Original Article

The dietary intake of two groups of lactating women in Shanghai during puerperium period

Rui Hu MSc[1], Jun Fei BSc[1], Yingchen Zhai MSc[1], Yi Feng MD[1], Janet Warren PhD[2], Yi Jin MD[3], Bianca Papi MSc[4], Bernd Stahl PhD[4], Zhixu Wang PhD[5], Jing Li MD[1]

[1] *Shanghai Children's Medical Center, Shanghai Jiao Tong University School of Medicine, Shanghai, China*
[2]*FirstStop Nutrition Ltd, c/o INCA Accounting, Oxfordshire, United Kingdom*
[3]*Danone Nutricia Early Life Nutrition, Shanghai, China*
[4]*Nutricia Research, Utrecht, The Netherlands*
[5]*Department of Maternal, Child and Adolescent Health, School of Public Health, Nanjing Medical University, China*

Background and Objectives: Lactation is a time of increased nutritional requirements for mothers, and inadequate nutrient intake may have a detrimental effect on a woman's nutritional status. To investigate the dietary intake of two groups of women in Shanghai during the traditional confinement period. **Methods and Study Design:** Two groups of women (1) a community dwelling sample (n=92); (2) residents in a Maternity Care Centre (MCC) (n=30), kept a prospective dietary record which was complemented by photographing. This data collection was done on a single day on three occasions in the community group, and for three days on five occasions in the MCC one. The mean nutrient intakes of the two groups were compared at common time points to dietary reference intakes, and the food intake was compared to dietary guidelines. **Results:** Over half of this population had high body mass indices (BMIs) which reported that an excessive proportion of calories had come from fat intake. The mean intakes of sodium were higher than the recommended. Fruit, vegetable, bean, tuber, and milk intakes were lower than the recommendations. Over 70% of the women failed to meet the Estimated Average Requirement (EAR) for calcium. A notable proportion of all women failed to meet the EAR for vitamin C, thiamin, and riboflavin. Dietary fiber intakes were low, with a group mean intake value less than half the Adequate Intake (AI). **Conclusions:** This study on dietary intakes indicates nutritional intake issues may exist among lactating women in Shanghai, particularly in community-dwelling women.

Key Words: lactation, women, dietary intake, maternity care center, community, Shanghai

INTRODUCTION

The benefits of breastfeeding to both infants and mothers are well established.[1] Lactation is a highly demanding state for a mother and causes a nutritive burden which is considerably greater than pregnancy. Achieving optimal nutritional status for lactation begins in pregnancy as this is the biological state of nutrient accumulation.[2] The duration and exclusivity of feeding affects the mother's nutritional status.[3] According to the "Dietary Guidelines for Chinese Lactating Women", lactating women should gradually compensate for the nutrient reserves lost during pregnancy and childbirth and promote the recovery of various organs and system functions. Furthermore, they must also produce milk and feed the baby. Therefore, due to the physiological characteristics of the lactation period and the need for milk production, the maternal diet should be well planned to ensure an adequate nutrient supply. Based on the ten guidelines of the general population diet guide, the following five recommendations have been added to the "Dietary Guidelines for Lactating Women": (1) The intake of animal foods, such as fish, poultry, eggs, lean meat, and seafood, is to be increased; (2) Drinking appropriate amounts of milk is the best food source for calcium supply; (3) Iron-rich foods are to be consumed more frequently; (4) Proper physical activity is required to maintain proper body weight; (5) No smoking, no irritating food are allowed.[4]

Until now, few studies have investigated the impact of lactation on the mother's nutritional status; rather, the focus has been placed on the influence of the maternal nutritional status on the composition of breast milk.[3]

It is generally considered that the composition of milk is preserved by homeostatic and nutrient transport mechanisms that compensate variable maternal supply. However, there is a point when maternal insufficiency leads to consequences in the maternal health status and the supply of nutrients in breast milk. The influence of maternal diet

Corresponding Author: Dr Jing Li, Shanghai Children's Medical Center, Shanghai Jiao Tong University School of Medicine, 1678 Dongfang Road, Shanghai 200127, China.
Tel: 86-21-38625779 ; Fax: 021-58393915
Email: zzhlq3@hotmail.com
Manuscript received 29 June 2018. Initial review completed 05 August 2018. Revision accepted 07 November 2018.
doi:

on milk composition varies in magnitude and does not hold for all nutrients.[5] During lactation, the maternal status and intake of the B vitamins (except folate), vitamin A, and iodine strongly affects the amount of these nutrients secreted in breast milk;[6] In general, the concentrations of fatty acids and both fat- and water-soluble vitamins are also influenced by maternal diet.[5] A recent systematic review of studies, which provided quantitative information on maternal diet and human milk composition, found that the majority of studies were focused on the association between maternal fatty acid intake (e.g., of docosahexaenoic acid) and their concentration in human milk.[7]

Vitamin D, folic acid, and iron have been identified as critical micronutrients in pregnancy and lactation along with vitamin B-12, iodine, and omega-3 fatty acids.[6,8-10]

Puerperium is the six-week period after childbirth, during which the mother's reproductive organs return to their pre-pregnant condition. With respect to maternal feeding, it is a critical time for the establishment of lactation, and, in the early days of this period, a dramatic maturation of breast milk occurs. In Chinese medicine, illness is viewed as an imbalance of "yin" and "yang"; pregnancy is a "yang" state, but during childbirth, the woman loses "yang" and becomes "yin"; hence, the equilibrium needs to be restored.[10] Traditionally, the first month postpartum is called the 'confinement month' in several countries and traditions, including China, where it is called 'Zuo yuezi', which literally means 'doing the month'.[11] It is an important time to promote recovery, and during this time rest, avoidance of physical work, and a nutritious diet are promoted along with other practices.

The aim of the 'confinement diet' is to benefit maternal health and increase the quality of breast milk during this crucial time. The details of the 'confinement diet' differ within China depending on the specific cultural and geographical influences. There are common characteristics of the recommendations, e.g., increased food quantity, avoidance of 'cold food', more protein-rich food, and other 'hot foods'. A study conducted in Fujian Province revealed that the practice of "Zuo yuezi" was common among both urban and rural families. Nevertheless, in cities, wealthier women may stay at a Maternal Care Center (MCC) during this confinement time. These centers provide daily care for the mother and the baby, but the specific services provided vary depending on the qualification and experience of the staff.

The last three decades has been a time of a dramatic change in the dietary habits of the Chinese, particularly those who dwell in urban areas.[12] The rapid economic development witnessed in the last 30 years in China and the concurrent influence of the Western lifestyle have increased the risk of non-communicable diseases, such as obesity, diabetes, and hypertension.[1] Thus, the research on the dietary intakes of Chinese populations has to elucidate both dietary insufficiency and dietary excess.

Dietary assessment methods include the use of estimated or weighed dietary diaries, repeated 24-hour recalls, and food-frequency questionnaires (FFQs).[13] A single day's intake can be adequate for surveying the intake at a large group level.[13] Importantly, comparisons of the dietary intakes at the group level to established recommendations can provide an indication of the overall dietary adequacy of the group examined.

The Chinese Dietary Reference Intakes (DRIs) were updated in 2013 to increase their consistency with the actual dietary needs of Chinese lactating mothers.[14] The energy recommendation is an estimated energy requirement (EER) rather than an estimated average requirement (EAR) in the DRIs. A new carbohydrate EAR was defined in the DRIs along with an acceptable macronutrient distribution range (AMDR). The major changes in the micronutrient recommendations consisted in the near halving of the recommended amount of zinc and, for the first time, an adequate intake (AI) of dietary fiber was set. The food-based Chinese Dietary Guidelines were updated in 2016,[15] with a greater emphasis on animal food and seafood to improve the quality of protein and vitamin A intake. These two sets of recommendations were used as criteria to evaluate the diet of the lactating women included in this study.

Only a limited number of studies have investigated the nutrient intake of pregnant or lactating women in China. Moreover, in these publications, the Chinese DRIs for 2013 and the dietary guideline of 2016 were seldom used.[1,12,16,17]

The aim of this study was to obtain an estimate of the dietary intake of two groups of women dwelling in Shanghai during their puerperium period, and compare the data obtained with the recommendations for the optimal nutritional intake during this period. The women were either residents in the community or stayed in an MCC. The dietary data were obtained from one or three days' intake recorded in repeated dietary diaries.

METHODS

This dietary intake study was a part of the MURU study, an observational investigation undertaken by the Shanghai Children's Medical Center (SCMC) and funded by Nutricia Early Life Nutrition (ELN). The MURU study aimed to determine the human milk composition and the dietary intake of a cohort of lactating women living in Shanghai. The study obtained ethical approval from the Institutional Review Board of the SCMC (SCMCIRB-K2013026).

Recruitment

The study was undertaken in two groups: subjects dwelling in the community being looked after by family members at home after the discharge from hospital; subjects who were residents in an MCC and stayed in the center for the first four weeks after delivery.

Most of the subjects were screened during the 3rd trimester of pregnancy during routine pregnancy examinations in the obstetrics departments of Renji Hospital and Shanghai First Maternity and Infant Health Hospital. Some of the subjects in the MCC group were recruited directly when they stayed in this MCC after delivery in obstetrics and gynecology departments in other hospitals.

A total number of 179 subjects were screened from March 2014 to February 2015. After delivery, 33 subjects were excluded because of deviation from the inclusion/exclusion criteria. In addition, 23 of them were excluded because of early termination, and another one did

not attend the first visit. The final sample comprised 122 subjects, 92 subjects from the community group and 30 subjects from the MCC group, who completed all their allocated visits. (Figure 1)

The subjects recruited were healthy Chinese mothers who gave birth to a healthy-term (37–42 weeks) infant, whose birth weight was >10 and <90 percentiles of the gestational birth weight chart and who met the inclusion and exclusion criteria outlined below.

Inclusion criteria

1. Generally healthy mothers who gave birth to a healthy-term (37–42 weeks) infant whose birth weight was >10 and <90 percentiles of gestational birth weight chart;
2. Aged 20–40 years;
3. Mothers who intended to exclusively breastfeed the infants for more than six weeks;
4. Chinese ethnicity of both parents;
5. Mothers who signed the informed consent form in writing.

Exclusion criteria

For the mothers

1. Participation in any other studies involving investigational or marketed products concomitantly or two weeks prior to the entry into this study;
2. Difficult to follow up and/or locate;
3. Current smoker or having smoked during the pregnancy;
4. Consumption of alcoholic drinks during pregnancy or lactation;
5. Illegal drug abuser: cannabinoids, stimulants, or opioids;
6. Acute infection disease or neoplastic disease or any kind or any weakening or debilitating condition;
7. Use of drug or pharmacologically active substances (e.g., herbal products, traditional medicine) to treat a particular disease or medical condition from the beginning of lactation (herbal/traditional medicine for maintaining or improving well-being was not an exclusion criteria);
8. Presence of mastitis, fungal infections of the nipple or areola; reactivation of herpes simplex (HSV) or vari-

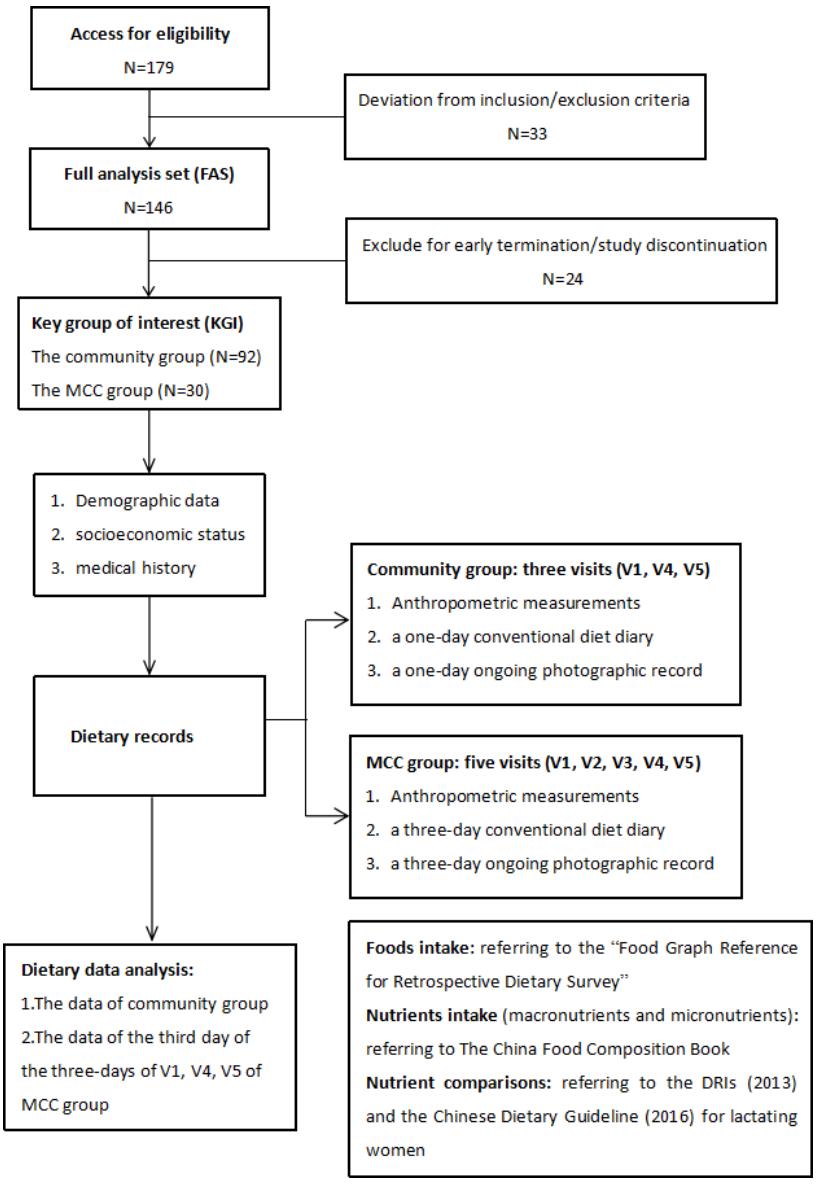

Figure 1. Muru subject flowchart.

cella zoster infection in the mammary or thoracic region at the time of enrolment;
9. Presence of endocrinology diseases, particularly diabetes mellitus and gestational diabetes;
10. Presence of obesity: pre-pregnancy body mass index (BMI) >28);
11. Presence of chronic diseases such as cardiovascular, renal, and respiratory and hepatic diseases;
12. Presence of psychosis and severe post-partum depression;
13. Presence of an autoimmune disease, such as systemic lupus erythematosus, systemic scleroderma, ulcerative colitis, Crohn's disease, or celiac disease;
14. Women whose health condition, according to the investigator's judgment, could interfere with the study conduct and assessment;
15. Mothers who have given birth to twins or multiples or infant conceived through assisted reproductive technology (ART);
16. Elimination diet due to chronic allergic diseases; any special diet for clinical reasons or vegan;
17. Incapability of the subject to comply with the study protocol or investigator's uncertainty about the willingness or ability of the mothers to understand and comply with the protocol requirements.

For the infants

Any known congenital abnormality, chromosomal disorder, or severe disease which could interfere with the study conduct and assessment.

Study visits

Originally the following time points were defined for visits to collect data. Five visits (V) after delivery were to be completed in the MCC group: V1- 4d (±2 days), V2- 10d (±2 days), V3- 17d (±2 days), V4- d28 (±2 days), V5- 42d (±2 days); the community subjects were to attend at V1, V4, and V5. In practice, the community subjects (and one MMC subject) found it difficult to comply with these visit times. Therefore, the visits were logged according to the infant age: (1) 0–7 days; (2) 8–13 days; (3) 14–21 days; (4) 22–35 days; and (5) 36–51 days. In the current study, this reclassification of the visits based on the infant age did not affect the results in any way as the mean of the intakes during the lactation period was primarily focused.

Demographic data, socioeconomic status, and medical history were recorded before or immediately after delivery. Anthropometric measurements (weight, height, and mid-upper arm circumference in mothers; weight, length, and head circumference in infants) were recorded at every visit. Human milk samples were also collected at every visit once milk production was established; the results of these analyses will be reported in subsequent papers. Blood samples were collected when the subjects provided permission. An illness record of mothers and infants was also collected at every visit.

Dietary records were kept by combining a conventional diet diary with an ongoing photographic record of the intake prior to every visit. Food photographs using a standard background board with scales were taken for every meal to increase the accuracy of the food record and assist with the portion size quantification estimation.

The community group completed a one-day diet diary and took photographs to record all food and beverages consumed in the day prior to their three visits. On the day of the visit, investigators inspected the record in detail to confirm the number of meals, food name, food type (raw or cooked), cooking method (boiled, fried, or baked), food texture (dry, wet, watery, or thick, etc.), and quantity of food consumed.

The meals of the MCC subjects were recorded for three consecutive days on five occasions. Furthermore, the recipe and portion size details were provided by the center staff and combined with photographs taken by the assigned care worker before and after every meal. The exception was at the last visit, which used a 3-day dietary dairy and photographs only as the subjects left MCC and returned home; the information in the diary was confirmed by the investigators at this visit in a way similar to that used for the community women.

Specific inquiry about the intake of vitamin or mineral supplements was not made in either group; only spontaneous reports by subjects were recorded.

The nutritionists in SCMC taught investigators and care workers in the MCC how to take pictures and record food intake. Subjects in the community group were taught by trained investigators to record their food intake.

Dietary data analysis

The three-day diet diaries that were collected from the MCC women were analyzed at each of the five time points specified earlier. In this study, the third day of the three-days was chosen in the MCC group at three time points as this best corresponded to the one-day community records for a direct comparison. One associate chief physician and one attending nutritionist from the Department of Clinical Nutrition of SCMC then analyzed the dietary data to obtain food intake data. An estimation of the quantity of food intake consumed by each subject was made by referring to the "Food Graph Reference for Retrospective Dietary Survey" designed by Professor Wang of Nanjing Medical University. Next, these data were transformed into nutrient intakes by the maternal nutrition team of the Nanjing Medical University School of Public Health using the China Food Composition Book as a reference.[18]

The China Food Composition Book is a comprehensive reference source, which contains the values for energy, macronutrients and some micronutrients, including calcium, iron, selenium, zinc, magnesium and vitamin A, vitamin B-1, vitamin B-2, nicotinic acid, vitamin C, and vitamin E. It does not contain values for iodine and vitamin D and has limited data for folate and omega-3 fatty acid, all of which are nutrients of interest during lactation.

Thus, the mean nutrient and food category intake from three, one-day repeated records were compared in both groups of women. The mean and standard deviation (SD) are presented herein, along with the 95% confidence interval (CI), along with the median values for macronutrients, micronutrients and food groups. Data are presented for the cohort, and then broken down to the community-dwelling women and those who were residents in MCCs.

There are a couple of instances where the median value of a food intake is zero as this was the most frequent response for that particular food. Nutrient comparisons are made with the EAR and AI rather than the recommended nutrient intake (RNI) and food intake is compared to the recommended intake from the different food groups. The reference recommendations of DRIs (2013) and the Chinese Dietary Guideline (2016) for lactating women were utilized in this research.

Due to the difference in the numbers of the group members and the days of recall (which was partially overcome by utilizing the third day of the MCC record only), any direct comparison between the community and MCC dwelling women would need to be further investigated in a subsequent study; in the present publication, only the observations have been reported.

BMI was calculated, and the subjects were classified by their weight statuses using standards for Asian populations.[19]

Data analysis

Data analysis was carried out using SAS version 9.4. Values were expressed as mean (SD), 95% CI, and a median value. The number and percentage of the subjects whose intake was out of the recommended range were calculated and expressed as N (%).

RESULTS

Sample characteristics

The characteristics of the women included in the study are listed in Table 1: age, ethnicity, education and occupational status, and annual income; all women were married. No apparent differences between the two groups in most of these characteristics were observed. An indication was present that more women were in the lower income bracket from the community women, with a higher proportion of women in the higher annual income from the MCC women; there were also more housewives in the MCC group.

Anthropometry

The weights and BMIs of the women at the first and final visit can be seen in Table 2. As expected, there was some post-delivery weight loss over the six-week study period, which was 1 kg overall, whereas this values were 2 kg and 1 kg for the community and MCC women, respectively. At the final visit around half of the women had a BMI within the healthy range, whereas most of the others were categorized as overweight/obese using Asian specific cut-offs.[18] The mean body weight was similar in both groups of women.

Macronutrient intake

The mean daily intakes of energy and each of the macronutrients are presented in Table 3. The mean energy levels were around the EER in the MCC group but lower in the community group. Over 70% of the community-dwelling women had an energy intake below the EER. The mean protein intake was higher in the MCC group but above the EAR in both groups; none of the MCC

Table 1. Socioeconomic descriptors of the study participants

	Total (122)	Community (92)	MCC (30)
Age (years), mean (SD)	29 (3.3)	29 (3.0)	30 (4.2)
Ethnicity, n (%)			
Han	118 (97)	88 (96)	30 (100)
Man	2 (1.6)	2 (2.2)	0 (0)
Other	2 (1.6)	2 (2.2)	0 (0)
Highest education completed, n (%)			
Secondary	5 (4.1)	4 (4.3)	1 (3.3)
Tertiary	117 (96)	88 (96)	29 (97)
Occupational status, n (%)			
Working	102 (84)	79 (86)	23 (77)
Self-employed	4 (3.3)	3 (3.3)	1 (3.3)
Unemployed	3 (2.5)	3 (3.3)	0 (0)
Studying	1 (0.8)	1 (1.1)	0 (0)
Housewife	12 (9.8)	6 (6.5)	6 (20)
Annual household income (RMB), n (%)			
<100,000	15 (12)	15 (16)	0 (0)
100,000-3000,000	76 (62)	58 (63)	18 (60)
300,000-500,000	22 (18)	14 (15)	8 (27)
>500,000	9 (7.4)	5 (5.4)	4 (13)

Table 2. Baseline and final visit body weights (kg) of the study participants

	Baseline			Final visit		
	Total (122)	Community (92)	MCC (30)	Total (122)	Community (92)	MCC (30)
Weight (kg), mean (SD)	63.5 (8.8)	63.7 (9.1)	62.8 (7.7)	61.8 (8.4)	61.9 (8.8)	61.7 (6.9)
Body mass index (kg/m^2), mean (SD)	24.0 (3.1)	24.2 (3.2)	23.3 (2.6)	23.4 (2.9)	23.5 (3.0)	22.9 (2.4)
Underweight (<18.5), n (%)	1 (0.8)	1 (1.1)	0 (0)	3 (2.5)	2 (2.2)	1 (3.3)
Healthy (18.5-22.9), n (%)	52 (43)	36 (39)	16 (53)	59 (48)	43 (47)	16 (53)
Overweight (23.0-27.4), n (%)	51 (42)	38 (41)	13 (43)	48 (39)	37 (40)	11 (37)
Obese (≥27.5), n (%)	18 (15)	17 (19)	1 (3.3)	12 (9.8)	10 (11)	2 (6.7)

women had a protein intake below the EAR value, but 15% of the community women did. The mean carbohydrate intakes were higher than the EAR for all women.

Table 4 shows the percentage contribution of the macronutrients to the total energy supply. It is obvious that the mean fat intake exceeds the recommendations for both groups of women with a corresponding lower percentage intake of the energy coming from carbohydrates than the recommended.

Micronutrient intake

The mean daily intakes of minerals and vitamins are listed in Table 5. The mean calcium intake values were lower than the recommendations in the community sample, and 85% of these women had an intake under the EAR. Although the mean calcium intakes were around the EAR in the MCC group, 70% of these women had intakes below the EAR. At the mean group level, the uptake of other mineral intakes appeared to meet the recommendations, including that of iron, selenium, zinc, and magnesium. However, in the community sample, the EARs were not met in a considerable proportion of the women concerning the following mineral nutrients: for iron (29%), magnesium (33%), selenium (46%), and to a lesser extent for zinc (16%). With regards to vitamins, at the mean level, the intakes appeared to meet the recommendations except for vitamin C in the community sample. I high proportion (62%) of all women failed to meet the EAR for vitamin A. Approximately 60% of the women (57% in the community and 60% in the MCC group), did not meet the EAR for thiamin (B1); for riboflavin (B2) these figures were 35% and 10%, respectively. Notably, 75% of all women did not meet the EAR for vitamin C. Dietary fiber intakes were below the EAR in all women, and the mean group intake was less than 50% of the AI.

Sodium intakes were higher than recommended in both groups of women with a mean intake of 2,969 (±866) mg which is approximately 135% of the AI.

The dietary data were also evaluated for high or excessive intakes. The intakes of all nutrients were safely below the upper limits (UL).

Food group intake

The food groups were compared against the recently updated dietary guidelines (Table 6). In all women, the mean vegetable, tuber, and fruit intakes were lower than the recommendations The mean grain intakes were around the recommended values, although slightly lower in the community sample, whereas the mean bean intakes were lower, especially in the community group, where they were around a third of the recommendations. The milk intake was low in all women with an overall mean intake approximately a quarter of the recommended quantity; the mean intake was 104 g in the community group, 172 g in the MCC group, whereas the recommendation is for 400–500 g. The mean meat/poultry, egg, and fish/shrimp intakes were higher than –the recommendations in all women, but in the MCC the mean figure was more than twice higher than the recommended amounts.

Supplement intake

Only six subjects in the MCC group spontaneously reported that they took a vitamin and mineral supplement: vitamin D in three subjects; calcium in two subjects; in one subject, the composition of the supplement was not apparent.

DISCUSSION

To the best of our knowledge, this is the first study revealing certain nutritional issues in this group of lactating women in Shanghai, particularly those dwelling in the community.

The two groups of the women that were involved in this study were of a similar age, ethnicity, and educational level; the annual income was higher in the MCC group, which could be expected for women staying at this private facility.

Comparisons in the current study were made with the EAR or AI rather than the RNI. The RNI was set to cover the nutritional requirements of 97.5% of the population; therefore, the failure to meet the RNI did not indicate a dietary gap. The EAR was set to meet the requirements of half the population, and the failure to meet the EAR may indicate a dietary gap. Moreover, the failure to meet the AI presents a nutritional concern.

The mean reported energy intake was lower than the EAR in the community group, and a considerable portion (over 70%) of all women failed to meet the EAR. The weight loss over the 6-week period after delivery was consistent with guidance which suggests a 0.8 kg weight loss per month during the first six months of lactation.14 Therefore, a weight loss of approximately 1.2 kg could have been expected for the duration of this study. The mean weight loss was 1.7 kg for the total group, and 1.8 kg and 1.1 kg for the community and MCC, respectively. Several possible explanations exist for these differences. First, the level of physical activity might have been so low that the actual requirements were below EAR. Second, it is also possible that under-reporting had occurred, but this is less likely for the MCC group, where trained center staff were responsible for recording the food intake. Third, the level of exclusive breastfeeding decreased during the study period, which would have reduced the energy requirements as formulated milk had been introduced to some infants.

The relative percentage of fat contribution to the energy intake was high with a concurrent lower contribution from carbohydrate. These findings on the energy intake and relative contribution of fat and carbohydrate are consistent with the results of a study in lactating women in the Fujian Province.[1] The protein intakes established in this study were 112–130 g/day over the study period,[1] which are consistent with the mean values in the MCC women, but higher than those in the community women. A total of 15% of the community women did not meet the

Table 3. Energy and macronutrient intakes of the study participants

	Total(122)				Community(92)				MCC(30)				EAR
	Mean (SD)	95% CI	Median	N (%) below EAR†	Mean (SD)	95% CI	Median	N (%) below EAR†	Mean (SD)	95% CI	Median	N (%) below EAR†	
Energy (kcal/d)	2074 (417)	1999-2149	2036	90 (74)	2032 (437)	1942-2123	1989	68 (74)	2202 (322)	2082-2322	2139	22 (73)	2300
Carbohydrate (g/d)	234 (50)	225-243	239	10 (8.2)	233 (51)	222-244	239	9 (9.8)	237 (48)	220-253	238	1 (3.3)	160
Fat (g/d)	80 (23)	76-84	78	-	78 (24)	73-83	75	-	86 (18)	79-93	81	-	-
Protein (g/d)	101 (26)	97-106	97	14 (12)	96 (24)	90-101	92	14 (15)	119 (22)	111-128	119	0 (0)	70

†N (%) below EAR, means the number and percentage of subjects whose intake of macronutrient is below EAR.

Table 4. Energy ratio (%) of carbohydrate, fat, and protein

Energy ratio (%)	Total (122)				Community (92)				MCC (30)				Recommendation
	Mean (SD) 95% CI	Median	N (%) above rec†	N (%) below rec‡	Mean (SD) 95% CI	Median	N (%) above rec†	N (%) below rec‡	Mean (SD) 95% CI	Median	N (%) above rec†	N (%) below rec‡	
Carbohydrate	46 (6.2) 45-47	45	1 (0.8)	91 (75)	47 (6.3) 45-48	46	1 (1.1)	65 (71)	43 (5.7) 41-52	43	0 (0)	26 (87)	50-65
Fat	34 (5.2) 33-35	34	97 (80)	-	34 (5.3) 33-35	34	73 (79)	0 (0)	35 (4.9) 33-37	34	24 (80)	-	20-30
Protein	20 (2.9) 19-20	19	-	-	18 (2.6) 18-19	19	-	-	22 (2.8) 21-23	22	-	-	-

†N (%) above rec, means the number and percentage of subjects whose dietary nutrients energy ratio is above recommendation.
‡N (%) below rec, means the number and percentage of subjects whose dietary nutrients energy ratio is below recommendation.

Table 5. Intake of micronutrients in the study participants

	Total (122)					Community (92)				
	Mean (SD)	95% CI	Median	N (%) below EAR†	N (%) below AI‡	Mean (SD)	95% CI	Median	N (%) below EAR†	N (%) below AI‡
Ca (mg)	606 (255)	561-652	585	99 (81)	-	549 (242)	499-599	511	78 (85)	-
Mg (mg)	341 (89)	325-357	331	31 (25)	-	326 (88)	308-344	308	30 (33)	-
P (mg)	1321 (314)	1265-1378	1293	0 (0.0)	-	1261 (304)	1198-1324	1213	0 (0)	-
K (mg)	2255 (569)	2153-2356	2236	-	73 (59)	2166 (566)	2049-2283	2134	-	57 (62)
Na (mg)	2969 (866)	2814-3124	2923	-	2 (1.6)	2813 (871)	2633-2994	2692	-	2 (2.2)
Fe (mg)	24 (8.3)	22-25	22	27 (22)	-	22 (7.7)	21-24	21	27 (29)	-
Se (ug)	86 (38)	79-93	82	43 (35)	-	77 (37)	69-85	68	42 (46)	-
Zn (mg)	14 (3.9)	13-15	13	15 (12)	-	13 (3.5)	12-14	13	15 (16)	-
VA (ugRAE)	1182 (1156)	974-1389	750	75 (62)	-	1121 (1036)	906-1335	763	56 (61)	-
VB_1 (mg)	1.2 (0.3)	1.1 - 1.2	1.1	70 (57)	-	1.2 (0.3)	1.0-1.2	1.1	52 (57)	-
VB_2 (mg)	1.6 (0.7)	1.5-1.7	1.4	35 (29)	-	1.5 (0.6)	1.4-1.6	1.3	32 (35)	-
Nicotinic acid (mgNE)	22 (6.9)	21-24	21	4 (3.3)	-	21 (7.0)	19-23	20	4 (4.3)	-
VC (mg)	103 (52)	94-113	91	91 (75)	-	96 (47)	86-115	89	72 (78)	-
VE (mgα-TE)	33 (7.9)	31-34	33	-	1 (0.8)	31 (8.0)	30-33	31	-	1 (1.1)
Dietary fiber (g)	10 (3.2)	9.7-11	9.7	-	122 (100)	10 (3.4)	9.3-10.8	9.6	-	92 (100)

Ca: calcium; Mg: magnesium; P: phosphorus; K: potassium; Na: sodium; Fe: iron; Se: selenium; Zn: zinc; VA: vitamin A; VB_1: vitamin B1; VB_2: vitamin B2; VC: vitamin C; VE: vitamin E.
†N (%) below EAR, means the number and percentage of subjects whose intake of micronutrient is below EAR.
‡N (%) below AI, means the number and percentage of subjects whose intake of micronutrient is below AI.

Table 6. Intakes of foods from specific food categories

	Total (122)			Community (92)			MCC (30)			Recommendation
	Mean (SD)	95% CI	Median	Mean (SD)	95%CI	Median	Mean (SD)	95% CI	Median	
Grains (g/day)	238 (56)	228-248	238	236 (57)	224-248	237	243 (52)	233-262	241	250–300
Vegetable(g/day)	259 (113)	238-279	238	242.(119)	218-267	222	308 (72)	281-335	302	500
Tubers (g/day)	16 (26)	11-21	0	16 (28)	11-22	0	14 (21)	6.5-22	0	75
Fruits (g/day)	154 (132)	131-178	142	174 (139)	145-203	150	93 (84)	62-125	62	200–400
Bean(g/day)	10 (11)	8.0-12	6.8	8.4 (9.7)	6.4-10	5.5	15 (14)	10-21	11	25
Milk(g/day)	115 (133)	91-138	83	104 (138)	75-133	67	147 (114)	104-189	141	412–515
Oil(g/day)	20 (5.9)	19-21	20	19 (6.3)	18-21	19	23 (3.9)	22-24	22	25
Eggs (g/day)	81 (44)	73-89	75	87 (46)	78-97	83	62 (31)	50-73	58	-
Fish/shrimp (g/day)	128 (96)	110-145	114	112 (92)	73-131	98	176 (93)	141-211	170	-
Meat/Poultry (g/day)	181 (76)	167-194	180	170 (78)	153-186	158	215 (61)	192-238	208	-
Sum of meat /poultry, eggs, and fish/shrimp	389 (122)	367-411	381	368 (121)	343-393	344	453 (101)	415-491	437	220

EAR for protein, whereas none of the MCC women failed to meet the standard. The high (as compared to the recommendations) mean intake of the meat/poultry, egg, and fish/shrimp is consistent with the mean protein intakes exceeding the EAR. This finding is noteworthy given the concern associated with a lack of animal foods in the diet, which had been addressed in the revised food guidelines for 2016. A decreasing contribution of plant foods to the energy intake of pregnant Chinese women was reported earlier.[12] Also, the higher fat consumption is consistent with the trends of an increasingly affluent population and stronger western influence on the dietary intake.

An inadequate intake of calcium was found in many subjects, which is consistent with the low reported intake of milk in all women, especially in the community women.

For the other micronutrients, it was important to look at the numbers and percentages not meeting the EAR as considering the mean intake values alone would have been misleading. A notable number of community-dwelling women failed to meet the EAR for iron, magnesium, selenium, and zinc to a lesser extent. In all women, there was a marked failure to meet the EAR for vitamin C, Vitamin A, and thiamin; this trend was less obvious for riboflavin, particularly in the MCC women. Fruit and vegetable intakes were below the recommendations, which would explain the vitamin C results. The low grain intake in the community women might have been responsible for the lower intakes of B vitamins along with the low bean and tuber intakes in all women. The low intakes of these food groups are also an explanation for the exceedingly low dietary fiber intakes that were recorded for all the women.

An insufficient nutritional intake affects the maternal health, reduces the amount of milk secretion, influences negatively the milk quality and in turn, hampers the normal growth and development of the infant. Some studies have found that the nutritional status of lactating women appears to influence fat concentration, and thus the energy content of breast milk as well as its fatty acid composition, vitamins, and immunological properties.[7,20]

The aforementioned results are broadly consistent with those reported previously for Fujian Province, where vitamin C, thiamin, folate, calcium, zinc, and dietary fiber were found to be between 5%–73% lower than the RNI.[1]

The results of the current study are also largely consistent with the ones obtained for pregnant women, which revealed an excessive contribution of fat to the total energy intake while the intakes of vitamin A, vitamin B-6, calcium, magnesium, and selenium were below the Chinese RNI and EARs in all trimesters.[12] The mean intake of sodium was found to greatly exceed the AI.[12] Furthermore, improved dietary intakes of some nutrients were associated with a higher socioeconomic status,[12] which is in agreement with the apparent differences between the community-dwelling and MCC women.

In the current study, sodium intakes were higher than the recommendations. This intake is an underestimated as data on discretionary salt used at the table were not collected, but salt in cooking was accounted for, as was the sodium present in soy bean sauce and fermented foods which are commonly consumed.

The intakes of fruit and vegetables were lower than the food-based guidance although, traditionally, the consumption of these ‘cold’ foods is limited in the confinement period. This finding suggests a conflict with the dietary recommendations and traditional practice. On the other hand, an earlier study showed that the pregnant women dwelling in rural areas were more likely to follow traditional food recommendations.[16] It has been argued that a single RNI for China is not feasible or realistic given the cultural, geographical, and socio-economic diversity in such a huge country.[1]

A strength of the current study are the repeated dietary intakes, we acknowledge that the total days of dietary data recorded varied between the groups, which is a limitation. The decision to do this was pragmatic: to reduce respondent burden and promote retention in the community group. Nevertheless, it meant that any comparisons between the groups should have been viewed as indicative and preliminary rather than conclusive. This is also the case, because the numbers of subjects included varied in the different groups.

The diet diary was supplemented by a photographic record of food intake, which was done to improve the accuracy of the dietary record. Recent studies have shown that instant photography (image quantification) is more effective than a conventional 24-hour recall, and intake values similar to weighed values can be obtained.[21,22]

The food composition reference used did not contain data on some key nutrients, which is a limitation of the study. A final limitation was the absence of a specific inquiry about the intake of supplements. This is particularly relevant for vitamin D as food contributes relatively little to its intake, whereas its importance at this early stage of life is increasingly recognized.[23] Currently, Vitamin D supplementation is not specifically recommended for lactating women in China. Iodine supplement during pregnancy and lactation is not applicable in China since the use of iodized salt is widespread.

Conclusion

The findings of this dietary intake study indicate that nutritional intake issues might be present in lactating women in Shanghai. Calcium, vitamin A, vitamin C, thiamin, and dietary fiber intakes were a concern in both groups. In the community-dwelling women, there were additional intake insufficiency was established for iron, magnesium, selenium, and to a lesser extent for zinc. No evidence of excessive intakes of fat and sodium was available. The caveat to these conclusions is that the intake of supplements and certain nutrients was not assessed.

Future research should address the supplement intake as well as vitamin D, omega-3 fatty acids, and iodine intake, since this will provide a more complete analytical data of the nutritional intakes in this population subgroup.

Our findings suggest that locally relevant nutrition education is highly needed given the important impact maternal nutritional intake exerts on breast milk composition.

ACKNOWLEDGEMENTS

The research has received scientific contribution from Nutricia Research, the Netherlands and Singapore. The dietary photos

and records were analyzed by nutritionists from the Department of Clinical Nutrition of SCMC and a professional maternal nutrition team of Nanjing Medical University School of Public Health. We extend our sincere gratitude to Berend-Jan Velhuis of Danone Nutricia Research, the Netherlands, for his devoted contribution to the statistical analysis and precious suggestions during the preparation of this paper.

AUTHOR DISCLOSURES

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript. Bernd Stahl and Bianca Papi are employees of Danone Nutricia Research, the Netherlands. Yi Jin is an employee of Danone Nutricia Early Life Nutrition, Shanghai, China.

The research has received financial support and scientific contribution from Danone Nutricia Early Life Nutrition, China. This work was also supported by the Maternal Care Center, Renji Hospital, and Shanghai First Maternity and Infant Health Hospital.

REFERENCES

1. Chen H, Wang P, Han Y, Ma J, Troy FA, 2nd, Wang B. Evaluation of dietary intake of lactating women in China and its potential impact on the health of mothers and infants. BMC Womens Health. 2012;12:18. doi: 10.1186/1472-6874-12-18.
2. Cervera P, Ngo J. Dietary guidelines for the breast-feeding woman. Public Health Nutr. 2001;6a:1357-62.
3. Hall Moran V, Lowe N, Crossland N, Berti C, Cetin I, Hermoso M, Koletzko B, Dykes F. Nutritional requirements during lactation. Towards European alignment of reference values: the EURRECA network. Matern Child Nutr. 2010: 39-54. doi: 10.1111/j.1740-8709.2010.00276.x.
4. Chinese Nutrition Society. Dietary guidelines for the breast-feeding woman. Chinese Journal of Perinatal Medicine. 2016;10:721-6. doi: 10.3760/cma.j.issn.1007-9408.2016.10.001.
5. Lonnerdal B. Effects of maternal dietary intake on human milk composition. J Nutr. 1986;4:499-513.
6. Allen LH. Multiple micronutrients in pregnancy and lactation: an overview. Am J Clin Nutr. 2005;5:1206s-12s.
7. Bravi F, Wiens F, Decarli A, Dal Pont A, Agostoni C, Ferraroni M. Impact of maternal nutrition on breast-milk composition: a systematic review. Am J Clin Nutr. 2016;3: 646-62. doi: 10.3945/ajcn.115.120881.
8. Hermoso M, Vollhardt C, Bergmann K, Koletzko B. Critical micronutrients in pregnancy, lactation, and infancy: considerations on vitamin D, folic acid, and iron, and priorities for future research. Ann Nutr Metab. 2011;1:5-9. doi: 10.1159/000332062.
9. Leung AM, Pearce EN, Braverman LE. Iodine nutrition in pregnancy and lactation. Endocrinol Metab Clin North Am. 2011;4:765-77. doi: 10.1016/j.ecl.2011.08.001.
10. Koletzko B, Cetin I, Brenna JT. Dietary fat intakes for pregnant and lactating women. Br J Nutr. 2007;5:873-7. doi: 10.1017/s0007114507764747.
11. Raven JH, Chen Q, Tolhurst RJ, Garner P. Traditional beliefs and practices in the postpartum period in Fujian Province, China: a qualitative study. BMC Pregnancy Childbirth. 2007:8. doi: 10.1186/1471-2393-7-8.
12. Liu FL, Zhang YM, Pares GV, Reidy KC, Zhao WZ, Zhao A et al. Nutrient intakes of pregnant women and their associated factors in eight cities of China: a cross-sectional study. Chin Med J (Engl). 2015;13:1778-86. doi: 10.4103/0366-6999.159354.
13. Council MR. Dietary and Physical Activity Toolkit (DAPA) 8th January 2017 [cited; Available from: http://dapatoolkit.mrc.ac.uk/dietary-assessment/methods/recalls/index.php).
14. Chinese Nutrition Society. Chinese Dietary Reference Intakes (DRIs) 2013.China: Science Publishing House. 2013.
15. Chinese Nutrition Society. Chinese Dietary Guideline 2016. China: People's Medical Publishing House. 2016.
16. Gao H, Stiller CK, Scherbaum V, Biesalski HK, Wang Q, Hormann E, Bellows AC. Dietary intake and food habits of pregnant women residing in urban and rural areas of Deyang City, Sichuan Province, China. Nutrients. 2013;8:2933-54. doi: 10.3390/nu5082933.
17. Mao G, Ding G, Lou X, Zhang R, Zheng P, Mo Z et al. Survey of iodine nutritional status in 2011, Zhejiang, China. Asia Pac J Clin Nutr. 2015;2:234-44. doi: 10.6133/apjcn.2015.24.2.08.
18. National Institute of Nutrition and Food Safety, China CDC. China Food Composition. Peking: University Medical Press; 2009.
19. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet. 2004;9403:157-63. doi: 10.1016/s0140-6736(03)15268-3.
20. Teo C, Chia AR, Colega MT, Chen LW, Fok D, Pang WW et al. Prospective associations of maternal dietary patterns and postpartum mental health in a multi-ethnic Asian cohort: The Growing up in Singapore towards Healthy Outcomes (GUSTO) Study. Nutrients. 2018;10, pii: E299. doi: 10.3390/nu10030299.
21. Wang Z, Zhang M, Wu J, Sun L, Jiang T, Song C. Study on establishment and evaluation of a novel method for dietary assessment with instant photography. Acta Nutrimenta Sinica. 2014;3:288-95.
22. Jiang T, Dai Y, Miao M, Zhang Y, Song C, Wang Z. Evaluation study on a new method of dietary assessment with instant photography applied in urban pregnant women in Nanjing city. Wei Sheng Yan Jiu. 2015;4:586-92.
23. Berti C, Agostoni C, Davanzo R, Hypponen E, Isolauri E, Meltzer HM, Steegers-Theunissen RP, Cetin I. Early-life nutritional exposures and lifelong health: immediate and long-lasting impacts of probiotics, vitamin D, and breastfeeding. Nutr Rev. 2017;2:83-97. doi: 10.1093/nutrit/ nuw056.