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# Behavior Change Communication and Breastfeeding Practices Measured by Deuterium-Oxide Turnover Method Among Infants Aged 4-5 Months in Rural Senegal

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**Abstract:** Breastfeeding promotion is widely recognized as one of the most cost-effective investments in promoting optimal child health, growth, and development. Several studies have shown that breastfeeding education and counseling interventions have a significant impact on improving breastfeeding practices, including exclusive breastfeeding (EBF) rates. However, very few studies have evaluated the association between breastfeeding education and infant breast milk intake. The objective of this study was to assess the contribution of behavior change communication provided by the Nutrition Enhancement Program (NEP) on improving infant breast milk intake and breastfeeding practices. A comparative cross-sectional study was conducted in 12 Local Communities in rural Senegal, of which 6 were located in the NEP intervention area and the remaining, in the non-intervention area. Breast milk intake and EBF were measured using the deuterium dose-to-mother isotope dilution (DTM) in 140 mother-infant (4-5 mo.) pairs. Breastfeeding and complementary feeding practices were also assessed by questionnaire. Student's t-test, ANOVA, chi-square test and McNemar test were used to compare means and percentages. A mixed model linear regression was performed to identify the associated factors of breast milk intake, measured by DTM. Breast milk intake was significantly higher in infants from the NEP area (994.7 ±197.3 g/d), compared to those from the non-NEP area (913.6 ± 222.8) g/d), p=0.023. Consumption of water from sources other than breast milk was not different between the groups. EBF rates measured by DTM were 37.0% and 28.4% in the NEP area and the non-NEP area, respectively. There was no difference on exclusive breastfeeding rate between the two areas regardless of evaluation method. Stunting and wasting were associated with lower milk intake of 107.1 g/d and 211.9 g/d, respectively. Mothers' participation in behavior change communication activities improved infants' breast milk intake, but not EBF rates. Lower breast milk consumption was associated with stunting and wasting.

**Keywords:** Breast Milk Intake, Exclusive Breastfeeding, Deuterium Dilution, Communication Intervention, Rural Senegal

# 1. Introduction

To improve child survival, breastfeeding is widely recognized as one of the most cost-effective investments [1]. Absence of breastfeeding has many short-term and long-term disadvantages for a child's health and development [2-4]. In developing countries, non-breastfed infants have 6 to 10 times higher risk of death during the first months of life than breastfed ones [4, 5]. Diarrhea and pneumonia, which are the leading causes of child death, are more frequent and more severe among non-breastfed infants [6]. Among mothers, breastfeeding reduces the risk of breast and ovarian cancer by 26% and 37% respectively, and the risk of type 2 diabetes by 32% [7]. On this basis, the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) has recommended early initiation of breastfeeding within one hour of birth, exclusive breastfeeding (EBF) for the first six (6) months and continued breastfeeding with diversified, adequate, safe, and age-appropriate complementary food until two years or beyond [8]. The EBF consists of giving only breast milk for the first 6 months of life, without any other food or water except medicines or syrups [9, 10]. Advantages of EBF compared to partial breastfeeding have been demonstrated for several decades by Feachem & Koblinsky, finding that the risk of death from diarrhea in partially breastfed infants aged 0-6 months was 6 to 8 times the risk for exclusively breastfed infants. For those who did not receive breast milk, the risk was 25 times higher than for those who were exclusively breastfed [11]. Recent studies have also confirmed the benefits of EBF on infants, including reduced risk of diarrheal diseases, respiratory and gastrointestinal infections and improved neurocognitive function [4, 12-14]. For the mother, EBF accelerates recovery of pre-pregnancy weight and is associated with longer duration of amenorrhea [7, 15, 16].

The World Health Assembly endorsed in 2012, through its resolution WHA65.6, the comprehensive implementation plan on maternal, infant and young child nutrition and set a series of six global nutrition targets among which to increase exclusive breastfeeding rates in the first 6 months of life to at least 50% by 2025 [17]. Despite the imminence of this deadline, EBF rates are well below 50% in most African countries [18]. In Senegal, only 41% of children under 6 months are exclusively breastfed [19]. Thus, there is an urgent need to accelerate efforts to scale up effective programs to promote exclusive breastfeeding. Several studies have shown that breastfeeding education and counseling interventions have a significant impact on improving breastfeeding practices, including early initiation of breastfeeding, EBF rates and continued breastfeeding [20-22]. The review conducted by Imdad et al. in 2011 concludes that EBF rates rose significantly as a result of educational interventions, with a greater effect observed in developing countries [22].

In Senegal, the Nutrition Enhancement Program (NEP) initiated by the *Conseil National de Developpement de la Nutrition* (CNDN), formerly the *Cellule de Lutte contre la Malnutrition* (CLM) since 2002, offers a set of community nutrition services in the country. Community nutrition sites are established in the intervention villages for the implementation of program activities. According to the last LQAS survey of 2021, EBF rates among 0 - 6 month-olds in the intervention area vary from 61% to 89% for Kaffrine and from 55% to 74% for Kaolack. However, these data do not allow for an accurate assessment of the actual level of the indicators and uptake of good breastfeeding practices. Indeed, these evaluations use the maternal recall to measure EBF in children under 6 months of age, whereas many studies have shown that this method tends to overestimate the real rates of this practice [23-25].

The deuterium isotope dilution technique (DTM) developed by Coward et al. [26] is a widely used method in human nutrition for assessing milk production and determining breastfeeding type. It allows the amount of breast milk consumed by the infant and the amount of water from sources other than breast milk to be accurately determined in order to objectively assess the type of breastfeeding. DTM has the advantage of being more accurate, less restrictive than the differential weighing method, does not interfere with infant feeding habits, and is easier to perform in the field [27-29]. In Senegal, two studies using this technique (DTM) were conducted in Dakar, the first in mother-infant pairs of 3 months to assess the impact of a food supplement on nutritional status and milk production [30] and the second in mother-infant pairs of 6 months to measure the coverage of the infant's energy needs [31].

Although the effect of counseling and education interventions on improving breastfeeding practices has been documented, their association with infant milk intake is underestimated. To our knowledge, only, the study conducted by Albernaz et al., in 2003 on a sample of 188 Brazilian infants assessed the impact of breastfeeding counselling on infant milk intake [32]. Thus, the objective of this study was to see if mother participation in behavior change communication activities improves breastfeeding practices as measured by DTM.

# 2. Method

### *2.1. Study Design*

This was a comparative cross-sectional study conducted in rural areas of Senegal (Kaolack and Kaffrine). The study was conducted in 12 local communities (LCs) selected by randomly drawing 6 LCs from each area. Of the 65 LC in the two regions, the program covers 48 LC (NEP area) where the entire NEP service package is implemented. In the remaining 17 LC (non-NEP area), no intervention is conducted by the CNDN, but women receive standard messages on IYCF through the media or health workers.

### *2.2. Study Setting*

The NEP has been implemented across the country since 2002. Phase 3 of the program was launched in 2017, covering 68%, of the country's local communities. Interventions are implemented from nutrition sites set up in villages or neighborhoods and management is entrusted to 2 community health workers. Pregnant, lactating women and children under 5 years of age benefit from a nutrition service package including: i) growth monitoring and promotion (GMP) which targets children under 2 years of age, ii) integrated management of childhood illnesses (IMCI-C), iii) early detection and management of acute malnutrition in children aged 6-59 months and iv) behavior change communication (BCC) targeting mothers/caregivers of children under two years of age for the promotion of exclusive breastfeeding (EBF), infant and young child feeding (IYCF), good hygiene and sanitation practices (WASH) for better nutrition. This communication is carried out by community workers through monthly nutrition education sessions focusing on 16 key topics including infant and young child feeding (IYCF), good hygiene and sanitation practices (WASH). Key messages delivered on IYCF include: "Practice early initiation of breastfeeding from birth", "Breastfeed infants exclusively from birth to 6 months", "Introduce appropriate diversified complementary feeding from 6 months", Continue breastfeeding up to 24 months". The benefits of these practices for the child and the mother are explained using picture boxes for better understanding. These sessions are coupled with growth monitoring and promotion activities targeting 0-24 months old children. The monitoring of the IYCF indicators, particularly the EBF rate is carried out by Lot Quality Assessment Sampling (LQAS) surveys every 6 months as well as from the Demographic and Health Surveys (DHS).

### 2.3. Participants, Recruitment and Inclusion Criteria

Participants were mother-infant (4 - 5.5 mo.) pairs living in the 12 LC targeted. For the NEP area, the mother-infant pairs were identified from the child follow-up records available at the nutrition sites. In the non-NEP area, mother-infant pairs were identified and recruited using the birth or immunization registers of the health facilities in each LC. In each LC, all mother-infant (4 - 5.5 mo.) pairs who met the inclusion criteria for participating in the study were included. Children suffering from severe acute malnutrition, diseases requiring hospitalization or congenital illnesses that do not allow the child to grow linearly (e.g. achondroplasia or Turner syndrome), as well as mothers suffering from diseases (such as mastitis) that prevent them from breastfeeding their children properly, were not included in the study.

### 2.4. Sampling and Sample Size

Sampling was carried out at two levels. In each area, 6 LC were randomly drawn. The sample size was calculated from the national EBF rate of 24% among children aged 4-5 months [33] with the formula of Machin et al., [34] to detect a 20% difference in EBF rate between NEP area and non-NEP area using the DTM. Considering a power of 80%, a significance level of 95% with a design effect of 1.05, the required sample size is 121 mother-infant pairs (i.e. 60/area). Due to the cumbersome nature of the DTM method, a drop-out rate of 20% was considered; thus the final sample size is 75 mother-infant pairs per group, i.e. an overall sample of 150 pairs.

### 2.5. Data Collection

#### 2.5.1. Measure of Breast Milk Intake and EBF Rate Using DTM

The principle consists of administering an oral dose of 30 g of deuterium with a minimum purity of 99.8% (Europa Scientific, Ltd, UK) and monitoring its disappearance in the mother and its appearance in her infant through breast milk [29, 35]. Deuterium is a stable isotope of hydrogen (non-radioactive) that exists in nature, in water and in food. It is administered orally as deuterium oxide at a dose that is not harmful to humans (max 0.1%) and has no toxicity [36]. The dose administered to the mother is homogeneously distributed in her body water and thus appears in breast milk. Thus, the breastfed infant receives deuterium through breast milk, which also enriches their body water [28, 35]. This method is very sensitive because deuterium enrichment of the infant's saliva can only come from breast milk. Saliva samples were taken with sterile cotton balls from the mother-infant pair before the dose (pre-doses) at day 0 (D0) to determine the baseline level and over a period of 14 days (D1, D2, D3, D4, D13 and D14) after the dose. Deuterium enrichment of saliva samples was measured with a Fourier Transform Infrared Spectrometer (FTIR Shimadzu IR Affinity, Kyoto, Japan). Samples were measured in duplicate with a coefficient of variation (CV) less than 1% for all enrichments retained in the analysis. A set of assumptions and equations have been developed by several authors for the calculation of human milk intake (HMI) and water from sources other than human milk intake (NMOI) by infants [29, 37, 38]. The enrichment values of the mother-infant pair were entered in an Excel spreadsheet that integrates all the equations and with the Solver function that allows to adjust the enrichment of the samples over 14 days. Classification of breastfeeding type was based on the intake of water from sources other than breast milk (non-milk oral intake) according to recommended thresholds [39]. EBF was defined as a non-milk oral intake < 86.6 g/d.

#### 2.5.2. Anthropometry

The weight and height of the mothers and their infants were measured in duplicate on the first day (D0) and the 14th day (D14) of saliva sample collection. The weight of the mothers was measured to the nearest 100 g using an electronic scale (SECA 874 U, GmbH & Co, Hamburg, Germany). Infants were weighed without any clothing using an electronic baby scale (SECA 354, GmbH & Co, Hamburg, Germany) with a maximum capacity of 20 kg and an accuracy of 10 g. The mother's height and the length of the infant were measured at 0.1 cm with a Seca board (SECA 216, GmbH & Co, Hamburg, Germany). For the mothers, body mass index (BMI; $kg/m^2$) was calculated and mothers were categorized as underweight ($<18.5$ $kg/m^2$), normal weight (18.5 to 24.9 $kg/m^2$), overweight (25 to 29.9 $kg/m^2$) and obese ($\geq 30$ $kg/m^2$) [40]. Among infants, weight-for-length z-scores (WLZ) and length-for-age z-scores (LAZ) were calculated and they were classified as wasted (WLZ $< -2$ z-score) or stunted (LAZ $< -2$ z-score) using the WHO child growth standard reference [41].

#### 2.5.3. Infant Feeding Practices and Characteristics of Households and Mothers Assessed by Questionnaire

Information on initiation of breastfeeding, exclusive breastfeeding, use of infant formula and complementary feeding was collected by the WHO IYCF questionnaire [42, 43]. Mothers were asked whether the child was still breastfeeding; whether they had already started giving water or complementary foods to their child, and if so, at what age.

Socio-economic data, household food security, breastfeeding patterns, knowledge, attitudes and practices (KAP) of mothers and infant morbidity were collected using a questionnaire. A socio-economic status (SES) index was generated using principal component analysis based on household characteristics (household occupancy, source of drinking water, type of sanitation facilities, type of fuel used for cooking) and possession of durable goods (household equipment and livestock) [44]. Based on the index score of each household, a household SES indicator consisting of 3 categories (lowest, medium and acceptable) was obtained. Household food insecurity was assessed using the Household Food Insecurity Access Scale (HFIAS) [45]. Data on children's immunization against BCG, Polio, Pentavalent and Pneumococcus were collected from children's health records. A 15-day recall was conducted to assess common childhood illnesses such as fever, diarrhea and acute respiratory infections. Fever is defined as a body temperature higher than normal as reported by the mother. Diarrhea is defined as more than 3 loose or watery stools in one day. Acute respiratory infections are defined as diseases of the respiratory system, nasopharynx, and lungs. All questionnaires were administered on the first day (Day 0) of the EBF measurement with the DTM.

### 2.6. Statistical Analysis

Data entry and processing were performed using Epi-info 3.5.1 (Centers for Disease Control and Prevention, Atlanta, USA), and Microsoft Excel 2016 (Microsoft Corporation, Redmond, USA). Statistical analysis was performed using STATA/SE 12.0 (STATA Corporation, Texas, USA). Categorical variables were expressed as percentages (%), and continuous variables were expressed as mean ± standard deviation (M±SD), for normally distributed variables and median with interquartile range (Me [P25; P75]) for skewed values. Student's t-test and analysis of variance (ANOVA) were used to compare means, while the Wilcoxon Mann-Whitney test was used to compare medians between groups. Pearson's chi-square test and Fisher's exact test were used to compare percentages. McNemar test was used to compare the two methods of measuring EBF.

A mixed model linear regression was performed to determine factors associated with infant milk intake. All socio-economic and dietary variables, as well as those related to maternal and infant characteristics, which were significant at $P<0.1$ in the binary regressions with infant milk consumption, were included in a multiple model controlling for a random group effect. The age of the child at the time of measurement (D0) was included as a covariate, as breast milk consumption and breastfeeding status changed with age. For all statistical analyses, a P-value < 0.05 was used for significance.

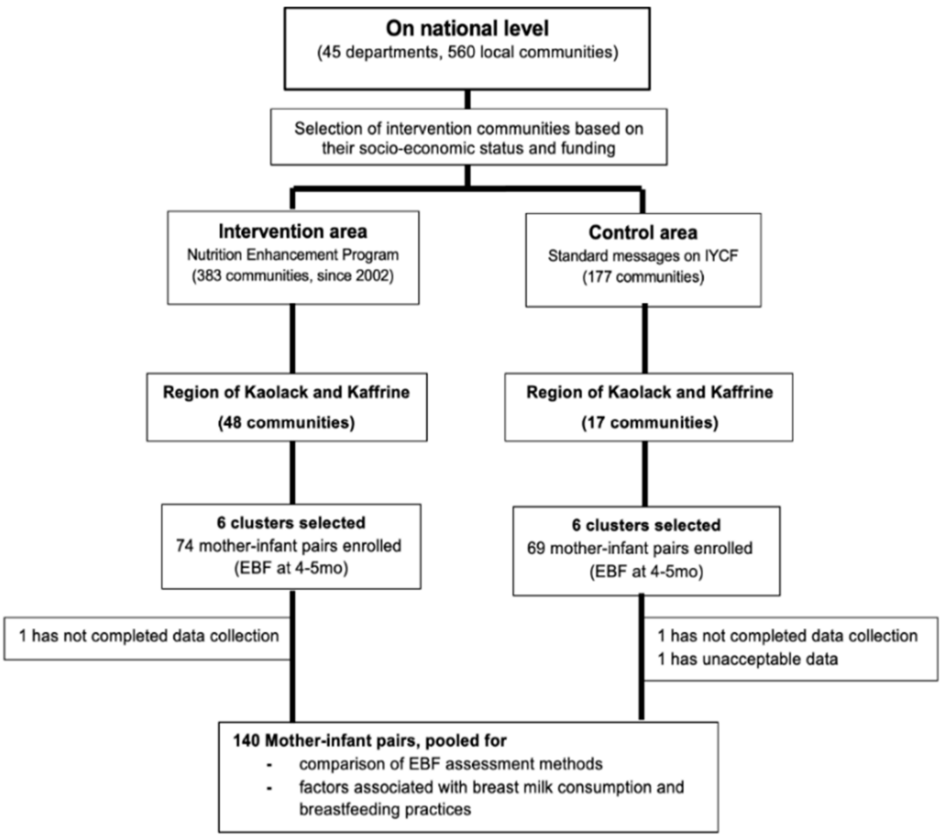


***Figure 1.*** *Study profile.*

# 3. Results

### 3.1. Characteristics of the Study Population

In each LC, all mother-infant (4-5 mo.) pairs that met the inclusion criteria were included in the study. Only two cases of refusal were recorded and this was due to the absence of the heads of household who had to agree to participate in the study. A total of 143 mother-child pairs were involved in the study. Of these, 2 did not complete the collection of saliva samples in the field and 1 had physiologically unacceptable data after enrichment measurements. Thus, 140 pairs had complete data and were retained for the overall analysis (Figure 1).

Data on mother-infant pairs households are presented in Table 1. The results showed that in the NEP area all heads of household were male, while in the non-NEP area there were 4.5% female heads, with no difference between the two areas. The average number of children under 5 years of age was comparable between the two areas. Both areas had the same socio-economic characteristics, with more than 50% of households in the middle and low categories. Food insecurity affected 38% and 37% of households in the NEP and non-NEP areas, respectively. There were no significant differences in socio-economic and food characteristics between the two areas.

***Table 1.*** *Characteristics of mother-infant pair's households.*

| Characteristics | NEP-area (n=73) | non-NEP-area (n=67) | *P* value |
|---|---|---|---|
| | M ± SD or % | M ± SD or % | |
| Head of household gender | | | |
| *Male* | 100 (73) | 95.5 (64) | 0.068 |
| *Female* | - | 4.5 (3) | |
| Number of children under 5 years | 3.0 ± 1.4 | 3.6 ± 2.3 | 0.094 |
| Socio-economics status | | | |
| *Low* | 37.0 (27) | 29.8 (20) | 0.096 |
| *Medium* | 38.4 (28) | 28.4 (19) | |
| *Acceptable* | 24.7 (18) | 41.8 (28) | |
| Household food insecurity | | | |
| Food insecure | 38.4 (28) | 37.3 (25) | 0.733 |
| *Mildly food insecure* | 12.3 (9) | 14.9 (10) | |
| *Moderately food insecure* | 16.4 (12) | 10.4 (7) | |
| *Severely food insecure* | 9.6 (7) | 11.9 (8) | |

M ± SD mean ± standard deviation; % (n): percentage (number)

### 3.2. Characteristics of Mother and Infant

The characteristics of mothers and infants by group are detailed in Table 2. The mean age of the mothers (25 ± 5 years) was comparable between the two areas. Mothers were mostly multiparous (73%) and the distribution of ethnic groups was identical in both areas, with a predominance of Wolof/Lebou ethnic (68.5% NEP-area vs. 65.7% non-NEP-area). More than half (63.6%) of the mothers were illiterate and very few (3.6%) had attained middle or higher education. The proportion of mothers living in polygamous households was significantly higher in the NEP intervention area (45.2%) than in the non-NEP-area (25.4%) (p=0.014). Mother's BMI mean was similar in the two groups (22.1 ± 4.3 kg/m$^2$). According to the WHO classification, 21.4% of them were underweight (BMI<18.5 kg/m$^2$) while 16.4% and 6.4% were overweight (25<BMI<30 kg/m$^2$) and obese (BMI>30 kg/m$^2$), respectively.

For infants, the mean age was 4.9 ± 0.5 months; 52.9% were boys, and almost all were correctly vaccinated (99.3%) with no difference between the two areas. Regarding morbidity during the last 15 days prior to the study, the prevalence of diarrhea and acute respiratory infection were significantly higher among infants in the non-NEP-area compared to those in the NEP-area (p<0.05). The mean WHZ and LAZ indices were comparable between the two groups, as were the proportions of stunting and wasting.

***Table 2.*** *Mother-infant pair characteristics.*

| Mothers | NEP-area (n=73) | non-NEP-area (n=67) | *P* value |
|---|---|---|---|
| | M ± SD or % | M ± SD or % | |
| Age (year) | 26 ± 5 | 24± 5 | 0.274 |
| Parity | | | |
| *Primiparous* | 19.18 (14) | 34.33 (23) | 0.042 |
| *Multiparous* | 80.8 (59) | 65.7 (44) | |
| Marital status | | | |
| *Married* | 98.3 (72) | 100 (67) | 0.336 |
| *Divorced/widowed* | 0.7 (1) | 0 (0) | |
| Ethnicity | | | |
| *Wolof/Lebou* | 68.5 (50) | 65.7 (44) | 0.153 |
| *Serere* | 11.0 (8) | 10.4 (7) | |
| *Pulaar* | 12.3 (9) | 22.4 (15) | |

| Mothers | NEP-area (n=73) | non-NEP-area (n=67) | *P* value |
|---|---|---|---|
| | M ± SD or % | M ± SD or % | |
| *Others* | 8.2 (6) | 1.5 (1) | |
| Education | | | |
| *None* | 65.7 (48) | 61.2 (41) | 0.485 |
| *Primary school* | 26.0 (19) | 23.9 (16) | |
| *Secondary school* | 6.8 (5) | 9.0 (6) | |
| *High school/University* | 1.4 (1) | 6.0 (4) | |
| BMI ($kg/m^2$) | 22.1 ± 4.1 | 22.1 ± 4.6 | 0.951 |
| *Underweight* | 19.2 (14) | 23.9 (16) | 0.726 |
| *Normal weight* | 60.3 (44) | 50.7 (34) | |
| *Overweight* | 15.1 (11) | 17.9 (12) | |
| *Obese* | 5.5 (4) | 7.5 (5) | |
| Infants | | | |
| Age (month) | 4.9 ±0.5 | 4.9 ± 0.5 | |
| Sex | | | |
| *Boys* | 49.3 (36) | 56.7 (38) | 0.381 |
| *Girls* | 50.7 (37) | 43.3 (29) | |
| Immunization[a] | 100 (73) | 98.5 (66) | |
| Morbidity | | | |
| Diarrhea | 30.1 (22) | 58.2 (39) | 0.001 |
| Fever | 15.1 (11) | 17.9 (12) | 0.650 |
| Acute respiratory infection | 2.7 | 11.9 | 0.035 |
| WLZ | -0.2 ± 1.1 | 0.08 ± 1.0 | 0.154 |
| Wasting | 8.2 (6) | 6.0 (4) | 0.606 |
| LAZ | -0.5 ± 1.1 | -0.5 ± 1.0 | 0.879 |
| Stunting | 11.0 (8) | 7.4 (5) | 0.476 |

M ± SD mean ± standard deviation; % (n): percentage (number); BCC Behavior Change Communication; BMI: body mass index; WLZ: weight-for-length z-score; LAZ: length-for-age z-score; Underweight: BMI < 18.5 $kg/m^2$; normal weight: 18.5 ≥ BMI < 25 $kg/m^2$; overweight: 25 ≤ BMI ≥29.9; obese: BMI ≥30 $kg/m^2$; wasting: WLZ < −2 z-score; stunting: LAZ < −2 z-score
[a]Both BCG, Polio, Pentavalent, Hepatitis B, and Pneumococcal vaccines.

### *3.3. Breast Milk Intake, Non-Milk Oral Intake and Breastfeeding Practices in Both Area*

Data on breastfeeding and infant feeding practices measured by DTM and questionnaire are presented in Table 3. The average breast milk intake per day was significantly higher among infants in the NEP-area (994.7 ± 197.3 g/d) compared to those of non-NEP-area (913.6 ± 222.8 g/d) p=0.023. But the daily intake of water from sources other than breast milk consumed by the infants was comparable between the two areas. According to the DTM, 37% and 28.4% of infants were exclusively breastfed in the NEP-area and non-NEP-area, respectively. However, according to the mothers' declaration, 46.6% of the infants in the NEP-area and 44.8% of those in the non-NEP-area were exclusively breastfed. No difference was observed in exclusive breastfeeding practices between the areas, regardless of the evaluation method. Other practices such as early initiation of breastfeeding, giving water to the infant and early introduction of complementary feeding were comparable between the two groups. The comparison between the two methods of measuring breastfeeding practices showed a significant difference between the exclusive breastfeeding rate measured by the DTM and that obtained by the questionnaire (p=0.016; 95%CI [-0.28; -0.01]).

***Table 3.*** *Breast milk intake and breastfeeding practices.*

| | NEP-area (n=73) | non-NEP-area (n=67) | *P* value |
|---|---|---|---|
| Breastfeeding practices (DTM) | | | |
| Human milk intake (HMI) (g/d) M±SD | 994.7 ± 197.3 | 913.6 ± 222.8 | 0.023 |
| Non-milk oral intake (NOMI) (g/d) Me [25e – 75e] | 123 [44 – 226] | 155 [75 – 260] | 0.105 |
| *EBF* | 37.0 (27) | 28.4 (19) | 0.278 |
| *Non-EBF* | 63.0 (44) | 71.6 (46) | |
| Breastfeeding practices (questionnaire) (%) | | | |
| *EBF* | 46.6 (39) | 44.8 (37) | 0.863 |
| *Non-EBF* | 53.4 (36) | 55.2 (34) | |
| Infant feeding practices (%) | | | |
| *early initiation of breastfeeding* | 74.0 (54) | 70.1 (47) | 0.614 |
| *Infant receiving water* | 37.0 (27) | 49.2 (33) | 0.143 |
| *eating porridge* | 15.1 (11) | 20.9 (14) | 0.369 |
| *eat the family meal* | 1.4 (1) | 4.5 (3) | 0.270 |

M ± SD: mean ± standard deviation; Me [25e – 75e]: median with interquartile range; % (n): percentage (number);
DTM: deuterium-oxide turnover method; g/d: gram/day; EBF: exclusively breastfeeding infants; Non-EBF: Non-exclusively breastfeed

### *3.4. Factors Associated with Infant Breast Milk Intake*

All socio-economic and dietary variables as well as those related to maternal and infant characteristics that were significant at P<0.1 in the binary mixed model linear regressions with infants milk intake were entered into multiple linear regression analyses. The results in Table 4 showed that participation in behavior change communication activities was associated with a higher consumption of breast milk by infants of 87.7 g/d compared to the mothers in the Non-NEP area (p=0.032). The type of breastfeeding was also associated with infant milk intake. Non-exclusively breastfed infants consumed 104.6 g/d less milk compared to exclusively breastfed infants (p=0.002). Giving infants porridge reduced their breast milk intake by 156.7 g/d (p<0.001). Significant negative associations were found between lower milk intake and infant nutritional status. Stunted and wasted infants had a lower breast milk intake of 107.1 g/d (p=0.044) and 211.9 g/d (p=0.001) respectively, compared to infants with normal nutritional status.

***Table 4.*** *Factors associated with infant's breast milk intake.*

| HMI (g/d) | β coefficient | 95% CI | *P* value |
|---|---|---|---|
| NEP-area | 87.7 | 7.5; 167.8 | 0.032 |
| EBF | 104.6 | 37.7; 171.4 | 0.002 |
| Porridge consumption | -156.7 | -245.5; -67.9 | 0.001 |
| Stunting | -107.1 | -211.5; -2.6 | 0.044 |
| Wasting | -211.9 | -329.2; -94.6 | 0.001 |

HMI: Human milk intake, g/d: gram/day, BCC: behavior change communication, EBF: exclusive breastfeeding

## 4. Discussion

This study using the isotope method to assess breast milk intake and exclusive breastfeeding practices is the first to be conducted in rural Senegal. It implies the use of precise methods in the monitoring and evaluation of programs to better assess their impact. Several studies have shown that breastfeeding counseling and education interventions improve the rate and duration of exclusive breastfeeding and the continuation of breastfeeding [20-22], however, their association with infant milk intake is under-estimated [32].

This finding showed that infants in the NEP area, whose mothers participated in breastfeeding education and counseling activities, consumed more breast milk than infants in the non-NEP zone. Indeed, a variation of 87.7 g/d was observed between infants in the two groups, and this variation was not related to the age of the children or to other potential confounding variables. This implies that mothers' participation in breastfeeding education and counselling improved their knowledge and predisposition to breastfeed their children correctly and more frequently. A similar result was observed in a recent study in Benin, where mothers participating in the breastfeeding education program were more likely to breastfeed their children more frequently and for longer [46]. However, our results differ from that of Albernaz et al. who found no significant difference in breast milk intake between a control group and a group receiving breastfeeding counseling [32]. Nevertheless, a difference of 38 ml/d in favor of the latter group was found in this study despite the relatively small sample size and low statistical power of the comparisons, which may have limited the effect of breastfeeding counseling on infant breast milk intake.

This analysis showed that exclusive breastfeeding was associated with higher breast milk consumption. This result is consistent with the fact that exclusively breastfed infants received only breast milk, while non-exclusively breastfed infants received water or other foods that decreased their breast milk intake. Indeed, infants who were given porridge had a 156.7 g/d decrease in breast milk intake. The early introduction of water and complementary foods results in a reduction in the frequency of feedings and thus a decrease in the amount of breast milk consumed by the infant [28, 31, 46]. The infant's daily intake of breast milk was also higher than WHO estimates for exclusively breastfed infants [47]. However, studies have shown that breast milk intake during this period can vary from 400 to 1200 g/d [47, 48]. The WHO estimates are based on a compilation of data usually obtained by differential weighing, whereas several studies have shown that breast milk intakes measured by the deuterium isotope dilution method are generally higher than the WHO values [49, 50]. In addition, the authors of these estimates concluded that the corresponding milk production rates represent only a small group of women and therefore do not reflect the variability in milk production and infant nutrient requirements in the population [47]. The amounts of breast milk consumed by infants in the present study are comparable to values found by other studies using the same isotopic technique in Senegalese infants less than 6 months of age [30, 31].

The association between infant milk intake and nutritional status, established in this study, has rarely been studied in the literature. Indeed, most studies in this area have focused on the relationship between the type of breastfeeding and nutritional status [51, 52]. Our results showed that stunted and wasted children had significantly lower breast milk intakes than those with normal nutritional status. Although the average breast milk intake according to the nutritional status of the infants was not presented in the study, the average among of milk consumed by stunted and wasted infants was low and below the WHO recommendations. This result reinforces the evidence for the importance of optimal breastfeeding for child growth, health, and development.

Several studies have reported that breastfeeding education and counseling interventions have positive effects on improving breastfeeding practices on both exclusivity and duration of breastfeeding [53, 54]. However, the majority of infants in both areas of this study received water and/or other fluids or complementary foods. This showed that the intervention was not effective in changing the practice of giving water to infants under 6 months of age, which is the main problem with EBF practice in African countries [55]. But, the effectiveness of the communication interventions may depend on several factors including the approach to counseling, the qualification of the actors, and the frequency of sessions [56, 57]. The assessment showed that the number of times women had attended breastfeeding education and counseling sessions in the last 6 months prior to the study was low compared to the WHO recommendation of at least 6 sessions in the pre- and post-natal period. In addition, Mcfadden et al. showed in a recent review that breastfeeding counseling interventions were effective with at least 4 sessions in the postnatal period [53], which was not achieved in the NEP program. The WHO also recommends that counseling should be face-to-face or by telephone, whereas in the NEP program, communication mostly occur in group during growth monitoring and promotion sessions, which may alter mothers' focus on the counseling given and thus affect their knowledge and practice of breastfeeding. In addition, some head nurses in the comparison area have taken initiatives to counsel or educate mothers on breastfeeding, health and hygiene during child immunization sessions. Some mothers also in this zone may receive advice on infant and young child feeding through the media. All this has potentially improved some mothers' knowledge of breastfeeding practices in this area.

EBF rates obtained from mother's self-reporting and accurately measured by DTM were compared in this study. The results showed that the questionnaire overestimated by more than 12% the rate of exclusive breastfeeding objectively measured by DTM in mothers of children aged 4-5 months in rural Senegal. The discrepancy between these two methods found in this study can be explained by the fact that a significant number of women give water to their infants while claiming to practice exclusive breastfeeding. Whereas the isotopic method is very sensitive to the amount of non-milk water received by the infant. Furthermore, having heard at least once about the importance of EBF, mothers tend to respond positively to exclusively breastfeeding their infant with the questionnaire; even if they do not practice it. Several authors have found similar results with sometimes larger differences (40%) between these two methods, notably in Cameroon [23], Morocco [58] and Guatemala [24]. Other studies in Malaysia and Botswana also showed that 100% of mothers reported exclusively breastfeeding their infants by questionnaire, whereas only 3% and 61.2% of infants were exclusively breastfed by the isotopic method in the studies by Yong et al [25] in rural areas and Motswagole et al. [59] in urban areas, respectively.

# 5. Conclusion

This study, conducted for the first time in rural Senegal, showed the benefits of behavior change communication in improving human milk intake among 4-5 months aged infants. However, the exclusive breastfeeding rate remains low in rural setting in Senegal despite the behavior change communication intervention received by the mothers through the NEP. This finding highlights the need to improve the communication strategy in accordance with the WHO guidelines on counseling mothers to better promote exclusive breastfeeding until 6 months for optimum infant growth.

Our result confirms that maternal recall questionnaire overestimated the rate of exclusive breastfeeding compared to that measured using DTM. This implies the need to use more accurate methods such as DTM to objectively monitor and assess the impact of breastfeeding promotion programs and interventions. In addition, it would be interesting to see if improved breastfeeding practices, particularly the adequacy of breast milk intake, are associated with subsequent improvements in infant growth, motor and cognitive development.

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# References

[1] United Nations International Children's Emergency Fund (UNICEF). (2013). Améliorer la nutrition de l'enfant. Un objectif impératif et réalisable pour le progrès mondial. New York.

[2] Fewtrell MS. (2004). The long-term benefits of having been breastfed. *Current Pediatrics* (14). doi: 10.1016/j.cupe.2003.11.010.

[3] World Health Organization (WHO). Evidence on the long-term effects of breastfeeding: systematic reviews and meta-analyses. Geneva: World Health Organization; 2007.

[4] Cesar G Victora, Rajiv Bahl, Aluísio J D Barros, Giovanny V A França, Susan Horton, Julia Krasevec, Simon Murch, Mari Jeeva Sankar, Neff Walker & Nigel C Rollins; Lancet Breastfeeding Series Group. (2016). Breastfeeding in the 21st century: epidemiology, mechanisms, and lifelong effect. *Lancet*. (387). doi: 10.1016/S0140-6736(15)01024-7.

[5] Rajiv Bahl, Chris Frost, Betty R Kirkwood, Karen Edmond, Jose Martines, Nita Bhandari & Paul Arthur. (2005). Infant feeding patterns and risks of death and hospitalization in the first half of infancy: multicentre cohort study. *Bulletin of the World Health Organization* (6).

[6] Laura M Lamberti, Christa L Fischer Walker, Adi Noiman, Cesar Victora & Robert E Black. (2011). Breastfeeding and the risk for diarrhea morbidity and mortality. *BMC Public Health* (3). S15.

[7] Chowdhury R, Sinha B, Sankar MJ, Taneja S, Bhandari N, Rollins N, et al. (2015). Breastfeeding and maternal health outcomes: a systematic review and meta-analysis. Acta Paediatrica (467). doi: 10.1111/apa.13102.

[8] World Health Organization (WHO). (2001). Global strategy for infant and young child feeding: The optimal duration of exclusive breastfeeding, Fifty-fourth World Health Assembly. Geneva: World Health Organization.

[9] World Health Organization (WHO). 2008. Indicators for assessing infant and young child feeding practices: Part 1: Definitions. Geneva: World Health Organization.

[10] World Health Organization (WHO)/United Nations Children's Fund (UNICEF). (2021). Indicators for assessing infant and young child feeding practices: definitions and measurement methods. Geneva: World Health Organization and the United Nations Children's Fund (UNICEF).

[11] Feachem RG & Koblinsky MA. (1984). Interventions for the control of diarrhoeal diseases among young children: promotion of breast-feeding. *Bulletin of the World Health Organization* (2).

[12] Bernardo L Horta, Christian Loret de Mola, Cesar G Victora. (2015). Breastfeeding and intelligence: a systematic review and meta-analysis. *Acta Paediatrica* (467) doi: 10.1111/apa.13139.

[13] Tamsen J Rochat, Brian Houle, Alan Stein, Hoosen Coovadia, Anna Coutsoudis, Chris Desmond, Marie-Louise Newell & Ruth M Bland. (2016). Exclusive Breastfeeding and Cognition, Executive Function, and Behavioural Disorders in Primary School-Aged Children in Rural South Africa: A Cohort Analysis. *PLoS Medecine*. (6). doi: e1002044. doi: 10.1371/journal.pmed.1002044.

[14] Felix Akpojene Ogbo, Hillary Nguyen, Sabrina Naz, Kingsley E Agho & Andrew Page. (2018). The association between infant and young child feeding practices and diarrhoea in Tanzanian children. *Tropical Medicine and Health* (2). doi: 10.1186/s41182-018-0084-y.

[15] Dewey KG, Cohen RJ, Brown KH and Rivera LL. (2001). Effects of Exclusive Breastfeeding for Four versus Six Months on Maternal Nutritional Status and Infant Motor Development: Results of Two Randomized Trials in Honduras. *The Journal of. Nutrition* (2). doi: 10.1093/jn/131.2.262.

[16] R H Gray, O M Campbell, R Apelo, S S Eslami, H Zacur, R M Ramos, J C Gehret & M H Labbok. (1990). Risk of ovulation during lactation. Lancet. doi: 10.1016/0140-6736(90)90147-w.

[17] World Health Organization. (2012). Comprehensive implementation plan on maternal, infant and young child nutrition. In: Sixty-fifth World Health Assembly Geneva, 21–26 May 2012. Resolutions and decisions, annexes. Geneva: World Health Organization.

[18] Global Nutrition Report. (2021). The state of global nutrition. Bristol, UK: Development Initiatives.

[19] Agence Nationale de la Statistique et de la Démographie (ANSD). (2019). Enquête Démographique et de Santé Continue (EDS-Continue). Rapport sur le Indicateurs Clés.

[20] Bridget A Aidam, Rafael Pérez-Escamilla & Anna Lartey (2005). Lactation counseling increases exclusive breast-feeding rates in Ghana. *The Journal of Nutrition* (7). doi: 10.1093/jn/135.7.1691.

[21] Donna J Chapman, Katherine Morel, Alex Kojo Anderson, Grace Damio & Rafael Pérez-Escamilla. (2010). Breastfeeding Peer Counseling: From Efficacy Through Scale-Up. *Journal of Human Lactation* (3). doi: 10.1177/0890334410369481.

[22] Aamer Imdad, Mohammad Yawar Yakoob & Zulfiqar A Bhutta. (2011). Effect of breastfeeding promotion interventions on breastfeeding rates, with special focus on developing countries. *BMC Public Health* (3). doi: 10.1186/1471-2458-11-S3-S24.

[23] Gabriel Nama Medoua, Estelle C Sajo Nana, Anne Christine A Ndzana, Caroline S Makamto, Lucien S Etame, Honorine A Rikong & Jean Louis E Oyono. (2012). Breastfeeding practices of Cameroonian mothers determined by dietary recall since birth and the dose-to-the-mother deuterium-oxide turnover technique: Breastfeeding practices of Cameroonian mothers. *Maternal & Child Nutrition* (3). doi: 10.1111/j.1740-8709.2011.00293.x..

[24] Monica Mazariegos, Christine Slater & Manuel Ramirez-Zea. (2016). Validity of Guatemalan Mother's Self-Reported Breast-Feeding Practices of 3-Month-Old Infants. *Food Nutrition Bulletin* (4). doi: 10.1177/0379572116654644.

[25] Chong Guey Yong, Nik Shanita Safii, Noor Zahila Mat Isa & Norimah A. Karim. (2019). Comparison of Breastfeeding Practice Using Deuterium Oxide Dose to Mother Technique with Maternal Recall Breastfeeding Practice Among Mothers in Klang Valley. *Jurnal Sains Kesihatan Malaysia* (1). doi: 10.17576/JSKM-2019-1701-14.

[26] W A Coward, M B Sawyer, R G Whitehead, A M Prentice & J Evans. (1979). New method for measuring milk intakes in breast-fed babies. *Lancet*. doi: 10.1016/s0140-6736(79)90177-6.

[27] Aïta Sarr Cissé, Leslie Bluck, Babou Diaham, Nicole Dossou, Amadou Tidiane Guiro & Salimata Wade. (2002). Use of Fourier transformed infrared spectrophotometer (FTIR) for determination of breast milk output by the deuterium dilution method among Senegalese women. *Food and Nutrition Bulletin* (3).

[28] Sophie E Moore 1, Andrew M Prentice, W Andy Coward, Antony Wright, Edward A Frongillo, Anthony Jc Fulford, Adrian P Mander, Lars-Ake Persson, Shams E Arifeen & Iqbal Kabir. (2007). Use of stable-isotope techniques to validate infant feeding practices reported by Bangladeshi women receiving breastfeeding counseling. *American Journal of Clinical Nutrition* (4). doi: 10.1093/ajcn/85.4.1075.

[29] International Atomic Energy Agency (IAEA). (2010). Stable isotope technique to assess Intake of human milk in breastfed infants, Human Health Series No. 7, Vienna.

[30] Aïta Sarr Cissé, Nicole Dossou, Mamadou Ndiaye, Amadou Lamine Guèye, El Hadji Issakha Diop, Babou Diaham, Amadou Tidiane Guiro, Djibril Cissé, Cheikh Saad Bouh Sarr & Salimata Wade. (2002). Stable isotope aided evaluation of Community Nutrition Program: effect of food supplementation schemes on maternal and infant nutritional status. *Food and Nutrition Bulletin* (3).

[31] Anta Agne-Djigo, Komlan M Kwadjode, Nicole Idohou-Dossou, Adama Diouf, Amadou T Guiro & Salimata Wade. (2013). Energy intake from human milk covers the requirement of 6-month-old Senegalese exclusively breast-fed infants. *The British Journal of Nutrition* (10). doi: 10.1017/S0007114513001074.

[32] Elaine Albernaz, Cesar G Victora, Hinke Haisma, Antony Wright & William A Coward. (2003). Lactation counseling increases breast-feeding duration but not breast milk intake as measured by isotopic methods. *The Journal of Nutrition* (1). doi: 10.1093/jn/133.1.205.

[33] Agence Nationale de la Statistique et de la Démographie (ANSD). (2018). Enquête Démographique et de Santé Continue (EDS-Continue). ANSD et ICF International.

[34] Machin D, Campell MJ, Tan SB, Tn SH. (2018). Sample sizes for clinical, laboratory and epidemiology studies. 4th ed. Oxford: John Wiley & Sons Ltd.

[35] W A Coward, T J Cole, M B Sawyer, A M Prentice. (1982). Breast-milk intake measurement in mixed-fed infants by administration of deuterium oxide to their mothers. *Human Nutrition, Clinical Nutrition* (2).

[36] Jones PJ, Leatherdale ST. (1991). Stable isotopes in clinical research: safety reaffirmed. *Clinical Science (London, England)* (4). doi: 10.1042/cs0800277.

[37] Fjeld CR, Brown KH, Scholler DA. (1988). Validation of the deuterium oxide method for measuring average daily milk intake for infants. *American Journal of Clinical Nutrition* (3). doi: 10.1093/ajcn/48.3.671.

[38] Wells JCK, Davies PSW, Coward WA. (2000). Simultaneous measurement of milk intake and total energy expenditure in mixed-fed infants: methodological approach and prediction of total body water. In: International Atomic Energy agency, NAHRES-55. Co-ordinated research project on isotopic evaluations in infant growth monitoring, a collaboration with WHO (partly report).

[39] Zheng Liu, Aly Diana, Christine Slater, Thomas Preston, Rosalind S Gibson, Lisa Houghton & Stephen B Duffull. (2019). Development of a nonlinear hierarchical model to describe the disposition of deuterium in mother–infant pairs to assess exclusive breastfeeding practice. *Journal of Pharmacokinetics Pharmcodynamics* (1) doi: 10.1007/s10928-018-9613-x.

[40] Organisation Mondiale de la Santé (OMS). (1996). Utilisation et interprétation de l'anthropométrie. Rapport d'un comité OMS d'experts. Genève: OMS.

[41] World Health Organization/Multicentre Growth Reference Study Group. (2006). WHO Child Growth Standards: Length/height-for-age, weight- for-age, weight-for-length, weight-for-height and body mass index- for-age: Methods and development. Geneva.

[42] World Health Organization. (2008). Indicators for Assessing Infant and Young Child Feeding Practices: Part I Definitions. Geneva, Switzerland: World Health Organization.

[43] WHO/UNICEF. (2021). Indicators for assessing infant and young child feeding practices: definitions and measurement methods. Geneva: World Health Organization and the United Nations Children's Fund (UNICEF).

[44] Seema Vyas 1, Lilani Kumaranayake. (2006). Constructing socioeconomic status indices: how to use principal components analysis. *Health Policy Planning* (6). doi: 10.1093/heapol/czl029.

[45] Coates, Jennifer, Anne Swindale and Paula Bilinsky. (2007). Household Food Insecurity Access Scale (HFIAS) for Measurement of Household Food Access: Indicator Guide (v.3). Washington, DC: FHI 360/FANTA.

[46] Lokonon JHF, Hounkpatin WA, Idohou-Dossou N. (2020). Participation in the "nutrition at the Centre" project through women's group improved exclusive breastfeeding practices, as measured by the deuterium oxide dose-to- mother technique. *International Breastfeed. Journal*. doi: org/10.1186/s13006-020-00302-y.

[47] World Health Organization. (2002). Nutrient adequacy of exclusive breastfeeding for the term infant during the first six months of life. Geneva: World Health Organization.

[48] Crawford MA. The role of essential fatty-acids in neural development: implications for perinatal nutrition. *American Journal of Clinical Nutrition* (3). doi: 10.1093/ajcn/57.5.703S.

[49] N F Butte, C Garza, J E Stuff, E O Smith, B L Nichols. (1984). Effect of maternal diet and body composition on lactational performance. American Journal of Clinical Nutrition (2). doi: 10.1093/ajcn/39.2.296.

[50] Rattigan, S.; Ghisalberti AV and Hartmann PE. Breast-milk production in Australian women. *British Journal of Nutrition* (2). doi: 10.1079/bjn19810100.

[51] Michael S Kramer, Tong Guo, Robert W Platt, Zinaida Sevkovskaya, Irina Dzikovich, Jean-Paul Collet, Stanley Shapiro, Beverley Chalmers, Ellen Hodnett, Irina Vanilovich, Irina Mezen, Thierry Ducruet, George Shishko, Natalia Bogdanovich. (2003). Infant growth and health outcomes associated with 3 compared with 6 mo of exclusive breastfeeding. *American Journal of Clinical Nutrition* (2). doi: 10.1093/ajcn/78.2.291.

[52] Kamudoni P, Maleta K, Shi Z & Holmboe-Ottesen G. Exclusive breastfeeding duration during the first 6 months of life is positively associated with length-for-age among infants 6-12 months old, in Mangochi district, Malawi. *European Journal of Clinical Nutrition* (1). doi: 10.1038/ejcn.2014.148.

[53] Alison McFadden, Lindsay Siebelt, Joyce L Marshall, Anna Gavine, Lisa-Christine Girard, Andrew Symon & Stephen MacGillivray. (2019). Counselling interventions to enable women to initiate and continue breastfeeding: a systematic review and meta-analysis. *International Breastfeeding Journal*. doi: org/10.1186/s13006-019-0235-8.

[54] Prakash Shakya, Mika Kondo Kunieda, Momoko Koyama, Sarju Sing Rai, Moe Miyaguchi, Sumi Dhakal, Su Sandy, Bruno Fokas Sunguya, Masamine Jimba. (2017). Effectiveness of community-based peer support for mothers to improve their breastfeeding practices: A systematic review and meta-analysis. *PLoS ONE* (5). doi: 10.1371/journal. pone.0177434.

[55] Alive and Thrive/ United Nations Children's Fund (UNICEF). (2019). Allaitement Exclusif en Afrique de l'ouest et du centre. https://www.aliveandthrive.org/sites/default/files/ecowas_swbo_research_brief_french_november_2019_1_0.pdf. Accessed 24 July 2022.

[56] Raisler J. (2000). Against the odds: breastfeeding experiences of low income mothers. *Journal of Midwifery Womens Health* (3). doi: 10.1016/s1526-9523(00)00019-2.

[57] World Health Organization. (2018) 0. Guideline: counselling of women to improve breastfeeding practices. Geneva: World Health Organization.

[58] Ghizlane Choua, Khalid El Kari, Noureddine El Haloui, Christine Slater, Hassan Aguenaou, and Najat Mokhtar. (2013). Quantitative Assessment of Breastfeeding Practices and Maternal Body Composition in Moroccan Lactating Women during Six Months after Birth Using Stable Isotopic Dilution Technique. International Journal of Maternal and Child Health (3). doi: 10.12966/ijmch.09.01.2013.

[59] Motswagole BS, Matenge STP, Mongwaketse T, Bogopa J, Kobue-Lekalake R, Mosetlha K, et al. (2015) Application of the deuterium-oxide dose-to-mother technique to determine the exclusivity of breastfeeding in women in Kanye, Botswana. *South African Journal of Clinical Nutrition*.