Are WHO/UNAIDS/UNICEF-recommended replacement milks for infants of HIV-infected mothers appropriate in the South African context?

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Objective Little is known about the nutritional adequacy and feasibility of breastmilk replacement options recommended by WHO/UNAIDS/UNICEF. The study aim was to explore suitability of the 2001 feeding recommendations for infants of HIV-infected mothers for a rural region in KwaZulu Natal, South Africa specifically with respect to adequacy of micronutrients and essential fatty acids, cost, and preparation times of replacement milks.

Methods Nutritional adequacy, cost, and preparation time of home-prepared replacement milks containing powdered full cream milk (PM) and fresh full cream milk (FM) and different micronutrient supplements (2 g UNICEF micronutrient sachet, government supplement routinely available in district public health clinics, and best available liquid paediatric supplement found in local pharmacies) were compared. Costs of locally available ingredients for replacement milk were used to calculate monthly costs for infants aged one, three, and six months. Total monthly costs of ingredients of commercial and home-prepared replacement milks were compared with each other and the average monthly income of domestic or shop workers. Time needed to prepare one feed of replacement milk was simulated.

Findings When mixed with water, sugar, and each micronutrient supplement, PM and FM provided <50% of estimated required amounts for vitamins E and C, folic acid, iodine, and selenium and <75% for zinc and pantothenic acid. PM and FM made with UNICEF micronutrient sachets provided 30% adequate intake for niacin. FM prepared with any micronutrient supplement provided no more than 32% vitamin D. All PMs provided more than adequate amounts of vitamin D. Compared with the commercial formula, PM and FM provided 8–60% of vitamins A, E, and C, folic acid, manganese, zinc, and iodine. Preparations of PM and FM provided 11% minimum recommended linoleic acid and 67% minimum recommended α-linolenic acid per 450 ml mixture. It took 21–25 minutes to optimally prepare 120 ml of replacement feed from PM or commercial infant formula and 30–35 minutes for the fresh milk preparation. PM or FM cost approximately 20% of monthly income averaged over the first six months of life; commercial formula cost approximately 32%.

Conclusion No home-prepared replacement milks in South Africa meet all estimated micronutrient and essential fatty acid requirements of infants aged <6 months. Commercial infant formula is the only replacement milk that meets all nutritional needs. Revisions of WHO/UNAIDS/UNICEF HIV and infant feeding course replacement milk options are needed. If replacement milks are to provide total nutrition, preparations should include vegetable oils, such as soybean oil, as a source of linoleic and α-linolenic acids, and additional vitamins and minerals.

Keywords Infant food/analysis/economics; Milk substitutes/chemistry/economics; Nutritive value; Nutritional requirements; Micronutrients; Fatty acids, Essential; Time factors; HIV infections/ prevention and control; Disease transmission, Vertical/ prevention and control; Infant; Mothers; Guidelines; South Africa (*source: MeSH, INSERM*).

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Introduction

Feeding recommendations for infants of infected HIV-mothers in developing countries remain controversial. As HIV can be transmitted to the infant by breastfeeding, the recommendation of WHO is that, "When replacement milk is acceptable, feasible, affordable, sustainable and safe, avoidance of all breastfeeding by HIV-infected mothers is recommended; otherwise, exclusive breastfeeding is recommended during the first months of life" (*1*). In the general population, exclusive breastfeeding for the first six months of life protects against i nfant morbidity and mortality from gastrointestinal and respiratory infections, which are especially common in developing countries (*2*). In resource-poor settings, this presents a dilemma for HIV-infected mothers and challenges health workers who counsel them about options for feeding their infants.

WHO/UNAIDS/UNICEF recommend several variations of exclusive breastfeeding and replacement milk for infants of HIV-infected mothers (Table 1) (*3*). The replacement milks include commercial infant formula and home-prepared modifications of evaporated milk, powdered full cream milk (PM), and fresh full cream milk (FM). Commercial infant formula needs to be reconstituted with water. Home-prepared milks need the addition of water, sugar, and micronutrients; preparation of FM needs the additional step of bringing the mixture to the boil to improve digestibility of the milk.

Very little is known about the nutritional adequacy and feasibility of the replacement milk options presented in the WHO/UNAIDS/UNICEF guidelines for infants of HIV-infected mothers (*4*). This paper reviews the 2001 feeding recommendations for infants of HIV-infected mothers and explores the suitability of these recommendations for a rural region in KwaZulu Natal, South Africa. In particular, the nutritional adequacy with respect to micronutrients and essential fatty acids and the cost and preparation time of replacement milks suggested in the WHO/UNAIDS/UNICEF HIV and infant feeding counselling guidelines are investigated (*3*).

Infant feeding in the rural South African context

According to the 2000 South African national HIV seroprevalence survey, 24.5% of women who presented to public antenatal clinics nationally and 36.2% of women who attended antenatal clinics in rural KwaZulu Natal were infected with HIV (*5*). A nevirapine treatment programme has been implemented recently in many districts throughout KwaZulu Natal province and the rest of South Africa to reduce the number of infants who become infected with HIV. Infant feeding counselling and support, often based on WHO/UNAIDS/UNICEF HIV counselling course materials, is offered as part of programmes (*3*). Depending on the district, free infant formula may or may not be offered.

In 1996, the year for which the latest data are available, the national demographic health surveillance indicated that in KwaZulu Natal, less than half of the households earned more than 6000 Rand (approximately US$ 600 in 2002), with the average household size of 7.5 members (*6*). Less than half of the rural households have access to clean water, electricity, and refrigeration. Most mothers do not exclusively breastfeed their infants. In a longitudinal study in the area, 130 breastfeeding mothers were followed weekly. Of the infants, 10% were breastfed exclusively for six weeks and 6% for 16 weeks (*7*).

Methods

We examined the nutritional adequacy, cost, and preparation time of home-prepared replacement milks. Evaporated milk was not included because of higher costs relative to the full cream milks, limited availability, and general lack of use by the local population. As commercial infant formula is assumed to be nutritionally complete, only the preparation time and cost were investigated.

Nutritional adequacy

The amount of milk, sugar, and water needed to meet the energy requirements of an infant who weighed 3 kg (1300 kJ or 310 kcal in 450 ml total volume) was calculated with the course instructions for home-prepared replacement milks (*3*). Box 1 shows details of the replacement milk preparations. Calculations were also made for the amount of replacement milk needed to meet the energy requirements of an infant aged 3–4 months who weighed 5 kg. These results were very similar to the former and are not shown. The micronutrient and essential fatty acid content of the PM and FM replacement preparations was determined with FoodFundi 2 (Pentanet, South African Medical Research Council, 1998) — a nutrient analysis program developed for foods eaten in South Africa.

We compared home-prepared replacement milks to which three different micronutrient supplements might be added: the 2 g UNICEF micronutrient sachet described in the course materials and available research studies, the government supplement routinely available in district public health clinics, and the best available liquid paediatric supplement found in local pharmacy shops. The amount of each micronutrient supplement used in calculations was the amount determined to achieve the best balance, i.e. providing the greatest percentage of estimated requirements without "excess" (defined arbitrarily as 400% of the US dietary reference adequate intake (AI) for

Table 1. **WHO/UNAIDS/UNICEF feeding options for infants of HIV-infected mothers[a]**

Breast milk	Replacement milks
1. Exclusive breastfeeding by the mother for first six months and continuing until age two years, or as long as mother chooses	1. Commercial infant formula, prepared according to manufacturer's directions
2. Exclusive breastfeeding by the mother with early cessation, with rapid weaning to replacement milk as early as feasible	2. Fresh full cream milk, with added water, sugar, and micronutrients; boiled before use
3. Breast milk expression with heat treatment; expressed milk fed via cup	3. Evaporated full cream milk or powdered full cream milk, with added water, sugar, and micronutrients
4. Wet-nursing by an HIV-uninfected mother	

[a] All feeding options recommend introduction of complementary foods at six months of age.

Box 1. **Home-prepared replacement milk recipes**

Full cream milk powder recipe
39 g full cream milk powder
30 g sugar
450 ml water

Fresh full cream milk recipe
300 ml fresh full cream milk
30 g sugar
150 ml water

infants aged <6 months for more than one individual micronutrient or exceeding the upper tolerance limit (UL)) (*8*, *9*). The UL in this age group has been established for only three micronutrients — zinc and vitamins A and D.

As there is no recommended dietary allowance (RDA) for infants aged <6 months, we compared home-prepared replacement milk content with the lower of two other reference values: the AI and the FAO/WHO recommended nutrient intake (RNI) (*10*). The AI is the mean intake for healthy, exclusively breastfed infants of North American and European mothers. It is used when adequate scientific evidence is not available to determine an RDA and usual intake at or above this amount has a low probability of inadequacy (*11*). The international standard for commercial infant formula, the Codex Alimentum, is undergoing draft revisions, so the micronutrient content of home-prepared replacement milks was also compared against the same volume of a commonly used commercial infant formula.

The manufacturer's statement of content of the micronutrient supplements, milks, and infant formula was accepted as reflecting the true content. Table 2 lists the micronutrient content of each supplement used in the nutrient analysis. Three other locally available micronutrient preparations were excluded as inappropriate because of lack of key nutrients (vitamins A, C, D, and E). The essential fatty acid content was compared with the FAO/WHO recommendation of 600 mg linoleic per kg body weight and 50 mg α-linolenic acid per kg body weight (*12*). The recommendation is 4–10% of total energy intake as linoleic acid and 0.5–1.0 % of total energy intake as α-linolenic acid, with a ratio of linoleic to α-linolenic acid of 5:1–10:1 (*12–15*).

Cost and preparation time

The cost of replacement milk ingredients available in the local markets was used to calculate the monthly cost for infants aged 1, 3 and 6 months. The total monthly costs of ingredients of the commercial infant formula and PM and FM preparations were then compared with each other and with the average monthly income of a domestic worker or shop worker (R 500; US$ 50 in 2002).

To estimate the time required for a mother to prepare replacement milks in a rural homestead, we simulated preparation of the volume needed for one feed in a home that was without electricity, gas, or tap water but was very close to a stream and shrubs. This was conducted as part of the WHO/UNAIDS/UNICEF HIV counselling course. Four groups, each comprising 4–6 course participants, prepared the replacement milks. Individual time to complete the following tasks

Table 2. **Micronutrient supplements available in KwaZulu Natal, South Africa**

Micronutrient	Unit	AI[a] <6 months	RNI[b] <6 months	Commercial (1.0 ml)	Government supplement (1.0 ml)	UNICEF sachet[c]
Vitamin A	µg	400	375	180	180	90
Vitamin D	IU	200	200	80	60	50
Vitamin E	IU	4	2.7	0	0	1
Vitamin C	mg	40	25	10	6	10
Thiamine	µg	200	200	300	330	50
Riboflavin	µg	300	300	200	264	80
Niacin	µg	2000	2000	2000	2200	300
Vitamin B6	µg	100	100	200	200	40
Folic acid	µg	65	80	0	0	5
Pantothenic acid	µg	1700	1700	0	0	400
Vitamin B12	µg	0.4	0.4	0.6	0	0.2
Iron	mg	0.27	–[d, e]	0.6	0	1.5
Zinc	µg	2000	2800	100	0	205
Copper	µg	200	–	0	0	100
Iodine	µg	110	57	15	0	5.6
Fluoride	µg	10	–[f]	0	0	0
Magnesium	mg	30	36	0.6	0	0
Manganese	µg	3	–[f]	0.05	0	7.5
Selenium	µg	15	6	0	0	0
Calcium	mg	210	400	0	0	0

[a] Adequate intake (USDRI) for infants aged <6 months.
[b] Recommended nutrient intake (RNI FAO) for infants aged <6 months.
[c] UNICEF's micronutrient supplement for use with home-prepared formula is in a powder form, packaged in a 2 g sachet, and intended to be mixed with 500 kcal of replacement milk (approximately 750 ml). Analysis in Table 4 uses a full packet in 450 ml formula, with 310 kcal.
[d] No recommended value.
[e] Neonatal stores of iron are sufficient to meet requirements of full term infant for the first 6 months of life.
[f] No recommended nutrient intake value for fluoride or manganese.

was recorded: collecting firewood and water, building a fire, boiling water, washing the mixing and feeding equipment, and preparing the replacement milk.

Results

Nutrient content

Table 3 shows the micronutrient content of the PM and FM mixtures expressed as a percentage of the lower of AI and RNI for infants aged <6 months. When mixed with water, sugar, and each micronutrient supplement, PM and FM provided <50% of the estimated required amounts of vitamins E and C and folic acid and the minerals iodine and selenium and <75% of the estimated required amounts of zinc and pantothenic acid. Either PM or FM made with the UNICEF micronutrient sachet provided 30% of AI for niacin. FM prepared with any micronutrient supplement provided no more than 32% of vitamin D. Because PMs are manufactured with added vitamin D, these preparations provided more than adequate amounts of vitamin D. Similarly, compared with commercial infant formula, the PM and FM mixtures provided 8–60% of the amount of vitamins A, E, and C and folic acid and manganese, zinc, and iodine. Preparations of PM and FM provide 200 mg linoleic acid (0.6% of total energy; 11% of minimum recommended) and 100 mg α-linolenic acid (0.29% of energy; 67% of minimum recommended) per 450 ml mixture, with a ratio of linoleic acid to α-linolenic acid of 2:1.

Cost and time

Table 4 shows the monthly cost of replacement milks compared with monthly income. As the costs of PM and FM were similar, these are listed together for comparison. Use of PM or FM represented approximately 20% of monthly income averaged over the first six months of life, while use of commercial formula represented approximately 32%.

It took 21–25 min to optimally prepare 120 ml of replacement feed from PM or commercial infant formula and 30–35 min for the fresh milk preparation. This included time to collect firewood and water from nearby sources, build a fire, boil the water, wash the utensils, and prepare the replacement milk mixture. The women who took part in this simulation were experienced in collecting wood and water and in fire building; all measuring devices were pre-marked. Table 5 shows the breakdown of time per component of preparation.

Discussion

This study suggests that PM and FM replacement milks made according to currently advised recipes in combination with different micronutrient supplements available in the South

Table 3. **Micronutrient content of prepared replacement milks**

Nutrient	Unit	Reference value			Fresh full cream milk[d]			Powdered full cream milk[e]		
		AI[a]	RNI[b]	Commercial infant formula[c]	Commercial supplement	Government supplement	UNICEF sachet	Commercial supplement	Government supplement	UNICEF sachet
Vitamin A	µg	400	375	1071 (286)[f]	318 (85)	318 (85)	228 (77)	355 (95)	355 (95)	265 (71)
Vitamin D	IU	200	200	185 (93)	64 (32)	64 (32)	54 (27)	236 (118)	216 (108)	206 (103)
Vitamin E	IU	4	2.7	3.65 (135)	0.3 (11)	0.3 (11)	1.3 (48)	0.1 (4)	0.1 (4)	1.1 (41)
Vitamin C	mg	40	25	30 (120)	9 (36)	9 (36)	13 (52)	13.1 (52)	9.1 (36)	13.1 (52)
Thiamine	µg	200	200	225 (113)	430 (215)	430 (215)	150 (75)	400 (200)	430 (215)	150 (75)
Riboflavin	µg	300	300	450 (150)	764 (255)	764 (255)	580 (193)	700 (233)	764 (255)	580 (193)
Niacin	µg	2000	2000	3150 (158)	2500 (125)	4500 (125)	600 (30)	2300 (115)	2500 (125)	600 (30)
Vitamin B6	µg	100	100	225 (225)	300 (300)	300 (300)	140 (140)	400 (400)	400 (400)	240 (240)
Folic acid	µg	65	80	27 (42)	15 (23)	15 (23)	20 (31)	12.1 (19)	12.1 (19)	12.1 (19)
Pantothenic	µg	1700	1700	1350 (79)	900 (53)	900 (53)	1300 (76)	800 (47)	800 (47)	1200 (71)
Vitamin B12	µg	0.4	0.4	0.9 (225)	1.2 (300)	1.2 (300)	1.4 (350)	1.3 (325)	0.7 (175)	0.9 (225)
Iron	mg	0.27	–[g]	3.6	0.9	0.3	1.8	3.0	2.4	3.9
Zinc	µg	2000	2800	2250 (113)	1200 (60)	1100 (55)	1305 (65)	1200 (60)	1100 (55)	1305 (65)
Copper	µg	200	–	180 (90)	0	0	100 (50)	100 (50)	100 (50)	200 (100)
Iodine	µg	110	57	45 (79)	15 (26)	0	5.6 (9)	15 (26)	0	5.6 (9)
Fluoride	µg	10	–	NA[h]	0	0	0	0	0	0
Magnesium	µg	30	36	20.3 (68)	36.6 (122)	36 (120)	36 (120)	33.8 (113)	33.2 (111)	33.2 (111)
Manganese	µg	3	–	20.3 (676)	14.2 (472)	14.1 (470)	21.6 (720)	2.2 (72)	2.1 (70)	9.6 (320)
Selenium	µg	15	6	NA	0	0	0	0	0	0
Calcium	mg	210	400	189 (90)	360 (171)	360 (171)	360 (171)	363 (173)	363 (173)	363 (173)

[a] Adequate intake (USDRI) for infants aged <6 months.
[b] Recommended nutrient intake (RNI FAO) for infants aged <6 months.
[c] 300 kcal per 450 ml, prepared from powder according to manufacturer instructions.
[d] 300 ml fresh full cream milk + 30 g sugar + 150 ml water with micronutrient supplement added (1 ml commercial or government liquid or 1 UNICEF sachet).
[e] 39 g full cream milk powder + 30 g sugar + 450 ml water with micronutrient supplement added (1 ml commercial or government liquid or 1 UNICEF sachet).
[f] Values in parentheses are percentage of lowest reference value for infants aged <6 months.
[g] Neonatal stores are sufficient to meet iron requirement for first 6 months in full term infants.
[h] No nutrient content listed.

Table 4. **Monthly cost of replacement milks by age of infant**

Infant age (months)	Fresh or powdered full cream milk[a]		Commercial infant formula	
	Cost (US$)	(% monthly income)	Cost (US$)	(% monthly income)
1	7.00	14	10.00	20
3	10.50	21	17.50	35
6	12.00	25	20.00	40
Average (0–6)	9.80	20	15.80	32

[a] Includes cost of milk, sugar, and micronutrient supplement.

African context do not provide adequate nutrients, are expensive in relation to average income, and need considerable time for optimal preparation. Home-prepared replacement milks made with UNICEF or local supplements provides amounts of vitamin C, vitamin E, folic acid, and pantothenic acid and zinc, copper, iodine, and selenium that most likely will not meet the needs of infants aged <6 months, despite stores of these nutrients that may have built up in utero. In addition, vitamin D is inadequate in all FM preparations, so whether infants have enough vitamin D may depend on their exposure to sunlight. Micronutrient deficiency in both HIV-infected and uninfected infants may be an unintended consequence of these feeding recommendations, although there is no current evidence that theoretical deficiencies in this age group will result in adverse clinical outcomes.

The South African Vitamin A Consultative Group estimates that nearly 25% of children 16–60 months are stunted, with increased prevalence of stunting in rural communities (*16*). The KwaZulu Natal Health Department's policy is to give infants who are not breastfed 50 000 IU vitamin A at age 6 weeks and 9 months. In the government clinics where the study was conducted, the availability of the paediatric liquid micronutrient supplement fluctuates and is sometimes unavailable. It generally is provided only if the infant is failing to thrive, regardless of the type of infant feeding. In the face of positive HIV status, poverty, and poor nutrition, use of PM and FM replacement milks seems to be a high-risk option with unknown potential negative consequences.

As there is no good basis for estimating the physiological micronutrient requirements of young infants, comparison with the intake of breastfed infants is assumed to be adequate, with both AI and RNI values used as reference values. In addition, we compared home-prepared replacement milks with a commonly used commercial infant formula. From our analysis, and taking into consideration the general lower bioavailability of nutrients in home-prepared replacement milks compared with breast milk, it seems that AI or RNI is a conservative estimate of need. It is interesting to note that as early as 1920, infantile scurvy was recognized as a result of cow's milk being fed to infants, and orange juice was given as a source of vitamin C (*17*). In addition, essential fatty acids were added to cow's milk-based infant formula preparations in the early 1960s (*17*).

Of equal or greater concern is that home-prepared replacement milks may not meet the essential fatty acid needs of young infants. Essential fatty acids are needed for cellular functions and as precursors of long-chain polyunsaturated fatty acids (*15*); early infancy seems to be a critical time for the incorporation of essential fatty acids into the membrane phospholipids of neural structures (*18*). Functional development of the retina and occipital cortex and long-term learning ability and visual function (*18*, *20*, *21*) may be affected by linoleic acid deficiency (*14*, *19*). Although 0.6% of energy as linoleic acid is enough to prevent essential fatty acid deficiency, it generally is recommended that infants be provided a minimum of 300 mg/100 kcal of linoleic acid (900 mg per 310 kcal replacement milk) or 2.7% of total energy (*13*). Ideally, the replacement milk for an infant who weighed 3 kg would provide 4–10% of total energy as linoleic acid, but the PM and FM products in South Africa provide 200 mg or 0.6% of total energy — i.e. 15% of the recommended amount.

Few studies have examined the biochemical, physiological, and developmental effects of feeding cow's milk to young infants or of replacement milks fed to infants in prevention of mother-to-child transmission programmes (*22*). The proportion of family income consistently needed to purchase replacement milks is a considerable burden for low-income families, and it may lead to overdilution of replacement milks. More than half of the population earns less than 6000 Rand per year (US$ 600 in 2002), and the cost of commercial infant formula averaged over 6 months represents approximately 32% of their monthly income, while the use of PM or FM represents 20%. Families may choose home-prepared replacement milks because they cost about 35–40% less than commercial formula.

On the basis of our findings, and taking into consideration that an infant needs replacement milks prepared 6–8 times per day, a mother may spend a minimum of 2.5 hours per day for optimal replacement milk preparation, not including the time taken to feed the infant. For rural women without access to tap water, electricity, or gas, this additional time is an important consideration and may result in the mother or caregiver taking shortcuts. The study women were a convenience sample of local women who participated in the course, so our replacement milk preparation times may not necessarily be

Table 5. **Time required for preparation of one replacement milk feeding**

Process	Average time (minutes)[a]
Collect wood	7 (5–9)
Collect water	5 (4–6)
Build fire	5 (4–6)
Boil water	3.5 (3–4)
Wash equipment	2.5 (2–3)
Measure and mix milk	4 (2–6)
Total	**27 (20–35)**

[a] Values in parentheses are ranges.

representative. In addition, sources of firewood and water were nearby: less than 1–2 minutes walk from the homestead. Our time estimates thus actually may be underestimates, if water and fuel sources are more than a few minutes away.

In developing countries, where HIV infection, hunger, and poverty are major problems, infant feeding counselling must aim to improve overall child survival not just avoidance of HIV transmission. Most babies of HIV-infected mothers, even in the absence of antiretroviral drugs, will not become infected with HIV (*23*). Therefore, the nutritional, developmental, and infectious outcomes associated with the use of PM and FM must also be considered before they are recommended as appropriate alternatives. To date, most of the discussion has focused on commercial formula as the option to replace breastfeeding for HIV-infected mothers.

When the nutritional and practical implications are considered, the following replacement milk options for infant feeding by HIV-infected mothers who choose not to breastfeed are suggested. Safely prepared exclusive commercial infant formula will meet all the nutrient needs of the infant if fed in amounts calculated to meet the infant's energy requirements. If such formula is not available and affordable in the volumes needed to meet the full nutritional needs of the infant, supplementation of commercial infant formula with a home-prepared replacement milk may be reasonable. Sole use of home-prepared replacement milks with available micronutrient supplement made up as currently suggested and the addition of 2.5 ml (0.5 teaspoon) soybean oil per day will better meet the essential fatty acid needs of the young infant. Soybean oil is recommended over other types of oil because it is high in linoleic acid and also contains α-linolenic acid. Intake of vitamin C, vitamin D, vitamin E, folic acid, and pantothenic acid and zinc, copper, selenium, and iodine still may be inadequate. These replacement milks are more appropriate for infants aged 6–12 months. Well chosen complementary foods, such as fresh orange juice, potatoes, dark green vegetables, and meats, can supplement the nutrients that replacement milk does not adequately provide.

Conclusion

No home-prepared replacement milks in this region of South Africa meet all the estimated micronutrient and essential fatty acid requirements of infants aged <6 months, and especially in the first months of life. Commercial infant formula is the only replacement milk that meets all nutritional needs. Revisions of the WHO/UNAIDS/UNICEF HIV and infant feeding course replacement milk options are needed. If replacement milks are to provide total nutrition, then, at the very least, the preparation should be altered to include addition of a vegetable oil such as soybean oil as a source of linoleic and α-linolenic acids. A micronutrient supplement could be developed to increase the content of selected "at-risk" vitamins and minerals. Home-prepared replacement milks, although cheaper than commercial infant formulas, are still expensive in relation to average income, and all require significant time to prepare safely. If PM and FM replacement preparations are recommended, outcomes should be monitored to ensure the infants' health and development are not jeopardized. Additional research on the nutritional adequacy and the feasibility of replacement milk options presented in the WHO/UNAIDS/ UNICEF guidelines for infants of HIV-infected mothers for the prevention of mother-to-child transmission is warranted.

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