

Is exclusive breastfeeding an option or a necessity in Africa? A pooled study using the deuterium oxide dose-to-mother technique

Helen Mulol,¹ Anna Coutoudis,¹
Waliou Amoussa Hounkpatin,²
Elisaphinate Urio,³ Philomène Kenguela
Wabolou,⁴ Yolande Sissinto,⁵
Khalid El-Kari⁶

¹Department of Paediatrics and Child Health, University of KwaZulu-Natal, Durban, South Africa; ²Department of Nutrition and Food Science, University of Abomey-Calavi, Benin; ³Tanzania Food and Nutrition Centre, Dar es Salaam, Tanzania; ⁴Centre for Outpatient Treatment (CTA), Community Hospital of Bangui, Central African Republic; ⁵Faculty of Health Sciences, University of Abomey-Calavi, Benin; ⁶National Centre for Energy, Sciences and Nuclear Techniques (CNESTEN), Rabat, Morocco

Abstract

Given the valuable health, development, and economic benefits of human milk Exclusive Breastfeeding (EBF) is recommended by the World Health Organisation for the first six months of an infant's life. Many resource-limited regions in Africa do not line-up with these recommendations, therefore EBF promotion efforts on the continent need to be scaled up and monitored. This study explores the human milk intake volumes of 5 countries (Benin, Central African Republic, Morocco, South Africa and Tanzania) both at country level and in a pooled sample of children at 3 months (n=355) and at 6 months (n=193). Mean human milk intake volumes in the pooled samples were 697.6 g/day at 3 months and 714.9 g/day at 6 months. EBF was determined both by maternal recall as well as using the deuterium oxide dose-to-mother technique, using two different cut-offs of non-milk oral intake. Comparison of these results showed substantial over-reporting of EBF by maternal recall, which suggests that actual rates of EBF are even lower than reported, thus highlighting the importance of scaling-up EBF promotion strategies.

Introduction

Exclusive Breastfeeding

Exclusive breastfeeding (EBF) is recommended by the World Health Organization (WHO) for the first six months for all infants,¹ and results in optimal infant health, growth and development.² However UNICEF (2016) reports show low EBF rates in many countries: regional EBF rates in Africa are 29-57% for 0-5.9 months and these values all decreased steadily over this period.³

One of the United Nations' Millennium Development Goals was to reduce under-5 mortality by two-thirds by 2015 and a study has shown that of the 10.8 million infants who die each year under the age of 5 years, 41% are found in sub-Saharan Africa⁴. A subsequent article showed that there was strong evidence that EBF for the first six months of life and continued breastfeeding for 6-11 months reduces diarrhoea and pneumonia, which are major contributors to infant morbidity and mortality.⁵ A pediatric cost analysis in the US which looked at 10 common infant diseases showed that if 90% of the infants in the US were EBF for 6 months 911 deaths would be prevented, of which 95% were infant deaths, and US\$ 13 billion would be saved annually in the US.⁶ A recent article stated that US\$ 302 billion would be added to the global economy and 800,000 child deaths prevented annually if EBF for 6 months was universally practiced.⁷ Improved breastfeeding practices could help achieve the recently formulated United Nations' Sustainable Development Goals by 2030, as breastfeeding affects many of the goals, such as alleviating poverty and improving nutrition, health and education.^{2,8} In an age of food insecurity and poverty in many African households, the contribution of mothers who could EBF for 6 months and continue breastfeeding afterwards would help to alleviate this food insecurity. An article, which studied four African countries, questioned whether human milk should be added to food production data and involved in policy making since it is such an important food resource for 10% of the population aged less than 3 years.⁹ Annual production figures for human milk in 1994 in sub-Saharan Africa were estimated at 5.38 million metric tons of human milk, or 10kg per head, which was just under half of the annual production of cow's milk at 11.53 million metric tons or 21.4 kg per head.

An article in francophone West Africa studied the monetary value of breastfeeding and calculated that to replace human milk with other commercial milk substitutes including the costs of water, fuel, bottles

Correspondence: Helen Mulol, Department of Paediatrics and Child Health, Nelson R Mandela School of Medicine, University of KwaZulu-Natal, 719 Umbilo Road, Durban 4001, South Africa. Tel.: +27 31 2604489 E-Mail: mulol@ukzn.ac.za

Key words: Exclusive breastfeeding, human milk intake, deuterium oxide dose-to-mother technique

Acknowledgements: The authors wish to acknowledge all the study participants and research assistants who were involved in this project.

Contributions: HM was involved in the study design, planned, conducted and analysed the samples for the South African study, analysed and interpreted the data at country level and as a pooled dataset; and prepared the draft of the manuscript. AC was involved in the study design, supervised the PhD research in South Africa and reviewed and edited the draft and final manuscript. KE, EU, PW, YS, WA were involved in the study design, planned and conducted the studies and analysed the samples in their respective countries. They also reviewed and edited the draft and final manuscript.

Conflict of interest: The authors declare no conflict of interests.

Funding: The projects were funded by the International Atomic Energy Agency (RAF 6039 and CAF 6003).

Received for publication: 12 July 2019.

Revision received: 26 February 2020.

Accepted for publication: 1 August 2020.

This work is licensed under a Creative Commons Attribution NonCommercial 4.0 License (CC BY-NC 4.0).

©Copyright: the Author(s), 2020

Licensee PAGEPress, Italy

Journal of Public Health in Africa 2020; 11:932

doi:10.4081/jphia.2020.932

and teats would cost 2 billion US\$ which amounted to 412 US\$ per infant per year or US\$ 1.13/day.¹⁰ They based their calculations on what they consider to be a conservative estimate of Human Milk Intake Volume (HMIV) of 714 mL/day from 0-5.9 months. At the time of their study up to 61% of families in the region lived on less than 1 US\$/day so the contribution of human milk to the family's food budget would not only alleviate them financially, but would also help to lower indirect costs that result from reduced infant morbidity. These financial, nutritional and health benefits of EBF, together with the added benefit of improved child spacing, could also help to break the

cycle of poverty experienced in many African countries. The long-term health benefits for the breastfed infant have also been widely documented² and there are also long-term economic benefits such as improved cognitive performance where breastfed infants scored higher in language and development tests than non-breastfed infants and EBF infants scored higher in cognitive development tests.^{2,11} The only cost associated with EBF would be the additional nutritional needs of the mother during lactation. The researchers in the West African study estimated the calorific value of producing a liter of human milk to be 940 kcal/liter, which amounted to a cost of US\$ 0.25 per 940kcal in the West African countries.¹⁰ Hence the cost of EBF is far less (US\$ 0.18/day) than the cost of formula feeding (US\$ 1.13/day), both based on the average human milk consumption of 714 mL/day. Apart from the monetary incentive of breastfeeding compared to formula feeding, human milk is nutritionally and immunologically superior to commercial human milk substitutes.² Another major burden for Africa as a continent is the high proportion of HIV-infections¹². Contrary to some doubts it has been shown that even HIV-infected mothers are able to produce sufficient human milk without compromising their own health¹³ and with the availability of maternal ARV treatment, the WHO now recommends that HIV-infected mothers should continue breastfeeding for 24 months or beyond, given the evidence which shows that the benefits of breastfeeding outweigh the risks of transmission if a mother is receiving ARV treatment and is virally suppressed.¹⁴ Their infants are thus able to receive the best nutrition and reduce the financial burden of using commercial human milk substitutes on government/households.

In developed countries such as Denmark, human milk is afforded a high monetary value - in 2010, donor mothers in Denmark were paid US\$24 per liter of human milk or US\$90 per liter when banked.¹⁰ This contrasts to the perception in some developing countries, which is sometimes aided by aggressive marketing of commercial human milk substitutes, that formula feeding is representative of a more modern lifestyle and breastfeeding can be seen as antiquated without proper education as to the superiority of human milk.

The WHO states that most women are capable of successful breastfeeding, which includes EBF for the first 6 months of life and there are just a few conditions that would justify using a human milk substitute on a temporary or permanent basis, *e.g.* infants with phenylketonuria or classic

galactosemia.¹⁵ In Egypt new measures were introduced recently to determine whether mothers were able to breastfeed before supplying them with subsidized infant formula, which included breast checks and required a doctor's letter.¹⁶ The policy was introduced as a measure to ease the country's national debt.

Globally 91% of the world's population has access to improved sources of drinking water, but for the least developed countries this figure is 69%.¹⁷ A similar trend exists for sanitation where globally 68% of the world's population has access to improved sanitation facilities, but for the least developed countries this figure is 37%.¹⁷ Rural communities are especially under-resourced with only half of rural communities having improved sanitation facilities and 20% having improved drinking water. Hence currently in Africa there are many communities where human milk is fortunately the only safe food that can be consumed even in areas with poor sanitation and unsafe drinking water. Human milk contains on average 87% water and even in hot countries, addition of water in otherwise EBF infants has been shown to be unnecessary and does not add any hydration benefit to the infant.¹⁸ Instead it results in reduced caloric intake, which can lead to early weaning and could also increase the incidences of diarrhoea if the water is not safe. Considering the plight of many communities in the world today who find themselves as refugees and who may be in camps, some of which have sub-optimal hygiene standards, EBF is even more important for infant survival, health and growth.

Measurement of Exclusive Breastfeeding

Measurement of EBF is often done by means of the mother's reported infant feeding, which may be subject to bias. The most common method used to assess current infant feeding practice is the 24-hour recall¹⁹ but surveys of EBF usually involve retrospective data from maternal recall which has been shown to be biased, especially in regards to EBF duration.²⁰ Hence even the published data on EBF rates could be an over-estimate of the actual rates.

The deuterium oxide dose-to-mother (DTM) technique can be used to objectively measure EBF as it can distinguish between an infant's HMIV and intake from other sources (*e.g.* formula, cow's milk, teas, juice, water). It was developed in 1982²¹ and standardised by the International Atomic Energy Agency (IAEA).²²

The only pooled study using the DTM technique to date provided data on HMIV²³ but provided no information on EBF since

the studies did not have a common protocol. Other studies that have looked at the difference between reported and measured EBF using the DTM technique have been undertaken and these all found differences between measured and reported EBF on a country level.²⁴⁻²⁸ This current study set out to investigate (1) the HMIV and EBF at 3 and 6 months following birth of the baby (2) some possible determinants of HMIV which had not been studied as part of the pooled human milk intake study²³ and (3) the agreement between reported infant feeding from the mother and infant feeding as determined by the DTM technique at 3 and 6 months following birth of the baby in a pooled dataset from African countries with a large sample size.

Materials and Methods

In this study, the reported infant feeding was done by means of a 24-hour recall of a list of possible foodstuffs that the mother gave to her infant *e.g.* water, milk, soups, juice, tea etc. and was reported as EBF only if it was in accordance with the WHO definition, *i.e.* human milk only with the exception of medicines, vitamins and mineral supplements.¹⁹

The DTM technique was used to determine HMIV and to objectively measure EBF and involves the mother consuming 30g of deuterium oxide (also known as labeled water, deuterated water or heavy water). Deuterium is a stable isotope of hydrogen, *i.e.* it is not radioactive and thus deuterated water is considered safe for use in all age groups. It mixes with the mother's body water, equilibrates rapidly and is distributed uniformly.²¹ A breastfeeding infant then consumes the deuterated water in its mother's milk and it can be detected in the infant's body water, which is sampled as saliva. Samples of saliva were collected from the mother and infant before the dose was provided and over a period of 14 days after the mother consumed the dose. The post-dose samples were subsequently analyzed for enrichment of deuterium compared to the pre-dose baseline saliva sample using a Fourier Transform Infrared Spectrometer. The DTM technique uses a model to calculate the total body water and curve fitting and calculations are performed using the method of least squares and the Solver function in an Excel[®] spreadsheet.²² If the infant is breastfed, the deuterium concentration in the infant's body water increases (labeled water) as it can only come from the mother's milk. In addition, quantitative information about consumption of water from other sources, non-milk oral

intake (NMOI) (unlabeled water), can be obtained using this method and this enables objective assessment of EBF. In this study an infant was reported as EBF using both the initially proposed cut-off value of ≤ 25 g/day NMOI²² and with the recently proposed new cut-off of ≤ 82.6 g/day NMOI.²⁹

Study Participants

Data for the analysis presented in this article were drawn from 5 countries that participated in various regional African projects supported by the IAEA (RAF 6039 and CAF 6003) to look at early infant feeding practices, namely Benin, Central African Republic, Morocco, South Africa and Tanzania. The data obtained was based on a common questionnaire and data sets were pooled after data cleaning had been completed for each country according to a set of common guidelines. This study enabled determination and pooling of HMIV data for all the 5 African countries at 3 months (n=355) and 4 of the African

countries at 6 months (n=193) using the DTM technique. Ethical Approval was obtained for each country undertaking the study in their respective countries.

Inclusion criteria for all the studies were that mother and infant were well (showing no clinical symptoms and having no medical history of chronic conditions), mother intends to breastfeed the baby and live close to the recruitment clinic after delivery. Exclusion criteria for the mother were pregnancy and unwilling to be visited at home. For the infant exclusion criteria were twins, any defect that could interfere with breastfeeding and infants with chronic illness *e.g.* congenital heart disease and cerebral palsy.

All analyses were carried out per country and in a pooled dataset. HMIV data was checked for normality using the Shapiro-Wilk test. Statistical analysis was carried out using STATA Version 13[®], Statacorp, Texas, USA. The Kappa analysis showed the strength of agreement between each mother's reported EBF and the results

obtained from the DTM method using both cut-offs for NMOI. The Kappa values were classified according to the strength of agreement as slight (0.01-0.20); fair (0.21-0.40); moderate (0.41-0.60); substantial (0.61-0.80) and almost perfect (0.81-1.0).^{30,31}

Results

Benin was the only country whose HMIV data at 3 months was not normally distributed ($P=0.0089$); at 6 months only South Africa displayed non-normal distribution ($P=0.0134$). As these data sets involved sample sizes over 40 it was decided to treat them using the usual parametric tests.³²

Table 1 shows the maternal and infant characteristics for all mother-infant pairs participating in the study per country and as a pooled dataset. Infant birth weights

Table 1. Maternal and infant characteristics.

Characteristic	BEN	CAR	MOR	SAF	TAN	Pooled
Birth weight (kg) ^a	3.1±0.5 (120)	3.0±0.4 (46)	3.6±0.5 (63)	3.1±0.5 (100)	3.0±0.6 (85)	3.1±0.5 (414)
Maternal age (y) ^a	27.2±6.0 (127)	28.7±4.8 (46)	30.2±5.6 (70)	24.9±5.4 (100)	27.8±5.6 (85)	27.4±5.8 (428)
Maternal HIV status ratio (uninfected / infected)	127/0	0/46	70/0	60/40	85/0	342/86
Maternal BMI ^b at 3 months	11 (8.7) / 77 (60.6) / 39 (30.7)	8 (17.4) / 31 (67.4) / 7 (15.2)	2 (2.9) / 21 (30.0) / 47 (67.1)	1 (1.2) / 31 (37.3) / 51 (61.4)	3 (3.5) / 61 (71.8) / 21 (24.7)	25 (6.1) / 221 (53.8) / 165 (40.1)
Maternal BMI ^b at 6 months	ND	8 (22.9) / 21 (60.0) / 6 (17.1)	1 (1.6) / 24 (38.1) / 38 (60.3)	3 (3.9) / 22 (28.6) / 52 (67.5)	1 (2.0) / 38 (74.5) / 12 (23.5)	13 (5.8) / 105 (46.5) / 108 (47.8)
Infant weight at 3 months (kg) ^a	5.5±1.4 (119)	5.9±0.9 (46)	6.4±1.0 (68)	6.6±1.0 (82)	6.1±1.2 (85)	6.1±1.2 (400)
Infant Gender (%) Male/Female	53.2/46.8	60.9/39.1	40.0/60.0	51.0/49.0	ND	50.9/49.1
HMIV at 3 months (g/day) ^a	660.1±210.1 (127)	733.3±182.9 (46)	503.3±130.9 (68)	914.2±210.6 (74)	705.2±207.6 (40)	697.6±234.2 (355)
Infant weight at 6 months (kg) ^a	ND	7.2±0.9 (35)	8.1±1.1 (53)	7.9±1.3 (77)	7.5±1.5 (51)	7.7±1.3 (216)
HMIV at 6 months (g/day) ^a	ND	719.0±199.5 (35)	560.2±141.3 (50)	890.2±286.8 (72)	575.2±260.9 (36)	714.9±276.4 (193)

^aMean±SD (n) ^bno. (%) underweight (<18 kg/m²) / normal (18-25 kg/m²) / overweight (>25 kg/m²). HIV, human immunodeficiency virus; BMI, body mass index; HMIV, human milk intake volume; BEN, Benin; CAR, Central African Republic; MOR, Morocco; SAF, South Africa; TAN, Tanzania; ND, no data.

Table 2. Bivariate linear regression of determinants of human milk intake for pooled data at 3 and 6 months.

Time point	3 months		6 months	
	Odds ratio ^a	P-value	Odds ratio ^a	P-value
EBF (DTM), NMOI ≤ 25 g/day	168.13	<0.001	208.23	0.004
EBF (DTM), NMOI ≤ 82.6 g/day	135.45	<0.001	267.56	<0.001
EBF (reported)	84.23	0.002	213.86	<0.001
Infant birth weight	-17.57	0.470	-30.60	0.420
Infant weight at time point	70.58	<0.001	40.02	0.012
Infant gender	62.31	0.020	81.64	0.059
Maternal BMI	3.96	0.132	5.32	0.198

EBF, exclusive breastfeeding; DTM, deuterium oxide dose-to-mother technique; NMOI, non-milk oral intake; BMI, body mass index. ^aUnadjusted.

ranged between 1.50–5.00 kg. Only 3 infants were <2.00 kg and 10 infants were ≥ 2.00 kg and <2.5 kg. There were a total of 14 missing birth weights (7 from Morocco and 7 from Benin). Only the Central African Republic and South African studies included all or some HIV-infected mothers, respectively. The Benin data were for the 3-month time point only, the other 4 countries had data for both 3- and 6- months following birth of the baby.

Figure 1 shows the box plots of HMIV at the 3-month and 6-month time points. The box plots showed a few, mostly maximum outliers at 3 months and a few, mostly minimum outliers at 6 months. At the 3-month time point South Africa recorded the highest mean HMIV of 914.2 g/day, which was significantly higher than all the other countries. All pairwise comparisons between the individual countries showed significant differences in the mean HMIV except when comparing Tanzania with Benin and with Central African Republic. At the 6-month time point the differences in mean HMIV amongst the different African countries persisted and only Morocco and Tanzania showed no significant difference in means.

Bivariate linear regression analyses were carried out to establish the possible determinants of HMIV on the pooled 3- and 6-month data from all countries. The results (Table 2) showed that current infant weight and EBF as determined by mother's report and objectively by the DTM technique using both cut-off values for NMOI were significant at both time points; maternal BMI and infant birth weight were not significant at either time point. Gender was significant at 3 months but was no longer significant at 6 months in the bivariate analysis.

Following multivariable linear regression of the HMIV for EBF as determined by the DTM technique and from the mother's report separately at both time points (Table 3), current infant weight remained significant for EBF as determined by all methods and at both time points. However, infant gender was no longer significant for all methods at 3 months.

Figure 2 shows the comparison of % EBF as determined objectively using both cut-offs and by mother's report. For some countries this resulted in substantial overestimation of EBF using mother's report compared to objectively determined EBF. Table 4 shows the Kappa analysis comparing each individual mother's report of EBF against the objective measure of EBF at country level and as pooled data.

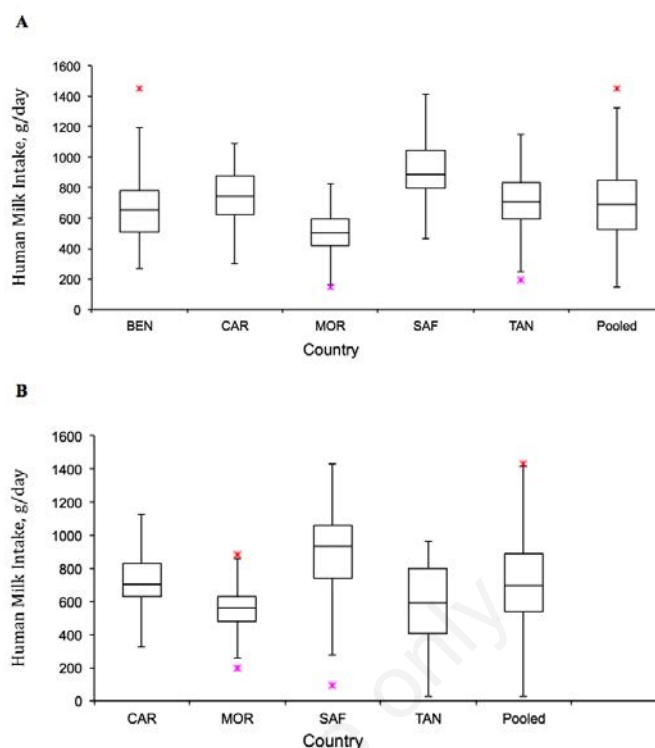


Figure 1. Box plots of human milk intakes at (A) 3 months and (B) 6 months.

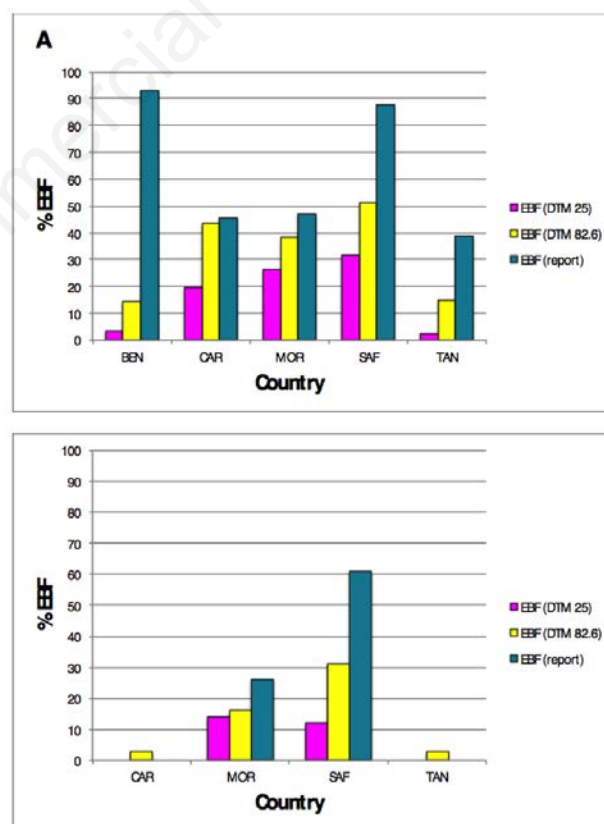


Figure 2. Exclusive breastfeeding rates at (A) 3 months and (B) 6 months. EBF, exclusive breastfeeding; DTM 25, deuterium oxide dose-to-mother technique non-milk oral intake ≤ 25 g/day; DTM 82.6, deuterium oxide dose-to-mother technique non-milk oral intake ≤ 82.6 g/day; BEN, Benin; CAR, Central African Republic; MOR, Morocco; SAF, South Africa; TAN, Tanzania.

Discussion

The pooled analysis gave a mean HMIV of 697.6 g/day at 3 months for the 5 African countries and 714.9 g/day at 6 months for the 4 African countries respectively, which is similar to the figure of 714 mL/day used to establish the cost of providing the additional nutritional needs of the mother during lactation¹⁰ and lower than the pooled study from 12 countries worldwide (mean HMIV of around 820 g/day at 3-4 months and at 5-6 months).²³ As could be seen from our study some countries *e.g.* South Africa exceeded this value for mean HMIV, which would increase the cost of providing additional nutrition for the mother but would

also increase the cost of replacing this if the mother was using commercial human milk substitutes.

The significance of current infant weight in the multivariate analysis of determinants of HMIV could be one of the reasons why South Africa had a much higher mean HMIV since infant weight at the 3-month time point was also the highest of all the countries and was significantly higher than the infant weight at 3 months in Benin ($P<0.0001$), Central African Republic ($P<0.0001$) and Tanzania ($P=0.0013$). In addition the South African study was set up to educate mothers as to the importance of breastfeeding and EBF and thus with improved EBF rates the amount of human

milk consumed by the infant also increased.

The EBF rates in Figure 2 showed that in particular Benin and Tanzania at 3 months and South Africa at 3 and 6 months had substantial over-reporting of EBF compared to the objective DTM method. The mother's report from Central African Republic at 3 months and Morocco at 3 and 6 months was closer to that obtained using the DTM method especially using the higher cut-off value. At 6 months mothers from Central African Republic and Tanzania all reported non-EBF and this was shown also by the DTM method using the lower cut-off.

The Kappa analysis in Table 4 showed that at the 3-month time point only

Table 3. Multivariate linear regression of determinants of human milk intake for pooled data at 3 and 6 months.

Time point	3 months		6 months	
	Odds ratio ^a	P-value	Odds ratio ^a	P-value
EBF (DTM), NMOI \leq 25g/d	144.03	<0.001	228.49	<0.001
Infant weight at time point	61.01	<0.001	45.11	0.004
Infant gender	44.15	0.081	-	-
EBF (DTM), NMOI \leq 82.6g/d	119.62	<0.001	273.32	<0.001
Infant weight at time point	62.36	<0.001	43.37	0.004
Infant gender	42.49	0.092	-	-
EBF (reported)	151.72	<0.001	209.28	<0.001
Infant weight at time point	79.86	<0.001	37.77	0.015
Infant gender	40.06	0.107	-	-

^aAdjusted. EBF, exclusive breastfeeding; DTM, deuterium oxide dose-to-mother technique; NMOI, non-milk oral intake.

Table 4. Comparison of mother's report of exclusive breastfeeding with exclusive breastfeeding as determined by the deuterium oxide dose-to-mother technique using two different cut-offs for non-milk oral intake.

Time point	Country	EBF (DTM), cut-off for NMOI	Measured agreement, %	Expected agreement, %	Kappa value	Classification
3 months	BEN	\leq 25g/day	10.24	9.79	0.0049	Slight
		\leq 82.6g/day	19.69	19.25	0.0054	Slight
	CAR	\leq 25g/day	47.83	52.65	-0.1018	Slight
		\leq 82.6g/day	50.00	50.57	-0.0115	Slight
	MOR	\leq 25g/day	79.41	51.38	0.5765	Moderate
		\leq 82.6g/day	73.53	50.69	0.4632	Moderate
	SAF	\leq 25g/day	36.49	36.71	-0.0035	Slight
		\leq 82.6g/day	51.35	52.05	-0.0145	Slight
	TAN	\leq 25g/day	62.50	64.25	-0.0490	Slight
		\leq 82.6g/day	65.00	60.50	0.1139	Slight
	POOLED (all)	\leq 25g/day	39.72	36.02	0.0578	Slight
		\leq 82.6g/day	45.63	42.12	0.0607	Slight
6 Months	CAR	\leq 25g/day	N/A	N/A	N/A	N/A
		\leq 82.6g/day	N/A	N/A	N/A	N/A
	MOR	\leq 25g/day	84.00	67.28	0.5110	Moderate
		\leq 82.6g/day	82.00	66.32	0.4656	Moderate
	SAF	\leq 25g/day	49.30	40.73	0.1446	Slight
		\leq 82.6g/day	57.75	45.45	0.2255	Fair
	TAN	\leq 25g/day	N/A	N/A	N/A	N/A
		\leq 82.6g/day	N/A	N/A	N/A	N/A
	POOLED (all)	\leq 25g/day	76.96	66.99	0.3021	Fair
		\leq 82.6g/day	78.53	63.40	0.4135	Moderate
	POOLED (excl. CAR, TAN)	\leq 25g/day	63.64	52.18	0.2396	Fair
		\leq 82.6g/day	67.77	51.46	0.3360	Fair

EBF, exclusive breastfeeding; DTM, deuterium oxide dose-to-mother technique; NMOI, non-milk oral intake; BEN, Benin; CAR, Central African Republic; MOR, Morocco; SAF, South Africa; TAN, Tanzania.

Morocco showed moderate agreement between reported and objectively measured EBF using both cut-offs. All the other countries investigated in this study and the pooled analysis gave Kappa values which were all <0.12 , showing only slight agreement using both cut-offs for the objective method, and many were close to 0 which represents an agreement expected by chance alone.

At the 6 month time point again only Morocco showed moderate agreement between reported and objectively measured infant feeding, the South African data only gave a Kappa value in the slight agreement range for the lower cut-off and fair agreement for the higher cut-off value. Central African Republic and Tanzania had no mothers who reported EBF hence the Kappa analysis was not feasible, however the results were included in the pooled analysis. For the pooled data at 6 months the Kappa values had improved to fair or moderate agreement between reported and objectively measured EBF, depending on the cut-off used for the objective method. It is possible that at 6 months the improved Kappa values could be due to the fact that although mothers know that EBF is best for the infant, many factors result in introduction of other liquids and foods into the baby's diet and at 6 months mothers are perhaps more likely to honestly reveal that other liquids and/or water have been added to the baby's diet as the recommended time for EBF of 6 months is close.

It is interesting to note that at the country level none of the Kappa analyses gave results in the substantial or almost perfect agreement ranges (Kappa >0.60), only Morocco had Kappa values in the moderate agreement range (0.41-0.60) and all other Kappa values were <0.23 . This is of great concern, especially where reported infant feeding has been used in studies as a measure of EBF and where national EBF rates are determined using reported EBF.

The UNICEF report showed EBF rates for the countries involved in this study from 0-5 months of 20-39% for Central African Republic and Morocco and 40-59% for Benin and Tanzania, while no current data was reported for South Africa.³ These contrasted with both the objective breastfeeding rates and reported EBF at 3 and 6 months established in this study, with Benin having the highest reported EBF rate of 93% at 3 months, yet an observed EBF rate of 3.2% or 14.2% depending on the cut-off used. Tanzania reported EBF rates of 38.8% at 3 months, which is close to the UNICEF data for this country³ yet the objective method showed EBF rates of only 2.5% or 15% depending on the cut-off used. Only

Morocco fell within the range of UNICEF EBF rates for both reported and objectively determined EBF rates using the lower cut-off. Hence it is possible that even the EBF rates reported by UNICEF could be underestimating actual EBF rates as most countries showed little correlation between reported and objectively determined EBF rates.

Conclusions

The results showed great variation between countries, both in the amount of human milk consumed by the infants and the correlation between reported and measured EBF. The pooled data for the Kappa analysis results showed only slight agreement at 3 months and fair or moderate agreement at 6 months between measured and reported EBF. At the country level, only Morocco showed moderate agreement at 3 and 6 months and the findings in all the other countries is of concern, as reported EBF is the method most commonly used to determine EBF rates. This leads to the conclusion that perhaps in Africa we are even further away from the goal of universal EBF than we think.

Given the challenges experienced on a daily basis in many regions of Africa, such as inadequate sanitation and drinking water supply, which can lead to increased risks of morbidity and the unsuitability of the use of commercial human milk substitutes, as well as the financial improvement that would be experienced in households that often experience food insecurity, the promotion and support of EBF is of paramount importance for African countries. Equally important therefore is the monitoring of these improvements and care should be given as to the method of choice of evaluation of EBF rates given the limitations of maternal recall.

References

1. WHO. Infant and young child nutrition: global strategy on infant and young child feeding. Geneva: 2002.
2. Victora CG, Bahl R, Barros AJD, et al. Breastfeeding in the 21st century: epidemiology, mechanisms, and lifelong effect. *Lancet* 2016;387:475-90.
3. UNICEF. "From the first hour of life" Making the case for improved infant and young child feeding everywhere, UNICEF data and analytics, Division of data, research and policy and nutrition section, New York: 2016.
4. Black RE, Morris SS, Bryce J. Where

and why are 10 million children dying every year? *Lancet* 2003;361:2226-34.

5. Jones G, Steketee RW, Black RE, et al. How many child deaths can we prevent this year? *Lancet* 2003;362:65-71.
6. Bartick M, Reinhold A. The burden of suboptimal breastfeeding in the United States: a pediatric cost analysis. *Pediatrics* 2010;125:e1048-56.
7. Rollins NC, Bhandari N, Hajeebhoy N, et al. on behalf of The Lancet Breastfeeding Group. Why invest, and what will it take to improve breastfeeding practices? *Lancet* 2016;387:491-504.
8. UN Sustainable development goals 2016. <http://www.undp.org/content/undp/en/home/sustainable-development-goals.html> (Accessed 09 July 2018).
9. Hatloy A, Oshaug A. Human milk: an invisible food resource. *J Hum Lact* 1997;13:299-305.
10. Aguayo VM, Ross J. The monetary value of human milk in Francophone west Africa: a PROFILES analysis for nutrition policy communication. *Food Nutr Bull* 2002;23:153-61.
11. Bernard JY, De Agostini M, Forhan A, et al. Breastfeeding duration and cognitive development at 2 and 3 years of age in the EDEN mother-child cohort. *J Pediatr* 2013;163:36-42.e1.
12. WHO Regional Office for Africa. Atlas of African Health Statistics 2018: universal health coverage and the Sustainable Development Goals in the WHO African Region, 2018.
13. Mulol H, Coutoudis A. Breastmilk output in a disadvantaged community with high HIV prevalence as determined by the deuterium oxide dose-to-mother technique. *Breastfeed Med* 2016;11:64-9.
14. WHO, UNICEF. Guideline: updates on HIV and infant feeding: the duration of breastfeeding, and support from health services to improve feeding practices among mothers living with HIV, Geneva: 2016.
15. WHO. Acceptable medical reasons for use of breast-milk substitutes, Geneva: 2009,1-11. http://apps.who.int/iris/bitstream/10665/69938/1/WHO_FCH_CAH_09.01_eng.pdf?ua=1 (Accessed 09 July 2018).
16. International Business Times, Sep 8, 2016. <http://www.ibtimes.co.uk/cash-strapped-egypt-check-if-mothers-can-breastfeed-before-supplying-subsidised-baby-formula-1580424> (Accessed 09 July 2018).
17. WHO. Progress on sanitation and drinking water. Update and MDG assess-

- ment, Geneva: WHO Press; 2015.
18. Sachdev HP, Krishna J, Puri RK, et al. Water supplementation in exclusively breastfed infants during summer in the tropics. *Lancet* 1991;337:929-33.
 19. WHO. Indicators for assessing infant and young child feeding practices. Part 1 Definitions. Geneva; 2008.
 20. Li R, Scanlon KS, Serdula MK. The validity and reliability of maternal recall of breastfeeding practice. *Nutr Rev* 2005;63:103-10.
 21. Coward WA, Cole TJ, Sawyer MB, Prentice AM. Breast-milk intake measurement in mixed-fed infants by administration of deuterium oxide to their mothers. *Hum Nutr-Clin Nutr* 1982; 36:141-8.
 22. International Atomic Energy Agency. Stable isotope technique to assess intake of human milk in breastfed infants, Human health series no. 7, Vienna: 2010. Available from: <https://www-pub.iaea.org/books/iaea-books/8168/Stable-Isotope-Technique-to-Assess-Intake-of-Human-Milk-in-Breastfed-Infants> (Accessed 09 July 2018).
 23. Da Costa TH, Haisma H, Wells JC, et al. How much human milk do infants consume? Data from 12 countries using a standardized stable isotope methodology. *J Nutr* 2010;140:2227-32.
 24. Moore SE, Prentice AM, Coward WA, et al. Use of stable-isotope techniques to validate infant feeding practices reported by Bangladeshi women receiving breastfeeding counseling. *Am J Clin Nutr* 2007;85:1075-82.
 25. Medoua GN, Sajo Nana EC, Ndzana AC, et al. Breastfeeding practices of Cameroonian mothers determined by dietary recall since birth and the dose-to-the-mother deuterium-oxide turnover technique. *Matern Child Nutr* 2012;8:330-9.
 26. Samuel TM, Thomas T, Bhat S, Kurpad AV. Are infants born in baby-friendly hospitals being exclusively breastfed until 6 months of age? *Eur J Clin Nutr* 2012;66:459-65.
 27. Motswagole BS, Matenge STP, Mongwaketse T, et al. Application of the deuterium-oxide dose-to-mother technique to determine the exclusivity of breastfeeding in women in Kanye, Botswana. *South Afr J Clin Nutr* 2015;28:128-33.
 28. Mulol H, Coutoudis A. Limitations of maternal recall for measuring exclusive breastfeeding rates in South African mothers. *Int Breastfeed J* 2018;13:19.
 29. Diana A, Liu Z, Luftimas D, et al. Development of a non-milk water intake cutoff to identify exclusive breastfed infants using the deuterium oxide dose-to-mother technique. *Ann Nutr Metab* 2017;71:1119.
 30. Viera AJ, Garrett JM. Understanding interobserver agreement: the kappa statistic. *Fam Med* 2005;37:360-3.
 31. Fleiss JL, Cohen J. The equivalence of weighted kappa and the intraclass correlation coefficient as measures of reliability. *Educ Psychol Meas* 1973;33:613-9.
 32. Ghasemi A, Zahediasl S. Normality tests for statistical analysis: a guide for non-statisticians. *Int J Endocrinol Metab*. 2012;10:486-9.