committee of the University of the Free State approved the study. A representative sample of 200 randomly selected households in Mangaung, a traditionally black township in Bloemfontein, was visited and caregivers of bottle-fed infants in the selected area were recruited for the study. The caregivers were defined as those individuals responsible for preparing the bottle feeds of each infant for at least 5 days per week. Only caregivers who gave informed consent were included in the study.

POPULATION AND SAMPLE SIZE

The study population included four neighbourhoods in Mangaung region, the number of households for each neighbourhood being proportional to its population size. The Department of Biostatistics, Free State University, determined the method of sampling. Ineligible households, i.e. not including a bottle-fed infant, were substituted by the second household to the left of the original household, or following that with the second household to the right of the original household. All black infants aged under 24 months and receiving bottle feeds were included in the study.

SAMPLE COLLECTION AND PREPARATION

In each household, the caregiver was requested to provide a 50 ml sample of a bottle feed given to the infants at the time of the visit or stored to be given during the next feeding session. Caregivers were unaware of the study before the visit.

Samples were collected in standard sterilised 50 ml sampling bottles and immediately placed in a dark container filled with ice and transported to the laboratories of the Technikon Free State. The samples were processed into aliquots. One aliquot was immediately sent to the Laboratories of Dairy Belle, Bloemfontein, for analyses of protein, fat and carbohydrate content. A commercially available milk sample was used as external control sample. The manufacturers of the various diagnostic kits used throughout the study supplied internal control samples. A water sample from the household was collected at the same time as the bottle feed sample in order to assess background contamination levels. Every participating caregiver was asked to complete a questionnaire after giving informed consent. Information regarding previous breast-feeding and bottle-feeding practices, whether the infant currently had diarrhoea and a total clinical history, including the infant's weight and height, were obtained. The information also included household socio-economic status, educational level, parity and other relevant particulars.

BIOCHEMICAL MEASUREMENTS

Carbohydrate, protein, and fat content

These analyses were performed in the laboratory of Dairy Belle, Bloemfontein. Samples were analysed on an ultraviolet Milk-O-Scan 104 Type 19900 automatic analyser. The coefficient of variation, expressed as the standard deviation as a percentage of the mean value of a set of control examples, for protein was 0.71, for lipids 0.32 and for lactose 1.17%.

MICROBIAL ANALYSES OF BOTTLE FEEDS

Analyses were performed according to the procedures as described in Annex A of Regulation 1555 of 1997 of the Foodstuffs, Cosmetics and Disinfectants Act (Act 54 of 1972). Counts recorded were minimum counts as no provision was made for fastidious bacteria. Procedures rely only on indicator organisms to indicate specific problem areas. The microbial analyses performed on the bottle feeds included the standard plate count, total *Escherichia coli* count and total coliform count. Standards for milk as described in the Foodstuffs, Cosmetics and Disinfectants Act (1972) were used. Total counts were determined using Petrifilm Total Aerobic Count supplied by 3M (St Paul, Minn., USA). The total *E. coli* counts were also determined using Petrifilm. The total coliform count was determined using Chromocult Coliform Agar supplied by Merck (cat. no. KgaA 64271, Darmstadt, Germany). *E. coli* detection was confirmed by coating the dark blue to violet colonies with a drop of Kovacs' Indole Reagent (Saarchem Pty Ltd).

Bottle feeds were classified as unfit for human consumption using a standard plate count greater than 50 000 organisms per millilitre, or a total coliform count greater than 10 coliform organisms per millilitre feed (as suggested by the Foodstuffs, Cosmetics and Disinfectants Act 54, 1972).

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RESULTS

A total of 200 households participated. A total of 84.5% of all the collected feeds had total plate counts greater than 50 000 organisms per millilitre feed, or total coliform counts greater than 10 coliform organisms per millilitre (Table I). These feeds were classified as unfit for human consumption. No significant differences in nutritional quality between the feeds classified as fit and unfit for human consumption were apparent, except for a higher fat content in the unfit group of feeds (1.89 ± 1.10 g/100 ml compared with 1.30 ± 0.93 g/100 ml, respectively; p = 0.005).

Caregivers responsible for preparation of the bottle feeds that were unfit for human consumption tended to be older than those who prepared the acceptable feeds, but this difference was not significant (Table I). However, the average level of education of the caregivers responsible for preparing the unfit bottle feeds was significantly lower than that of the caregivers who prepared the fit bottle feeds (3.38 ± 3.72 and 4.93 ± 2.61 years of schooling, respectively; p = 0.005).

Infants who received bottle feeds with high levels of contamination were significantly younger than those receiving bottle feeds with acceptable levels of contamination (11.1 ± 6.9 months in the unfit group compared with 14.0 ± 7.6 months in the fit group; p = 0.010).

Caregivers responsible for preparing unfit bottle feeds reported a lower monthly income than the other group (Table I). This difference was not significant. However, the proportion of households in the group that prepared the unfit bottle feeds with direct access to electricity was significantly higher than that for the group that prepared fit bottle feeds (41% v. 23%; p = 0.040, χ^2 = 3.702). Furthermore, a significantly higher proportion of households in the unfit group had access to an electric stove for cooking purposes (32% v. 21% within each

TABLE I. RESULTS FOR FIT AND UNFIT BOTTLE FEEDS

	Bottles fit for human consumption (N = 31)		Bottles unfit for human consumption* (N = 169)		
	Mean	SD	Mean	SD	p-value
Coliforms organisms/ml	1.97	3.22	399.85	465.32	0.000†
Total counts/ml	9 782	10 987	4 114 732	4 488 321	0.000†
Demographics					
Age of caregiver	29.7	8.9	30.9	10.7	NS†
Educational level of caregiver/years schooling	4.93	3.72	3.38	2.61	0.005†
Infant background					
Age of infant (mo.)	14.0	7.6	11.1	6.9	0.010†
Gender					
Males	20		84		NS
Females	11		85		NS
Birth weight of infant (g)	2 993	553	2 894	521	NS†
Current weight of infant (g)	9 562	2 784	8 717	3 365	NS†
Age at weaning (mo.)	13.9	1.4	6.3	0.8	0.000†
Age at introducing solids (wks)	15.0	7.8	11.8	8.8	0.045†
Household information					
Household income (R)	1 290	739	1 252	804	NS†
Electricity (%)	23		41		0.040
Open fire (%)	10		9		NS
Water in house (%)	8.5		9.0		NS
Stove (%)	21		32		0.016
Primus (%)	55		58		NS
Knowledge on preparing a bottle					
From label (%)	25.8		4.2		NS
From family (%)	61.3		37.2		0.022
Clinic (%)	12.9		56.2		NS
Work (%)	–		1.2		NS
Guessed (%)	–		1.2		NS
Nutrient contents					
Fat (g/100 ml)	1.30	0.93	1.89	1.10	0.005†
Protein (g/100 ml)	0.98	0.90	1.36	1.00	0.052†
Carbohydrates (g/100 ml)	4.91	1.70	5.18	2.56	0.571†
Solids	7.65	2.90	8.94	3.78	0.072†

*Bottles were classified as unfit for human consumption using the following criteria: standard plate counts > 50 000 organisms/ml, and total coliform counts > 10 coliform organisms/ml, as suggested by the Foodstuffs, Cosmetics and Disinfectants Act 54, 1972.
†Independent sample t-tests; categorical variables were tested using the X^2-test.

respective group; $p = 0.016$, $\chi^2 = 8.254$). There was no significant difference in access to water supply between the two groups.

Antenatal clinics (56.2%) or family members (37.2%; $p = 0.022$, $\chi^2 = 3.888$) were reported to be the main source of knowledge on how to prepare infant formulas by caregivers responsible for the preparation of unfit bottle feeds. The caregivers who prepared the fit bottle feeds reported either a family member (61.3%) or formula feed container label (25.8%) as their main source of knowledge.

DISCUSSION

The results of this study show that while the nutritional content of bottle feeds was adequate, levels of bacterial contamination were unacceptable. Contaminated complementary foods account for a substantial proportion of cases of diarrhoea among infants and young children, especially in developing countries.[8] Factors such as unhygienic living conditions, an unsafe water supply, inadequate refuse removal and disposal of excreta, contamination of food and kitchen utensils and the decline in the prevalence of breast-feeding are believed to be directly associated with high levels of bacterial contamination of food sources, yet the importance of food safety in the prevention of diarrhoeal disease is often overlooked or neglected. It is estimated that up to 70% of diarrhoeal episodes could be due to pathogens transmitted through food.[8] Contaminated bottles, teats and bottle feeds are associated with high bacterial counts that can increase the risk of diarrhoeal events.[9]

Frequent diarrhoeal episodes, in turn, suppress infant growth, leading to wasting and malnutrition. Diarrhoeal infections are second only to respiratory infections in negative impact on the growth of infants and young children.[8] The relationship between diarrhoea and malnutrition is well established. Diarrhoea has a direct effect on the nutritional status of the infant that not only prolongs the individual diarrhoeal episodes, but also increases the risk of mortality.[10] Yet health professionals tend to regard energy-poor weaning foods and liquids as the major cause of malnutrition in infants receiving complementary feeds.[11] In this study the nutritional content of bottle feeds was acceptable and there was no major difference in nutritional quality between the feeds classified as fit and unfit for human consumption. At the same time, the current weight of the infants tended to be lower in the group receiving contaminated bottle feeds.

The majority of caregivers responsible for preparation of the bottle feeds that were fit for human consumption were trained by a family member, while the majority of those who prepared the unfit feeds were trained by personnel of the local clinic. This finding is of great concern and underlines the need to address the content of bottle feeding literacy programmes according to current needs. A successful literacy programme should also address other determinants of infant health, such as the age of weaning, which was shown in this study to contribute significantly towards the risk of receiving contaminated bottle feeds.

CONCLUSION

This study supplies valuable information that could be used to educate caregivers in the Mangaung district of Bloemfontein. The main shortcoming of the study is its inability to isolate a single source of contamination. However, it does show that the level of contamination is multi-factorial and depends on a combination of demographic, socio-economic and environmental factors. Literacy programmes should be based on these findings. Only then should mothers infected with HIV be encouraged to use bottle-feeding as a safe alternative to breast-feeding.

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