Maternal Diet during Exclusive Breastfeeding can Predict Food Preference in Preschoolers: A Cross-Sectional Study of Mother-Child Dyads in Enugu, South-East Nigeria

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Abstract: *Background*: The relationship between food preference in early childhood and prenatal exposure to flavor in the amniotic fluid is well documented. Although its association with flavor transmission in the breast milk has also been noted, it is poorly reported in this country.

Objective: The present study aims to determine the relationship between mothers' dietary exposure during exclusive breastfeeding and food preference in their preschool-aged children.

Methods: Two hundred and twenty (220) mother-child dyads who met the study criteria were enrolled. A pre-tested, structured questionnaire was administered to the mothers. The relationship between maternal consumption of flour-based snacks and staple foods during exclusive breastfeeding and the child's preference for these foods was determined using risk estimates. After controlling for potential confounders, logistic regression was used for multivariate analysis. Statistical significance was determined at $p < 0.05$ and all the risk estimates were presented as odds ratios (OR) at 95% confidence intervals (CI).

Results: The relationship between daily maternal exposure to staple foods during exclusive breastfeeding and the children's preference for this variety of food was not statistically significant ($p = 0.847$, OR= 1.083, 95% CI = 0.481-2.437). However, the children's preference for flour-based snacks was significantly related to weekly or fourth-nightly maternal exposure to similar diet during exclusive breast feeding ($p = 0.035$, OR = 2.405, 95% C.I = 1.064 - 5.435).

Conclusion: Transmission of flavor in the breast milk may contribute in shaping children's feeding behavior early in life.

Keywords: Food preference, maternal diet, flavors, feeding behavior, preschoolers.

INTRODUCTION

Food preference in children is determined by food likes and dislikes, and is shaped by both genetic and environmental factors [1]. Flavor appreciation (which is related to food preference) is also explained by both genetic [2-4], and non-genetic influences [5, 6]. In fact, one report has documented a co-efficient of heritability for food varieties, with indications of genetic influence on food preferences being strong for protein diets (co-efficient of heritability: 0.78) and moderate for fruits (co-efficient of heritability: 0.51), vegetables (co-efficient of heritability: 0.37), and dessert diets (co-efficient of heritability: 0.12) [7]. The first few years of life constitute a critical period for the development of feeding patterns [8-10]. For instance, some human behavioral studies have shown that gustatory and olfactory functions are already present in newborn babies, and continue to develop in the postnatal period [11-13]. The subsequent imprinting effects on behavior are manifested in the preference for sensory stimuli such as flavor.

Other environmental factors that can shape food preference in children emanate from the family: the first social milieu which serves as the primary influence on feeding behaviors of preschool children. These include parental control of food availability and accessibility, and meal structure, food modeling, food socialization practices and food-related parenting style [8]. Recently, the responsibility for children's feeding behaviors has shifted to child-care providers who are now seen as important models in molding food preference in young children [14]. Available evidence suggests that parents and child-care providers influence feeding patterns of children in varied and complex ways [8].

Nevertheless, some investigators have demonstrated an association between infant-feeding practices and picky-eating behavior in early childhood, [15] while other studies have reported that prenatal and postnatal exposure to flavor in the amniotic fluid and breast milk may influence food acceptance [16, 17]. A comprehensive review on the subject has concluded

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that such exposure to flavor through gustatory and olfactory stimuli results in modifications in the expression of flavor, food and drink preferences which may be seen later in life [18]. For instance, some authors have observed that exposure to flavor in the intrauterine life influences subsequent flavor preference [19], as shown by the response of premature infants to gustatory stimuli [20]. This observation has also been corroborated by the findings of previous reports [11-13]. Flavors from maternal diets infuse the amniotic fluid, and it therefore makes good adaptive sense for the fetus to experience these dietary components and to form a postnatal preference for them [21]. Thus, prenatal and postnatal experiences with flavors may induce a gustatory imprinting which is manifested by preferences for the same stimuli in early childhood [18]. It is believed that the first few years of life specifically represent a sensitive phase for the development of food acceptance patterns [9, 10]. Several reports also indicate that children's food preferences are learned through repeated exposure to foods, as a minimum of 8-10 exposures to new foods were noted to have increased preferences for these foods [22-26]. Obviously, flavor thus plays a key role in the development of food preference early in childhood as it is the most important feature of foods and beverages: its perception resulting from the interaction and integration of tastes and odorants [6, 27].

The relationship between prenatal exposures to flavors transmitted in the amniotic fluid (which lead to gustatory imprinting) and food preference in infancy has been well documented. For example, the study by Mennella *et al.* reported a differential negative facial expression on being fed on carrot-flavored cereal between infants with repeated prenatal maternal exposure to carrot juice and infants without such history [16], while an interview-based study showed a direct correlation between the dietary type consumed by Mexican infants at weaning and their mothers' prenatal diet [28]. Flavor transmission in the breast milk has also been observed to exert a similar gustatory imprinting; several studies have indeed confirmed that infants' responsiveness to their mothers' breast milk varies as a function of the presence or absence of specific flavors related to maternal diet, such as alcohol and vanilla [29-32]. However, this relationship with respect to both infants and preschoolers is scantily reported in this country. The present study was therefore conducted in a south-east Nigerian city in order to determine the relationship between mothers' exposure to a specific variety of food during exclusive breastfeeding and food preference in their preschool-aged children.

METHODS

Study Participants

Two hundred and twenty (220) mother-child dyads who met the study criteria were enrolled consecutively from the daily clinic attendance of the under-five welfare clinic at a tertiary health institution (Enugu State University Teaching Hospital) situated in Enugu metropolis, south-east Nigeria.

Inclusion criteria comprised (a) age bracket of 1 to 5 years, (b) absence of chronic illnesses in the child,(c) biological parenthood, and (d) mothers who exclusively breastfed their enrolled children. Exclusion criteria were (a) adopted children, and (b) foster parenthood.

All the participants (the mothers) gave informed written consent. The study protocol was approved by the Health-Research and Ethics Committee of the Enugu State University Teaching Hospital, Park-lane Enugu. The study was cross-sectional and descriptive, and was conducted between May and August, 2015.

Study Instrument

A pre-tested, structured questionnaire (appendix 1) was solely administered to the study respondents by one of the investigators (CIE), in order to ensure accuracy and uniformity in data collection. It was made up of five major sections:

(1) Maternal socio-demographics (age, educational attainment, and occupation).

(2) Child's bio-data (age, gender and day-care/school attendance).

(3) Mothers' self-reported history of consumption of flour-based snacks during exclusive breast-feeding compared with consumption of staple foods (family menu) during the same period.

(4) Frequency of consumption of flour-based snacks and staple foods during the 6-month period (equivalent to the number of exposures to these varieties of foods), and

(5) The child's preference for flour-based snacks or staple foods which was determined using the binary scale of 'Yes' and 'No'. (proxy-reported by the mothers)

Mothers were asked to recall whether each variety of food was consumed daily, on alternate-day basis, twice weekly or weekly, and fourth nightly during the period of exclusive breastfeeding. Confounders such as the children's possible repeated exposures to each variety of food early in life, cultural environment, genetic factors and other parental/ care-giver practices and influences were admittedly not accounted for in the questionnaire.

In this study, flour-based snacks were chosen for comparison with staple foods because they are rich in fats and sugars, and were likely to be preferred by children because of their pleasant taste.

Food preference was defined as frequent or habitual ingestion of a particular food based on food likes (in other words, 'the child eats what he likes'). In this study, a daily or alternate day consumption of staple foods or flour-based snacks by the child was taken as the measure of the child's preference for either of these food varieties.

The Diet-Derived Flavors Used as Stimuli in the Study

(1) Flour-based snacks – In this part of the country, westernization of the diet has resulted in increased patronage of fast foods. Most fast foods in this locality consist of flour-based snacks. The common flour-based snacks assessed in the current study were doughnut, bun or meat pie, oven-baked or fried in oil, each of which are characterized by high-energy density flavors.

(2) Staple foods- Usually formed part of the daily family menu. Carbohydrate and fat were the predominant macronutrients. In this part of the country, typical examples usually eaten by most families on daily basis are pounded boiled yam or pounded dried cassava flour after soaking in hot water. The diet was eaten as finger pinches of easily swallowed balls with different varieties of vegetable-based soups, and is characterized by low-energy density flavors

Statistical Analyses

The relationship between maternal exposure to either flour-based snacks or staple foods during exclusive breastfeeding and the child's preference for any of this variety of food was determined using risk estimates. After controlling for potential confounders, the logistic regression was used for multivariate analysis. Statistical significance was determined at $p < 0.05$ and all the risk estimates were presented as odds ratios (OR) at 95% confidence intervals. For this analysis, each frequency response of the outcome variable (child's food preference) was transformed to a binary variable ('Yes' or 'No'). Statistical significance was determined at p value of less than 0.05, and all the risk estimates were presented as odds ratios (ORs) and 95% confidence intervals. The rest of the results were reported as numbers and proportions for categorical variables; and means and standard deviations for numeric variables.

RESULTS

Socio-Demographic Characteristics of Mother-Child Dyads

A total of 220 completed questionnaires were analyzed. The socio-demographic characteristics of the mother-child dyads are shown in Tables **1-3**. Majority of the mothers were aged between 31-35 years (36.8%). Few were aged 21-25 years (4.5%), 41-45 years (9.5%) and 46-50 years (0.5%). The rest were aged 26-30 years (30.9%) and 36-40 years (17.7%). Their estimated mean age was 32.9 $\pm$ 5.2 years (Table **1**).

Table 1: Age Groups of the Mothers and their Distribution

Age group (years)†	Number of mothers	%
21-25	10	4.5
26-30	68	30.9
31-35	81	36.8
36-40	39	17.7
41-45	21	9.5
46-50	1	0.5

†mean age = 32.9 $\pm$ 5.2 years.

With respect to their best educational attainment, 61.4% had acquired tertiary education, 30.9% had secondary education, 7.3% attained post-secondary education (such as Colleges of Education or Polytechnic institutions), while a paltry 0.5% had only primary education. Most of them were either self-employed (39.1%) or public-sector employed (28.2%). Only 10.9% were employed in the private sector while 21.8% were full-time housewives. Majority of the mothers (84.5%) had a parity of 1-4, and few (15.5%) had a parity of more than 4 (Table **2**).

Table 2: Mothers' Educational Attainment, Occupation and Parity

Maternal variables	Number of mothers	%
Education attainment		
-Primary	1	.5
-Secondary	68	30.9
-Post-secondary education	16	7.3
-Tertiary	135	61.4
Occupation		
-Full-time housewife	48	21.8
-Public-sector employed	62	28.2
-Private-sector employed	24	10.9
-Self employed	86	39.1
Parity		
-1 – 4	186	84.5
-> 4	34	15.5
Children alive		
-1 – 4	196	89.1
-> 4	24	10.9

A greater proportion of the children were aged between 1 to 3 years (62.7%) with a mean age of 3.1 $\pm$ 1.5 years; there were more males than females (57.3% versus 42.7%) giving a ratio of 1.3:1. About 23.6% of the children had not started schooling; 31.4% were in pre-nursery schools, 42.7% in nursery schools while only 2.3% had commenced primary education (Table **3**).

Mother's Exposure to the Food Varieties during Exclusive Breastfeeding Versus Child's Reported Food Preference

In Table **4**, maternal dietary exposure during exclusive breastfeeding was compared with the reported food preference in the child. Twenty seven of the 220 mothers (12.3%) reported a weekly or fourth-nightly consumption of flour-based snacks while 193/220 (87.7%) reported a daily consumption of staple foods during the six-month period of exclusive breastfeeding. Among mothers in the latter category, analysis of the child's preference for staple foods (measured by maternal self-report of daily or alternate-day consumption of the food variety by the child) showed that 82/193 (42.5%) preferred this variety of food while 111/193 (57.5%) did not. In comparison to the former category of mothers, analysis of the child's preference for flour-based snacks revealed that 12/27 (44.4%) developed preference for this diet while 15/27 (55.6%) failed to do so. The relationship between daily maternal exposure to staple foods and the child's preference for this variety of food was not statistically significant: estimated odds ratio [OR] ($p = 0.847$, OR= 1.083, 95% confidence interval [CI] = 0.481-2.437).

However, regarding the child's preference for flour-based snacks among mothers exposed to weekly or fourth-nightly ingestion of similar diet during exclusive breastfeeding (measured by maternal self-report of daily or alternate-day of food consumption by the child), 15/27 (55.6%) reportedly preferred this food variety while 12/27 (44.6%) did not prefer it. When compared to children who showed preference for staple foods among mothers exposed to daily consumption of similar diets during exclusive breastfeeding, 66/193 (34.2%) preferred these diets while 127/193 (65.8%) did not. ($p = 0.035$, OR = 2.405, 95% C.I = 1.064 - 5.435). Thus, children whose mothers consumed flour-based snacks weekly or fourth nightly during exclusive breastfeeding had 2.4 times higher odds of showing preference for this variety of food: a result which was also statistically significant.

Table 3: Demographics of the Children

Variables	Number of children	%
Age group of children (years)†		
1 - 3	138	62.7
4 - 6	82	37.3
Children's gender		
Male	126	57.3
Female	94	42.7
School grade		
Not schooling	52	23.6
Pre-nursery	69	31.4
Nursery	94	42.7
Primary	5	2.3

†mean age = 3.1 $\pm$ 1.5 years.

Table 4: Mothers' Dietary Exposure during Exclusive Breastfeeding Versus Reported Children's Food Preferences

Reported children's food preferences	Mothers' dietary exposure during exclusive breastfeeding*		p value	Odds ratio (OR)	95% confidence interval (CI)
	Fast food** n=27(%)	Family menu† n=193(%)			
Preference for family menu					
Yes	12(44.4)	82(42.5)	0.847	1.083	0.481- 2.437
No	15(55.6)	111(57.5)			
Preference for fast food					
Yes	15(55.6)	66(34.2)	0.035	2.405	1.064- 5.435
No	12(44.4)	127(65.8)			

*equivalent to weekly and fourth-nightly exposure or less for fast food and daily or alternate-day exposure for family menu. **flour-based snacks. †staple foods.

DISCUSSION

The present study has shown that child's preference for flour-based snacks was significantly related to similar maternal diet during exclusive breastfeeding. The observation is in tandem with the findings of a study on pre-weanling rats which aimed to determine if these animal models could learn to associate an arbitrary flavor with post-ingestive effects of nutrients, as well as show a post-weaning preference for the same flavor [33]. In that study, the authors noted a pre-weaning neural mechanisms for flavor-nutrient associations, allowing the murine models to learn associations between arbitrary flavors and nutritive consequences [33]. It underscores the fact that nutrient conditioning may be a mechanism by which early experience (such as breast-milk transmitted flavors from maternal diets) influences later dietary preferences [33]. Moreover, a previous report suggests that intrauterine exposure to specific flavors influences flavor preferences later in life [19]. It has been observed that as early as the 15th week of gestation, the fetal gustatory function has developed, and contact with amniotic fluid ensures at least some experience of the chemical compounds (flavor agents) derived from maternal diets [18]. These compounds make contact with fetal chemo-receptors as the amniotic fluid circulates through the oral-nasal pathways [21]. Similarly, flavors from maternal diets transmitted in her breast milk may be perceived by the breastfeeding infant; such early exposure may lead to acquisition of preferential responsiveness to food-related tastes and odors which remain evident throughout weaning [16]. It has also been noted that breastfeeding increases the likelihood to learn flavors in all foods ingested by mothers and may protect against the evolution of picky-eating behavior in infancy [6].

We suggest that these observations may partly explain why preschoolers in our study who frequently preferred flour-based snacks had maternal history of frequent consumption of similar diet during exclusive breastfeeding. Better still, since children have an innate tendency for preferring sweet flavors and avoiding bitter flavors [34], it is not surprising that the causal relationship between maternal diet during lactation and food preference in children (as seen in our study) occurred with dietary exposure to flour-based snacks rather than with exposure to staple foods including vegetables: despite a more frequent maternal exposure to the latter food variety.

On the other hand, the present study could not establish a significant relationship between daily maternal consumption of staple foods during the six-month period of exclusive breastfeeding and the child's preference for this variety of food. Although the reason for this finding is not clear, we suggest it may be due to the concept of flavor-nutrient learning as a basis for food preference in children [18]. For instance, some studies have shown that young children preferred high energy-density flavored edible substances over low energy-density flavors, following a series of repeated pairings of those flavored edible substances with energy source such as carbohydrate or fat [35, 36]. One of the studies reported a post-exposure preference for flavors associated with higher-energy drinks and higher-fat yogurts than to flavors associated with lower-energy and low-fat versions [35].

Energy density is specifically an important feature of food which is linked to food preference, and is defined as calories per weight of food (kcal/g) [22, 35]. Because of an innate preference for high energy-density foods, children instinctively choose energy-dense foods which are rich in fat and low in fibers [1]. Most of the staple foods evaluated in the current study are characterized by low energy-density flavors compared to flour-based snacks which have high energy-density flavors. Secondly, there are five well-

established fundamental tastes which determine flavor perception, namely 'sweet', 'bitter', 'sour', 'salt' and 'umami' [37]. The staple foods of which vegetables are a substantial component are characterized by tastes that vary from 'bitter', 'sour' to 'salt'. Conversely, the tastes from flour-based snacks are essentially 'sweet' and 'salt'. Flavors from both dietary categories may thus result in disparate gustatory imprinting, since children have a natural predisposition to prefer sweet and salty tastes over the bitter and sour tastes [38].

Remarkably, it was thus easy for children in our study to display significant preference for snacks following a maternal history of exposure to similar diet during exclusive breastfeeding. This also agrees with the observations of some researchers who noted that postnatal exposure to a flavor in the breast milk increased the infant's acceptance and enjoyment of the same flavor in solid foods during weaning [39].

STUDY LIMITATIONS

The validity of the study findings is limited by the small sample size and possible maternal memory lapse; the power of recall by some mothers might have introduced some bias in the results. Another major limitation is the non-consideration of the role of parental influence in shaping the children's food preferences. The study set out primarily to determine the role of flavor transmission in determining food preferences without controlling for parental influence and other factors as confounding variables. Finally, determination of the children's food preferences was by proxy (maternal report) and did not involve a direct interview of the preschoolers. In addition, the family's financial capability could have influenced the frequency of food availability to the child.

CONCLUSIONS

Although there is a genetic influence on flavor appreciation, it is also learned. Thus, the child's gustatory exposure to flavors in the postnatal period may be critical in shaping his feeding behavior early in life, as flavor transmission occurs through the breast milk during this period. A future research with a much larger sample size is recommended to validate the possible association between food preference in Nigerian preschoolers and their mothers' prenatal dietary history, more so when the local staple foods show the peculiarity of having low energy-density flavors. In addition, our study findings may have some implications for enhancing healthy food-intake patterns in young children. While it may be difficult to alter children's innate tendency of preferring sweet tastes to bitter tastes, their flavor preferences can be modulated by providing early flavor exposure both in the prenatal and postnatal periods [34]. Given the fact that flavors emanating from foods mothers consume during lactation are also transmitted in the breast milk with subsequent gustatory imprinting in the infants, lactating mothers should be encouraged to widen their food choices to encompass many well-flavored and healthy foods: since these experiences will increase the likelihood that children will choose and enjoy a more nutritious diet.

AUTHORS' CONTRIBUTIONS

SNU conceived the study and designed its protocol; CIE administered the questionnaires. IKN and KI participated in the study coordination. CIE made the data entry for statistical analysis. SNU drafted the manuscript; CIE, IKN, KI and MIU made contributions to the draft. All the authors read and approved the final draft.

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CONFLICT OF INTERESTS

None to declare by the authors.

APPENDIX 1

Study Questionnaire – (Interviewer Administered)

TOPIC: Maternal diet during exclusive breastfeeding can predict food preference in preschoolers: a cross-sectional study of mother-child dyads in Enugu, south-east Nigeria

SERIAL NUMBER…….. STUDY CENTRE…… DATE…….

SECTION A: Mother's socio-demographic data (Tick/shade in the applicable box)

1. Age (years): (i) 16-20 [ ]

(ii) 21-25 [ ]

(iii) 26-30 [ ]

(iv) 31-35 [ ]

(v) 36-40 [ ]

(vi) 41-45 [ ]

(vii) 46-50 [ ]

(viii) >50 [ ]

2. Educational attainment: (i). No formal education [ ]

(ii). Primary education [ ]

(iii). Secondary education [ ]

(iv). Post-Secondary education [ ]

(v). Tertiary education [ ]

3. Occupation: (i).Unemployed/full-time house wife [ ]

(ii). Public-sector employed [ ]

(iii). Private-sector employed [ ]

(iv). Self-employed [ ]

4. Parity: (i) 1-4 [ ] (ii) >4 [ ]

5. Number of living children: (i) 1-4 [ ] (ii) >4 [ ]

SECTION B: Child's biodata (Tick/shade in the applicable box)

1. **Age (years):** (i) 1-3 [ ] (ii) 4-6 [ ]
2. **Gender:** (i) Male [ ] (ii) Female [ ]
3. **School attendance:** (i). Not schooling [ ]

(ii). Pre-nursery [ ]

(iii). Nursery [ ]

(iv). Primary [ ]

SECTION C: Maternal recall of food consumption during exclusive breastfeeding (Tick/shade in the applicable box)

1. Consumption of flour-based snacks (snacks to be assessed are the most frequently consumed within the locality)

(i) Month 1: a. Yes [ ] b. No [ ]

(ii) Month 2: a. Yes [ ] b. No [ ]

(iii) Month 3: a. Yes [ ] b. No [ ]

(iv) Month 4: a. Yes [ ] b. No [ ]

(v) Month 5: a. Yes [ ] b. No [ ]

(vi) Month 6: a. Yes [ ] b. No [ ]

2. Consumption of staple foods (staple foods to be assessed are the most frequently consumed within the locality)

(i) Month 1: a. Yes [ ] b. No [ ]

(ii) Month 2: a. Yes [ ] b. No [ ]

(iii) Month 3: a. Yes [ ] b. No [ ]

(iv) Month 4: a. Yes [ ] b. No [ ]

(v) Month 5: a. Yes [ ] b. No [ ]

(vi) Month 6: a. Yes [ ] b. No [ ]

SECTION D: Frequency of maternal consumption of flour-based snacks and staple foods during exclusive breastfeeding based on recall (Tick or shade the applicable box)

1. Flour-based snacks

(i) Month 1: (a) daily [ ] (b) alternate day [ ] (c) twice weekly or weekly [ ] (d) every fourth night [ ]

(ii) Month 2: (a) daily [ ] (b) alternate day [ ] (c) twice weekly or weekly [ ] (d) every fourth night [ ]

(iii) Month 3: (a) daily [ ] (b) alternate day [ ] (c) twice weekly or weekly [ ] (d) every fourth night [ ]

(iv) Month 4: (a) daily [ ] (b) alternate day [ ] (c) twice weekly or weekly [ ] (d) every fourth night [ ]

(v) Month 5: (a) daily [ ] (b) alternate day [ ] (c) twice weekly or weekly [ ] (d) every fourth night [ ]

(vi) Month 6: (a) daily [ ] (b) alternate day [ ] (c) twice weekly or weekly [ ] (d) every fourth night [ ]

2. Staple foods

(i) Month 1: (a) daily [ ] (b) alternate day [ ] (c) twice weekly or weekly [ ] (d) every fourth night [ ]

(ii) Month 2: (a) daily [ ] (b) alternate day [ ] (c) twice weekly or weekly [ ] (d) every fourth night [ ]

(iii) Month 3: (a) daily [ ] (b) alternate day [ ] (c) twice weekly or weekly [ ] (d) every fourth night [ ]

(iv) Month 4: (a) daily [ ] (b) alternate day [ ] (c) twice weekly or weekly [ ] (d) every fourth night [ ]

(v) Month 5: (a) daily [ ] (b) alternate day [ ] (c) twice weekly or weekly [ ] (d) every fourth night [ ]

(vi) Month 6: (a) daily [ ] (b) alternate day [ ] (c) twice weekly or weekly [ ] (d) every fourth night [ ]

SECTION E: Child's food preference (Tick or shade the applicable box)

1. Flour-based snacks: (a) Yes [ ] (b) No [ ]

   (Yes – measured by maternal report of child's daily or alternate day consumption of food variety)

   (i) Daily [ ]

   (ii) Alternate day [ ]

   (iii) Weekly [ ]

   (iv) Every fourth night [ ]

2. Staple foods: (a) Yes [ ] (b) No [ ]

   (Yes- measured by maternal report of child's daily or alternate day consumption of food variety)

   (i) Daily [ ]

   (ii) Alternate day [ ]

   (iii) Weekly [ ]

   (iv) Every fourth night [ ]

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