

RESEARCH ARTICLE

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Food sources of energy and nutrients in the diets of infants and toddlers in urban areas of China, based on one 24-hour dietary recall

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Abstract

Background: Food sources of nutrients in young children in China have been little investigated. The objective of this study was to understand feeding patterns of young children through an analysis of food sources of energy and nutrients in the diets of infants and toddlers living in urban areas in China.

Methods: This study was part of the cross-sectional study, Maternal Infant Nutrition Growth (MING). One 24-h dietary recall was completed for a total of 1409 children (infants 6–11 months, younger toddlers 12–23 months, and older toddlers 24–36 months) via face-to-face interviews with the primary caregivers. All food, beverage and dietary supplements that the child consumed on the previous day were recorded and processed with a database including data from Chinese Food Composition tables. All reported foods and supplements were assigned to one of 83 food groups developed for the study. Percent contribution of each food group to nutrient intakes was calculated.

Results: Children in all 3 age groups received a majority of energy (52 to 69 %) from few foods including infant formula or growing-up (fortified) milk, rice, noodles, pork and eggs, with rice becoming the number one source of energy by 24 months. Rice and noodles were not only top sources of energy (17 to 26 %) and carbohydrate (27 to 40 %) but also top sources of protein (13 to 16 %), iron (13 to 18 %) and zinc (11 to 18 %). Supplements made substantial contributions to intakes of vitamin A, zinc, iron and calcium. Salt added during home-cooking was the main source of sodium (60 to 80 %).

Conclusions: Few foods made up the core of the diets of infants and young toddlers living in urban areas in China. Low nutrient-dense rice and noodles were top sources of many nutrients, which could potentially lead to inadequate intakes of some key nutrients.

Background

Early childhood is a time when food preferences and dietary habits are being established. The dietary patterns established during this time often persist into adulthood and have implications for developing diet-related chronic diseases later [1], such as cardiovascular disease and diabetes [2]. Knowledge about the sources of energy and nutrients in young children's diets can help health professionals to gain a more complete understanding about their diets and the specific strategies for improvement.

Food sources of energy and nutrients in young children have been studied in the US [3–6]. With a focus on the US infant and toddler population, the Feeding Infants and Toddlers Study (FITS) recently reported the sources of energy and 24 nutrients in detail and described shifts in major nutrient sources as children age [6]. Dietary sources of nutrients have also been studied in pre-school children in Belgium and Sweden [7, 8]. By comparison, such studies in China are very limited. To date, few published studies available in China only described the intake of one nutrient such as energy or fats or iron with limited information for food sources [9–11].

The current paper describes the major food sources of energy and nutrients among infants and toddlers in China

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using data from the Maternal Infant Nutrition Growth (MING) study, in which one 24-h dietary recall was collected from infants and toddlers (6 to 35 months of age).

Methods

Sample design and subjects

The MING study methods and sample will be subsequently described in detail. Briefly, the MING study was a cross-sectional study to investigate the dietary and nutritional status of pregnant women, lactating mothers and young children aged from birth up to 3 years. Infants and toddlers were recruited from maternal and child care centres in 8 tier 1 and tier 2 cities in China. Subjects were recruited randomly based on the child registration list in each of the maternal and child care centres (two in each city) until the target number was reached. Final samples sizes in three subgroups were 444 children 6 to 11 months (infants), 476 children 12 to 23 months (younger toddlers) and 489 children 24 to 35 months (older toddlers).

The study was conducted according to the guidelines in the Declaration of Helsinki. All of the procedures involving human subjects were approved by the Medical Ethics Research Board of Peking University (No.IRB00001052-11042). Written informed consent was obtained from the primary caregiver of each infant or toddler participating in the study.

Data collection methods

One 24-h dietary recall was collected for each child by trained interviewers via face-to-face interviews with the primary caregiver. Interviewers asked the primary caregiver about all food, beverages and supplements that the child consumed on the previous day. Portions were estimated using measurement aids (including spoons, cups and bowls) and a picture booklet of common foods consumed in China (designed for national nutrition survey by the Centre of Disease Control in China). The information collected was then converted to weight in grams using a portion to weight conversion list for common foods. Use of nutrient supplements was also collected during the face-to-face interview with the primary caregiver as part of a general questionnaire. A list of dietary supplements commonly used in China was used to code the supplement(s) reported. The primary caregiver was also encouraged to bring the packing of the nutrient supplement to the interviewer. The information collected included the name and brand of the supplement, age when supplement was first given and the amount used.

Food records were entered and processed with a food composition database created for this study that included data from Chinese Food Composition (CFC) tables 2004 & 2009 [12, 13] and branded baby food products and dietary supplements commonly consumed in China. CFC contains information of 1773 foods with 36 nutrients. The

values for both beta-carotene and retinol were available in the database, thus vitamin A was estimated in retinol activity equivalents using the following formula [14]: Retinol activity equivalents = $\mu\text{g retinol} + 1/2 (\mu\text{g beta-carotene equivalents}/6)$.

We did not collect data on the amount of human milk fed, but simply the number of times the mother nursed during the day and estimated the amount based on published literature [15]. For infants aged 6 to 11 months fed human milk as the sole milk source, the amount of human milk was assumed to be 600 mL/day; for partially breastfed infants, the amount of human milk was estimated as 600 mL/day minus the amount of formula or other milks consumed. For breastfed toddlers aged 12 to 23 months, the amount of human milk was estimated as 89 mL per feeding occasion; and for toddlers aged 24–35.9 months, the amount of human milk was estimated as 59 mL per feeding occasion [15].

Analytic methods

A comprehensive listing of dietary sources of nutrients was initially developed by Krebs-Smith and colleagues [16] and later expanded by other researchers [4, 17]. To make the results of the present study comparable with the information obtained in other countries, the classifications of food group were designed to be similar to those used by Fox and colleagues [6], but at same time reflect the characteristics of the Chinese diet by having traditional, frequently consumed foods listed individually such as noodles, steamed bread and Chinese cabbages. Thus, a list of 83 food groups including two for dietary supplements were created based on similarities in nutrient content and role in the diet (Table 1).

A total of 680 individual foods and supplements were reported by the caregivers in this study. These foods and supplements were assigned to one of the 83 groups except 16 food mixtures that were infrequently consumed such as hamburgers, pizzas, dumplings or sushi, etc. The 16 food mixtures were disaggregated into their ingredients, and the ingredients were then assigned to one of the 83 groups.

Statistical analysis

Statistical Analysis Software (version 9.2, 2008, SAS Institute, Inc, Cary, NC) was used to calculate the contribution of each food group to the overall intake of energy and nutrients. After all foods and supplements reported were assigned to one of the 83 groups, the weighted percentage contribution of each food group for all infants and toddlers was calculated by summing the amount of a given nutrient provided by each food group for all individuals and dividing by the total intake of that nutrient consumed by all individuals from all foods and supplements. Only foods/food groups that contributed over 1 % of the nutrient intake are represented including

Table 1 Food group classifications among infants and toddlers 6–35 months from the MING study

<i>Milk and milk products</i>	Other grains/grain products ^e	Peaches/nectarines/plums
Breast milk	Flour/baking ingredients ^f	Pears
Infant formula	<i>Vegetables</i>	Grapes
Growing-up milk ^g	Broccoli	Melons
Milk ^b	Chinese cabbages	Dried fruits
Soy milk	Coles	Other fruits ⁱ
Cheese	Celeries	100 % juice
Yogurt	Carrots	Baby food fruits
<i>Meat/poultry/fish/meat alternates</i>	Corn	<i>Desserts and sweets</i>
Beef	Green beans	Cakes/pies
Lamb	Eggplants	Cookies
Sausages	Peas	Ice cream
Pork	Potatoes	Honey
Organ meats	Pumpkins	Chocolates
Chicken/duck	Spinach	Candy
Fish/shellfish/shrimps	Sweet potatoes/yams	Sugar/syrups/jams/jellies/other sweeteners
Eggs ^c	Tomatoes/tomato sauce	Other desserts
Other meat ^d	Pickles	Sweetened beverages
Soy/tofu/meat substitutes	Other root vegetables ^g	<i>Other</i>
Nuts/seeds	Other leafy vegetables ^h	Salad dressings/mayonnaise
Baby food meat	Other baby food vegetables	Oil/other fats ^j
<i>Grains and grain products</i>	<i>Fruits</i>	Condiments ^k
Infant cereal	Apples/applesauce	Chips/puffed food/other salty snacks
Bread/biscuits	Apricots	Salts ^l
Pancakes/sesame seed cakes	Kiwi fruits	Soups
Noodles	Dragon fruits	Other beverages ^m
Rice	Mangoes	<i>Supplements</i>
Millet	Jujube	Vitamin and mineral supplements
Steamed bread	Bananas	Other supplements
Cornmeal	Berries	
Other baby food grains	Citrus fruits	

^aFortified milk for young children

^bIncludes cow's milk and goat's milk

^cIncludes eggs reported separately and eggs included in disaggregated food mixtures

^dIncludes donkey, horse, dog, rabbit and turkey meat

^eIncludes buckwheat, barley, glutinous rice, highland barley and sorghum

^fIncludes flour, corn-starch, yeast and baking powder included in disaggregated food mixtures

^gIncludes white radish, asparagus, water chestnut, lotus root, onion, winter squash and bean sprout, peppers, cucumbers, mushrooms and balsam pear

^hIncludes Chinese leeks, baby cabbage, lettuce, coriander, fennel, heartleaf houttuymia herb, fiddlehead, crown daisy and Shepherd's purse

ⁱIncludes pineapple, cherries, papaya, hawthorn, persimmon, pomegranate, coconut and mangosteen

^jIncludes olive oil, soybean oil, canola oil, lard oil, butter and fats included in disaggregated food mixtures

^kIncludes shallot, garlic, ginger, Chinese red pepper, peppermint, vinegar, soy sauce and other condiment sauces

^lIncludes cooking salts and salts included in disaggregated food mixtures

^mIncludes unsweetened tea and coffee and alcoholic beverages

dietary supplements. Sources of energy and nutrients were assessed separately for infants aged 6 to 11 months, younger toddlers aged 12 to 23 months and older toddlers aged 23 to 35 months in descending order of contribution to overall nutrient intake.

Results

Dietary supplements

As reported by the caregivers, 57 % of the young children received dietary supplements on the day of their 24-h dietary recall. The main types of supplements used

were fish liver oil, multiple vitamin and mineral supplements.

Energy, macronutrients and fibre

The food sources of energy are displayed in Table 2. The top 5 energy sources for infants aged 6 to 11 months were infant formula, breast milk, rice, eggs and noodles. For younger and older toddlers, the top 5 sources of energy were growing-up milk, rice, noodles, pork and eggs. The top 5 food sources of energy contributed 69, 59 and 52 % of total energy in each of the age groups respectively (Fig. 1, Table 2), showing a decrease in milk product consumption along with an increase in dietary diversity as children grew older.

Infant formula (26 %) and breast milk (19 %) contributed 45 % of total energy among infants. Rice and noodles were major contributors to energy, together providing an additional 17 % of calories. Infant formula was replaced by growing-up milk as the number one and number two source of energy among younger and older toddlers respectively. Rice became the number one source of energy among older toddlers and was number two among the younger toddlers. Other foods in the top five sources of energy included noodles, pork and eggs (Fig. 1 and Table 2). After the top 5, other food sources of energy were infant cereal (infants only), oil/other fats, pancakes/sesame seed cakes and milk and bread/biscuit (Table 2).

The top 5 food sources of energy were also the major sources of protein contributing 69 to 50 % among the three age groups (Fig. 1 and Table 3). Infant formula and growing-up milk were the number one sources of protein among infants and younger toddlers respectively. Eggs were the most important non-milk source of protein, with the contribution ranging from 15 to 18 % (Table 3). Rice, pork, fish/shellfish/shrimps and noodles were other major sources of protein.

Infant formula was the leading source of carbohydrate (21 %) among infants while growing-up milk was the number two and number three source of carbohydrate among younger and older toddlers respectively (Fig. 1 and Table 4). Rice was the number two source of carbohydrate among infants (16 %) and then became the number one source of carbohydrate contributing a quarter or more among younger and older toddlers. Noodles were also major sources of carbohydrate. Rice and noodles together accounted for 27 to 40 % of carbohydrate intake among the children. Other important sources of carbohydrate were infant cereal among infants, pancakes/sesame seed cakes, bread/biscuits and apples/applesauce among the children.

Table 5 shows changes in the sources of dietary fibre for the different age groups. Among infants 6 to 11 months, the number one source of dietary fibre was apples/applesauce and infant formula was number two,

Table 2 Sources of energy among infants and toddlers 6–35 months from the MING study

Rank	Age 6–11 months		Age 12–23 months		Age 24–35 months	
	Food Group	% of Total	Food Group	% of Total	Food Group	% of Total
1	Infant formula	26	Growing-up milk	22	Rice	18
2	Breast milk	19	Rice	15	Growing-up milk	11
3	Rice	10	Noodles	8	Pork	9
4	Eggs	7	Pork	7	Noodles	8
5	Noodles	7	Eggs	7	Eggs	6
6	Infant cereal	7	Oil/other fats	7	Pancakes/sesame seed cakes	6
7	Pancakes/sesame seed cakes	3	Pancakes/sesame seed cakes	5	Oil/other fats	5
8	Oil/other fats	3	Milk	4	Milk	5
9	Pork	3	Bread/biscuits	3	Bread/biscuits	4
10	Bread/biscuits	2	Fish/shellfish/shrimps	2	Fish/shellfish/shrimps	2
11	Apples/applesauce	2	Apples/applesauce	2	Soy/tofu/meat substitutes	2
12	Bananas	1	Bananas	2	Chicken/duck	2
13	Growing-up milk	1	Steamed bread	1	Apples/applesauce	2
14	Steamed bread	1	Citrus fruits	1	Bananas	2
15	-		Breast milk	1	Nuts/seeds	2
16	-		Millet	1	Citrus fruits	1
17	-		Soy/tofu/meat substitutes	1	Steamed bread	1
18	-		Nuts/seeds	1	Yogurt	1
19	-		Chicken/duck	1	Cakes/pies	1

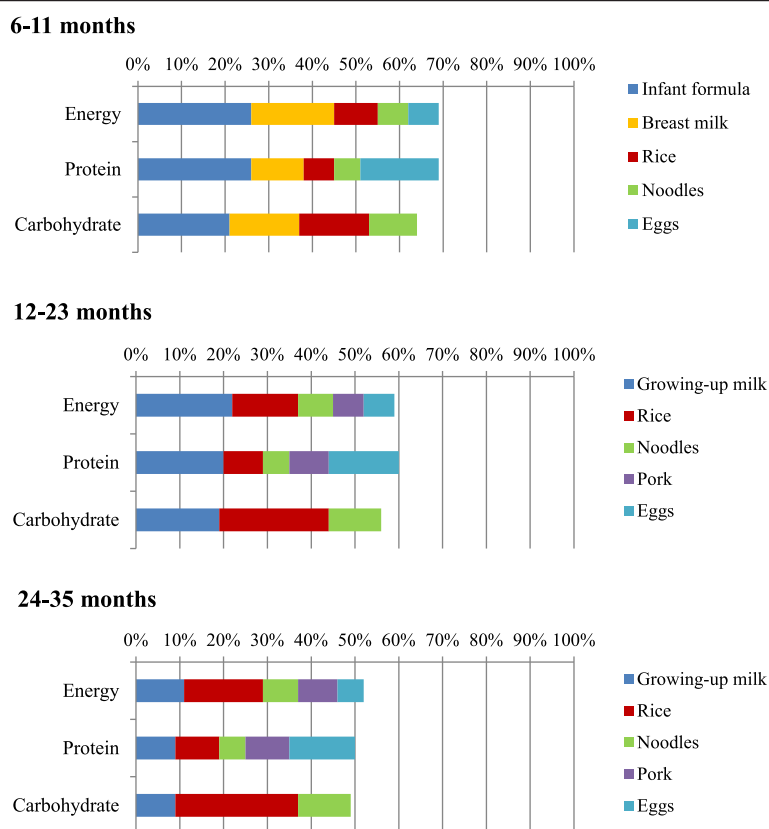


Fig. 1 Percent contribution of top 5 foods of energy to intakes of energy, protein and carbohydrate of infants and toddlers from the MING study

Table 3 Sources of protein among infants and toddlers 6–35 months from the MING study

Rank	Age 6–11 months		Age 12–23 months		Age 24–35 months	
	Food Group	% of Total	Food Group	% of Total	Food Group	% of Total
1	Infant formula	26	Growing-up milk	20	Eggs	15
2	Eggs	18	Eggs	16	Pork	10
3	Breast milk	12	Fish/shellfish/shrimps	10	Rice	10
4	Rice	7	Pork	9	Fish/shellfish/shrimps	10
5	Noodles	6	Rice	9	Growing-up milk	9
6	Pork	5	Noodles	6	Milk	7
7	Infant cereal	5	Milk	5	Noodles	6
8	Fish/shellfish/shrimps	5	Pancakes/sesame seed cakes	4	Pancakes/sesame seed cakes	5
9	Pancakes/sesame seed cakes	3	Chicken/duck	3	Chicken/duck	5
10	Growing-up milk	2	Soy/tofu/meat substitutes	2	Soy/tofu/meat substitutes	4
11	Milk	2	Bread/biscuits	2	Beef	2
12	Bread/biscuits	2	Steamed bread	1	Bread/biscuits	2
13	Steamed bread	1	-	-	Other root vegetables	2
14	Chicken/duck	1	-	-	Nuts/seeds	1
15	-	-	-	-	Steamed bread	1

Table 4 Sources of carbohydrate among infants and toddlers 6–35 months from the MING study

Rank	Age 6–11 months		Age 12–23 months		Age 24–35 months	
	Food Group	% of Total	Food Group	% of Total	Food Group	% of Total
1	Infant formula	21	Rice	25	Rice	28
2	Rice	16	Growing-up milk	19	Noodles	12
3	Breast milk	16	Noodles	12	Growing-up milk	9
4	Noodles	11	Pancakes/sesame seed cakes	7	Pancakes/sesame seed cakes	9
5	Infant cereal	10	Bread/biscuits	4	Bread/biscuits	5
6	Pancakes/sesame seed cakes	4	Apples/applesauce	4	Apples/applesauce	4
7	Apples/applesauce	4	Bananas	3	Bananas	3
8	Bread/biscuits	3	Milk	2	Milk	3
9	Bananas	2	Citrus fruits	2	Citrus fruits	2
10	Steamed bread	2	Steamed bread	2	Soy/tofu/meat substitutes	2
11	Millet	1	Millet	2	Steamed bread	2
12	Growing-up milk	1	Infant cereal	1	Cakes/pies	1
13	-		Cakes/pies	1	Sweet potatoes/yams	1
14	-		Soy/tofu/meat substitutes	1	Millet	1

Table 5 Sources of fibre among infants and toddlers 6–35 months from the MING study

Rank	Age 6–11 months		Age 12–23 months		Age 24–35 months	
	Food Group	% of Total	Food Group	% of Total	Food Group	% of Total
1	Apples/applesauce	17	Pancakes/sesame seed cakes	11	Soy/tofu/meat substitutes	16
2	Infant formula	12	Apples/applesauce	11	Pancakes/sesame seed cakes	11
3	Pancakes/sesame seed cakes	7	Soy/tofu/meat substitutes	8	Other root vegetables	10
4	Rice	7	Growing-up milk	8	Apples/applesauce	8
5	Noodles	6	Rice	7	Rice	7
6	Bananas	6	Bananas	6	Bananas	4
7	Pears	5	Pears	5	Pears	4
8	Corn	3	Noodles	5	Nuts/seeds	4
9	Cornmeal	3	Kiwi fruits	4	Noodles	4
10	Spinaches	3	Nuts/seeds	3	Chinese cabbages	3
11	Kiwi fruits	3	Chinese cabbages	3	Growing-up milk	3
12	Soy/tofu/meat substitutes	3	Citrus fruits	3	Citrus fruits	3
13	Steamed bread	2	Spinaches	2	Other leafy vegetables	2
14	Chinese cabbages	2	Cornmeal	2	Spinaches	2
15	Bread/biscuits	2	Other root vegetables	2	Corn	2
16	Citrus fruits	2	Steamed bread	2	Carrots	2
17	Carrots	1	Bread/biscuits	2	Bread/biscuits	1
18	Other leafy vegetables	1	Other leafy vegetables	2	Coles	1
19	Dragon fruits	1	Dried fruits	2	Steamed bread	1
20	Other fruits	1	Corn	1	Sweet potatoes/yams	1
21	Millet	1	Sweet potatoes/yams	1	Other fruits	1
22	Other root vegetables	1	Peaches/nectarines/plums	1	-	
23	-		Green beans	1	-	
24	-		Carrots	1	-	

followed by pancakes/sesame seed cakes, rice, noodles, bananas. Among toddlers, in addition to apples/apple-sauce, pancakes/sesame seed cakes, and soy/tofu/meat substitutes were the most important sources of dietary fibre. Despite being commonly consumed, various leafy vegetables including Chinese cabbages and spinach are not significant contributors to dietary fibre among toddlers.

Infant formula and breast milk together contributed nearly 60 % of the fat in the diets of infants (32 % and 28 % respectively) (Table 6). Growing-up milk and milk together contributed 30 and 21 % of fat among the younger and older toddlers respectively. Oil/other fats, pork were also in the top 5 infant sources of fat, and became more important in the diets of toddlers. By age 24 to 35 months, pork was the number one (23 %) and oil/other fats the number two (17 %) source of fat. These two foods together contribute 38 % of the fat in the diet of younger toddlers. Eggs were also major sources of fat among the children (Table 6). Cholesterol is not a concern among children in these age groups; however, top sources of cholesterol in the diet were eggs, fish/shellfish/shrimps and pork.

Micronutrients

The top 5 food sources of energy were also major contributors to the intakes of a number of vitamins and minerals as shown by Fig. 2 with more pronounced contributions seen among infants contributing from 79 to 53 %. The contribution of the top 5 food sources of energy to the intakes of micronutrients was reduced among older toddlers, however, still contributed 50 % or more to most micronutrient intakes among younger toddlers (Fig. 2).

Infant formula and growing-up milk were the number one sources of iron among infants and toddlers, contributing nearly one third of the daily intake among infants, 27 % to younger toddlers and 12 % to older toddlers (Fig. 2 and Table 7). Rice was the number two source among both younger and older toddlers. Other important sources of iron were eggs, infant cereal, noodles and rice among infants, noodles and eggs among younger and older toddlers. Root vegetables and soy/tofu/meat became major sources of iron among older toddlers (Table 7).

Infant formula and growing-up milk were the number one sources of zinc among infants and younger toddlers (Fig. 2 and Table 8). Among older toddlers, rice was the number one source of zinc, followed by growing-up milk. Other important sources of zinc were breast milk, infant cereal and eggs among infants, eggs and pork among toddlers (Fig. 2 and Table 8). In addition, infant formula or growing-up milk was the number one source of calcium contributing 44 % among infants, and nearly 50 % among younger toddlers. Growing-up milk combined with other milk contributing 47 % to calcium intake among older toddlers (Fig. 2 and Table 9). Other major sources of calcium were infant cereal and breast milk among infants and eggs and fish/shellfish/shrimps among toddlers (Table 9).

For selenium, eggs were the number one source among all children, followed by infant formula, noodles and fish/shellfish/shrimps among infants, and fish/shellfish/shrimps, growing-up milk and noodles and pork among toddlers (Table 10). For sodium, the number one source was the salt added during home cooking contributing the vast majority: 60 % of the total sodium intake among infants and about 80 % among toddlers (Table 11). The number two sources

Table 6 Sources of fat among infants and toddlers 6–35 months from the MING study

Rank	Age 6–11 months		Age 12–23 months		Age 24–35 months	
	Food Group	% of Total	Food Group	% of Total	Food Group	% of Total
1	Infant formula	32	Growing-up milk	25	Pork	23
2	Breast milk	28	Oil/other fats	21	Oil/other fats	17
3	Eggs	14	Pork	17	Growing-up milk	13
4	Oil/other fats	8	Eggs	12	Eggs	12
5	Pork	5	Milk	5	Milk	8
6	Infant cereal	2	Nuts/seeds	3	Nuts/seeds	5
7	Bread/biscuits	2	Bread/biscuits	3	Chicken/duck	4
8	Growing-up milk	1	Chicken/duck	2	Bread/biscuits	3
9	Milk	1	Breast milk	2	Fish/shellfish/shrimps	2
10	-		Fish/shellfish/shrimps	1	Soy/tofu/meat substitutes	2
11	-		Rice	1	Rice	1
12	-		Infant formula	1	Yogurt	1
13	-		-		Sausages	1

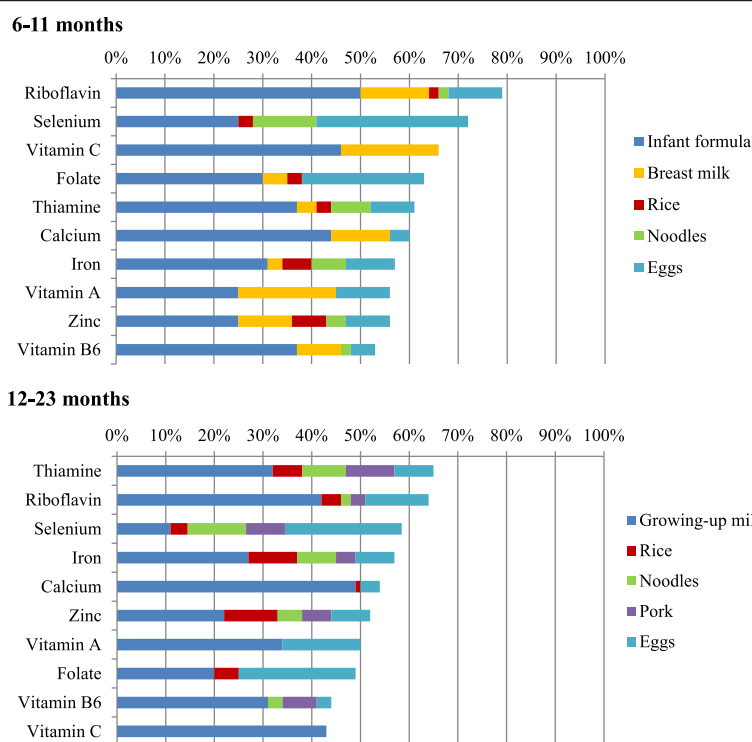


Fig. 2 Percent contribution of top 5 food sources of energy to intakes of micronutrients among infants and toddlers from the MING study

Table 7 Sources of iron among infants and toddlers 6–35 months from the MING study

Rank	Age 6–11 months		Age 12–23 months		Age 24–35 months	
	Food Group	% of Total	Food Group	% of Total	Food Group	% of Total
1	Infant formula	31	Growing-up milk	27	Growing-up milk	12
2	Supplements	13	Rice	10	Rice	11
3	Eggs	10	Noodles	8	Supplements	11
4	Infant cereal	8	Eggs	8	Other root vegetables	10
5	Noodles	7	Supplements	5	Soy/tofu/meat substitutes	8
6	Rice	6	Pancakes/sesame seed cakes	4	Noodles	7
7	Breast milk	3	Fish/shellfish/shrimps	4	Eggs	7
8	Pancakes/sesame seed cakes	2	Pork	4	Pancakes/sesame seed cakes	5
9	Apples/applesauce	2	Soy/tofu/meat substitutes	3	Pork	4
10	Pork	2	Other root vegetables	2	Fish/shellfish/shrimps	3
11	Growing-up milk	2	Apples/applesauce	2	Milk	2
12	Organ meats	1	Oil/other fats	2	Spinach	2
13	Spinach	1	Spinach	2	Apples/applesauce	2
14	Millet	1	Millet	1	Bread/biscuits	1
15	Soy/tofu/meat substitutes	1	Bread/biscuits	1	Oil/other fats	1
16	-	-	Chinese cabbages	1	Chicken/duck	1
17	-	-	Milk	1	Chinese cabbages	1
18	-	-	Organ meats	1	Beef	1

Table 8 Sources of zinc among infants and toddlers 6–35 months from the MING study

Rank	Age 6–11 months		Age 12–23 months		Age 24–35 months	
	Food Group	% of Total	Food Group	% of Total	Food Group	% of Total
1	Infant formula	25	Growing-up milk	22	Rice	13
2	Supplements	16	Supplements	18	Growing-up milk	12
3	Breast milk	11	Rice	11	Supplements	12
4	Infant cereal	10	Eggs	7	Pork	8
5	Eggs	9	Pork	6	Eggs	7
6	Rice	7	Fish/shellfish/shrimps	5	Milk	5
7	Noodles	4	Noodles	5	Noodles	5
8	Pork	3	Milk	3	Fish/shellfish/shrimps	5
9	Pancakes/sesame seed cakes	2	Pancakes/sesame seed cakes	3	Pancakes/sesame seed cakes	4
10	Growing-up milk	2	Soy/tofu/meat substitutes	2	Soy/tofu/meat substitutes	4
11	Fish/shellfish/shrimps	2	Infant cereal	1	Beef	3
12	Apples/applesauce	1	-	-	Chicken/duck	2
13	-	-	-	-	Bread/biscuits	1
14	-	-	-	-	Nuts/seeds	1
15	-	-	-	-	Other root vegetables	1

of sodium were infant formula, contributing 14 % to the diets of infants and growing-up milk contributing 3–5 % to the diets of toddlers.

For all children in the study, infant formula and growing-up milk were the number one sources of vitamin A, vitamin C, thiamine, riboflavin, vitamin B6 (Fig. 2 and Tables 12 and 13. Data for thiamine, riboflavin and vitamin B6 are not shown). Eggs were commonly eaten and were major sources of vitamin A, thiamine, riboflavin and folate. For folate, eggs were the number one source (Table 14). With

age, the contribution of growing-up milk to vitamin C intake was reduced (Fig. 2 and Table 13) but citrus fruits began to make a contribution to vitamin C ranging from 4 % among infants to 10 and 14 % among younger and older toddlers respectively (Table 13). Among toddlers, Chinese cabbage was also an important source of vitamin C contributing about 7 to 10 %, indicating that Chinese cabbages were commonly consumed by this population.

Dietary supplements made substantial contributions to the overall intakes of several vitamins and minerals

Table 9 Sources of calcium among infants and toddlers 6–35 months from the MING study

Rank	Age 6–11 months		Age 12–23 months		Age 24–35 months	
	Food Group	% of Total	Food Group	% of Total	Food Group	% of Total
1	Infant formula	44	Growing-up milk	49	Growing-up milk	30
2	Supplements	15	Supplements	13	Milk	17
3	Infant cereal	13	Milk	10	Supplements	17
4	Breast milk	12	Eggs	4	Eggs	5
5	Eggs	4	Fish/shellfish/shrimps	4	Fish/shellfish/shrimps	4
6	Growing-up milk	3	Infant cereal	2	Yogurt	3
7	Milk	2	Yogurt	2	Soy/tofu/meat substitutes	3
8	Fish/shellfish/shrimps	1	Chinese cabbages	2	Chinese cabbages	2
9	-	-	Soy/tofu/meat substitutes	2	Other root vegetables	2
10	-	-	Other root vegetables	1	Citrus fruits	2
11	-	-	Rice	1	Rice	2
12	-	-	Citrus fruits	1	Coles	2
13	-	-	-	-	Infant cereal	2
14	-	-	-	-	Bread/biscuits	1
15	-	-	-	-	Pancakes/sesame seed cakes	1

Table 10 Sources of selenium among infants and toddlers 0–35 months from the MING study

Age 6–11 months			Age 12–23 months			Age 24–35 months		
Rank	Food Group	% of Total	Rank	Food Group	% of Total	Rank	Food Group	% of Total
1	Eggs	31.3	1	Eggs	23.7	1	Eggs	22.7
2	Infant formula	24.7	2	Fish/shellfish/shrimps	18.8	2	Fish/shellfish/shrimps	14.8
3	Noodles	12.6	3	Growing-up milk	11.3	3	Noodles	11.0
4	Fish/shellfish/shrimps	6.6	4	Noodles	11.5	4	Pork	9.7
5	Pork	4.4	5	Pork	7.7	5	Growing-up milk	6.3
6	Rice	3.4	6	Rice	3.5	6	Milk	5.5
7	Bread/biscuits	2.8	7	Milk	3.3	7	Rice	4.2
8	Steamed bread	2.1	8	Bread/biscuits	3.0	8	Chicken/duck	4.2
9	Pancakes/sesame seed cakes	1.9	9	Pancakes/sesame seed cakes	2.7	9	Pancakes/sesame seed cakes	3.4
10	Organ meats	1.4	10	Chicken/duck	2.3	10	Bread/biscuits	2.9
11	Chicken/duck	1.0	11	Steamed bread	1.8	11	Steamed bread	1.8
12	-		12	Cakes/pies	1.2	12	Cakes/pies	1.4
13	-		-	-		13	Soy/tofu/meat substitutes	1.1
14	-		-	-		14	Beef	1.1

(Fig. 3). Supplements were the number two or number three sources of vitamin A among the children contributing between 22 to 25 % (Fig. 3 and Table 12). Supplements were also the major sources of iron, zinc and calcium among all children (Fig. 3 and Tables 7, 8 and 9). To a lesser extent, supplements contributed to the intakes of thiamine, riboflavin, vitamin B6 and vitamin C (Fig. 3).

Discussion

To our knowledge, this was the first study conducted in China to describe, in detail, the sources of energy and nutrients from the diets of infants and toddlers. Our previous analyses of nutrient intakes among these children found potential risks for inadequate intakes of fat, vitamin B6, folate, iron and selenium and excessive

intakes of vitamin A and sodium [18]. The present study provides further insights on those findings.

Majority of energy and nutrients come from few foods

The findings of the study show that relatively few foods provide the majority of energy and nutrients in the diets of young Chinese children. The top five foods for energy provided about 70 % of energy among infants and more than 50 % energy intake among toddlers. Infant formula and growing-up milk were important sources of many key nutrients. Indeed, in this study infant formula and growing-up milk made significant contributions to the intakes of all the nutrients described, and were the number one or two sources for most of the nutrients we assessed.

However, after the contribution from milks, the next two key contributors of energy were predominantly

Table 11 Sources of sodium among infants and toddlers 6–35 months from the MING study

Rank	Age 6–11 months		Age 12–23 months		Age 24–35 months	
	Food Group	% of Total	Food Group	% of Total	Food Group	% of Total
1	Salts	60	Salts	80	Salts	77
2	Infant formula	14	Growing-up milk	5	Growing-up milk	3
3	Eggs	7	Fish/shellfish/shrimps	4	Eggs	3
4	Fish/shellfish/shrimps	4	Eggs	3	Fish/shellfish/shrimps	3
5	Infant cereal	2	Milk	1	Milk	2
6	Bread/biscuits	2	-		Pork	1
7	Noodles	1	-		Bread/biscuits	1
8	Oil/other fats	1	-		Sausages	1
9	Steamed bread	1	-		-	
10	Pork	1	-		-	

Table 12 Sources of vitamin A among infants and toddlers 6–35 months from the MING study

Rank	Age 6–11 months		Age 12–23 months		Age 24–35 months	
	Food Group	% of Total	Food Group	% of Total	Food Group	% of Total
1	Infant formula	25	Growing-up milk	34	Growing-up milk	24
2	Supplements	25	Supplements	25	Eggs	22
3	Breast milk	20	Eggs	16	Supplements	22
4	Eggs	11	Organ meats	6	Carrots	5
5	Organ meats	8	Spinach	2	Milk	4
6	Infant cereal	4	Citrus fruits	2	Citrus fruits	4
7	Spinach	1	Carrots	2	Spinach	3
8	Carrots	1	Milk	2	Organ meats	3
9	Growing-up milk	1	Breast milk	2	Broccoli	2
10	-		Broccoli	2	Chinese cabbages	2
11	-		-		Pork	1
12	-		-		Fish/shellfish/shrimps	1
13	-		-		Other root vegetables	1
14	-		-		Chicken/duck	1

refined carbohydrate containing foods, rice and noodles, which provided 17 to 25 % of total energy intake. Given the low protein content of rice and noodles, the fact that these two foods, taken together, contributed about 13 to 16 % of protein intake among the young children

suggests that these foods were frequently consumed and consumed in a significant amount. Presently, the rice consumed in China is refined white rice that is not enriched or fortified. Noodles are also made of refined wheat flour that is not fortified. Therefore, they are

Table 13 Sources of vitamin C among infants and toddlers 6–35 months from the MING study

Rank	Age 6–11 months		Age 12–23 months		Age 24–35 months	
	Food Group	% of Total	Food Group	% of Total	Food Group	% of Total
1	Infant formula	46	Growing-up milk	43	Growing-up milk	26
2	Breast milk	20	Citrus fruits	10	Citrus fruits	14
3	Infant cereal	5	Chinese cabbages	7	Chinese cabbages	10
4	Citrus fruits	4	Kiwi fruits	6	Supplements	5
5	Chinese cabbages	3	Other root vegetables	4	Other leafy vegetables	5
6	Kiwi fruits	3	Spinach	3	Coles	5
7	Apples/applesauce	2	Bananas	3	Spinach	4
8	Supplements	2	Broccoli	2	Bananas	3
9	Spinach	2	Apples/applesauce	2	Tomatoes/tomato sauce	3
10	Growing-up milk	2	Other leafy vegetables	2	Broccoli	3
11	Bananas	2	Tomatoes/tomato sauce	2	Apples/applesauce	3
12	Other leafy vegetables	1	Coles	2	Potatoes	2
13	-		Supplements	2	Kiwi fruits	2
14	-		Potatoes	1	Other root vegetables	2
15	-		Breast milk	1	Carrots	2
16	-		Sweet potatoes/yams	1	Other fruits	2
17	-		-		Jujube	2
18	-		-		Milk	1
19	-		-		Sweet potatoes/yams	1
20	-		-		100 juice	1

Table 14 Sources of folate among infants and toddlers 6–35 months from the MING study

Rank	Age 6–11 months		Age 12–23 months		Age 24–35 months	
	Food Group	% of Total	Food Group	% of Total	Food Group	% of Total
1	Infant formula	30	Eggs	24	Eggs	20
2	Eggs	25	Growing-up milk	20	Other root vegetables	20
3	Organ meats	7	Citrus fruits	6	Growing-up milk	9
4	Breast milk	5	Spinaches	6	Citrus fruits	6
5	Spinaches	5	Rice	5	Rice	5
6	Rice	3	Organ meats	4	Spinaches	5
7	Citrus fruits	2	Other root vegetables	3	Coles	5
8	Chinese cabbages	2	Coles	3	Soy/tofu/meat substitutes	3
9	Infant cereal	2	Chinese cabbages	2	Pancakes/sesame seed cakes	2
10	Coles	2	Pancakes/sesame seed cakes	2	Chinese cabbages	2
11	Apples/applesauce	2	Nuts/seeds	2	Nuts/seeds	2
12	Pancakes/sesame seed cakes	1	Soy/tofu/meat substitutes	2	Supplements	2
13	Mangoes	1	Bananas	2	Milk	2
14	Supplements	1	Apples/applesauce	2	Bananas	1
15	Bananas	1	Milk	2	Bread/biscuits	1
16	Growing-up milk	1	Bread/biscuits	1	Apples/applesauce	1
17	-	-	-	-	Sweet potatoes/yams	1
18	-	-	-	-	Yogurt	1
19	-	-	-	-	Fish/shellfish/shrimps	1

relatively poor sources of many important nutrients. Due to the widespread consumption of rice and noodles in this population, rice actually was the top one or two sources for iron and zinc. In addition, noodles were also among the major sources for thiamine, iron and selenium. When foods that are poor sources of nutrients become major sources in the diet, it is quite reasonable to speculate that risk of nutrient shortfall could exist. A recent review reported that anaemia prevalence of children under 5 years old in China was 11.3 % in 2005 [19] and the peak of anaemia prevalence was between infants aged 6 to 12 months [20].

In this study, growing-up milk remained to be one of the major contributors to energy and many nutrients among toddlers, which indicated that growing-up milk was commonly consumed among toddlers of the study. In comparison, in the diets of US infants and toddlers [6], the contribution of infant formula or growing-up milk to energy and nutrients declines steadily as children age and drops out of top five sources among toddlers. Optimally, when the intake of growing-up milk is reduced in older toddlers, it should be replaced with nutrient rich foods such as milk, eggs and meat, but in reality, the children were consuming a large portion of energy from rice and noodles, two nutrient poor foods. Education is needed on the nutrient rich foods that toddlers should be consuming, such as milk, meat and fish, vegetables and fruits,

especially as the amount of growing-up milk, a major nutrient contributor, is reduced.

The fact that the majority of energy and nutrients come from few foods also implies that the variety of food consumed by these young children was limited. Eating a variety of food is essential to achieve adequate intake of macro- and micronutrients to meet nutritional needs. In addition, it is critical to expose infants to a wide variety of healthy foods, as it has been found that infants exposed to a variety of solid foods more readily accept new foods compared to infants exposed to a monotonous solid diet [21]. Food preferences established during childhood persists during adulthood [22]. Our findings point out the need to counsel caregivers of young children in China on how to select and serve a variety of nutrient rich foods to improve nutrient intakes of young children and teach healthy eating habits. This is especially important among the infants aged 6–11 months, but also for toddlers, as they are transitioning from reliance on infant formulas and growing-up milk to the family meals.

Another important finding of this study was that dietary supplements were significant contributors to the intakes of many nutrients, especially for the intakes of vitamin A, vitamin B6, calcium, iron and zinc (Fig. 3). This was particularly important for this population whose diets contained significant amounts of refined rice

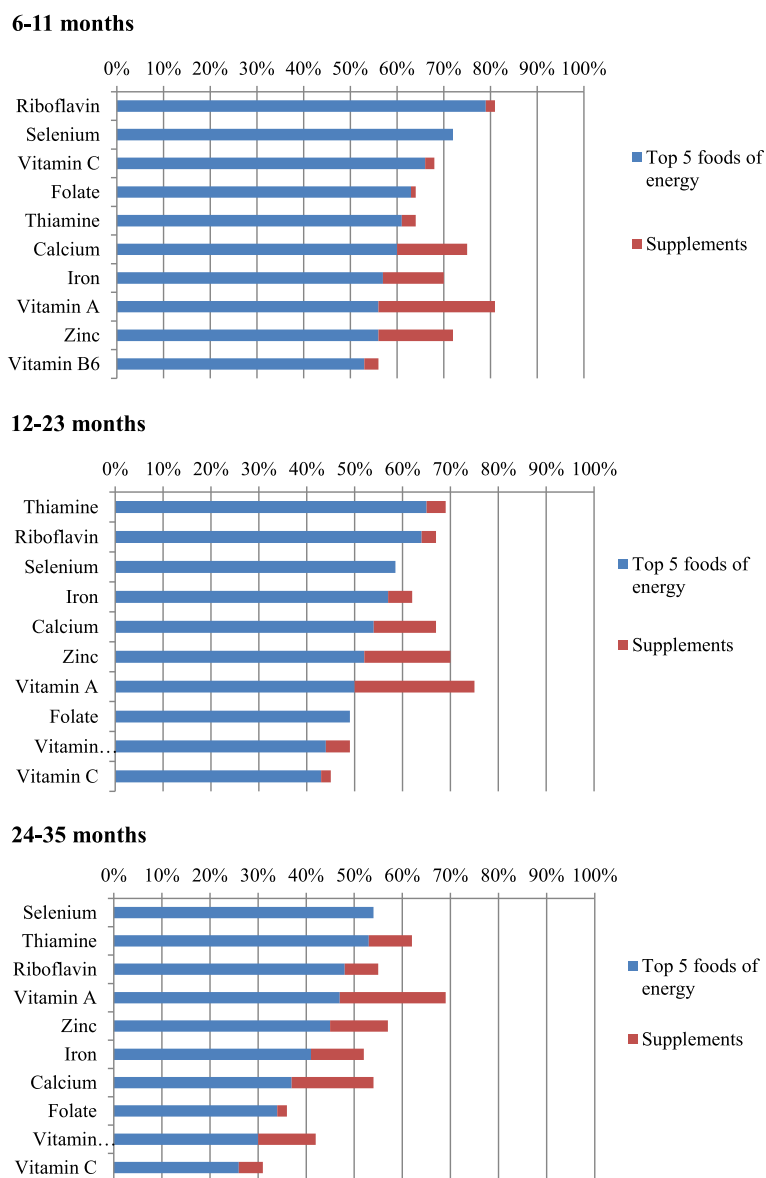


Fig. 3 Percent contribution of dietary supplements to micronutrient intakes among infants and toddlers from the MING study

and noodles. Indeed, although subclinical vitamin A deficiency has decreased from 40 % to less than 10 % from 1988 to 2009 but prevalence of marginal vitamin A deficiency (serum retinol level 0.70–1.05 μmol/l) was still 20 to 45 % [19]. However, excessive intake of vitamin A was observed in our previous analysis on nutrient intakes of this population [18]. In this study, the contributions of supplements to vitamin A intake were substantial: 22 to 25 % (Table 12). Although supplements may be beneficial to prevent nutrient deficiencies [23], it is also important to understand that the majority of nutrient intakes should be consumed as part of a normal diet composed of a variety of food groups and in that way

the potential risk of excessive nutrient intakes can be avoided.

Fruit and vegetable intakes needs improvement

In this study, infant formula or growing-up milk was the number one source of vitamin C for all age groups and it was remarkable to see that even among infants 12–23 months, growing-up milk contributed 43 % of vitamin C. Chinese cabbages were also among the major contributors to vitamin C intake reflecting its widespread consumption. However, the fact that a large part of the vitamin C and folate intakes was from infant formula, growing-up milk or eggs suggests that the contribution of fruits and

vegetables to micronutrient intakes in the diets of these Chinese infants and toddlers was not optimal. Fruits and vegetables are not only excellent natural sources of micronutrients [24, 25] but also associated with reduced risk of chronic diseases later in life [26–28]. Infancy and early childhood are critical periods for forming lifelong dietary habits [29]. Therefore, public health workers should encourage caregivers of young children to increase the consumption of fruits and vegetables among infants and toddlers to meet nutrient requirements as well as develop healthy dietary habits.

Strength and limitation

The strength of this study is that it used a much more detailed food group classification method than any previous studies conducted among infants and toddlers in China and so was able to describe the sources of energy and a number of key nutrients in detail.

However, we are aware that this study has some limitations. First, data for food consumption of these infants and toddlers relied totally on self-reports of caregivers and the information was only collected using a single 24-h dietary recall. The approach of using 1 day of intake to gain insight into food sources of energy and nutrients assumes that the diet on that day is representative or typical of habitual intake, and some evidence suggests that day-to-day variation is much less in the diets of infants and toddlers than among older children and adults [30]. Secondly, this study was conducted among infants and toddlers recruited from the maternal and child care centres in selected cities in China, including the three most industrialised cities, and was not a nationally representative sample. Therefore, sample weights or other sampling adjustments were not applied. Some children may come from better-off families indicated by the reported household income. Therefore the data may represent the children from more developed urban areas rather than the general population of infants and toddlers in China. Thirdly, although the subjects of the study were recruited from a wide-spread of geographic locations in China, food consumption of children from different regions could be different but this was not investigated in the present study.

Conclusions

This study provides important insights from an analysis of food sources of energy and nutrients in the diets of infants and toddlers recruited from the maternal and child care centres in 8 cities in China. The results show that few foods made up the core of the diets of infants and young toddlers and a large proportion of energy was from low-nutrient dense foods (rice and noodles), which potentially could lead to inadequate intakes of some key nutrients. The intakes of more nutrient dense foods

including fruits and vegetables, milk and meat should be encouraged. Information from this study could be used for the development of various public health strategies to improve diet quality and address nutrient shortfalls in the diets of this vulnerable population.

Competing interests

The author(s) declare that they have no competing interests. The study was funded by the Nestle Nutrition Institute China and the Nestle Research Centre. It was a collaborative effort between Peking University School of Public Health and Nestle.

Authors' contributions

HW contributed to the data collection, performed the statistical analyses and drafted the manuscript; LD contributed to interpretation of the data and critical revision of the manuscript; YZ contributed to data collection and statistical analyses; GVP contributed to the data interpretation and revision of the manuscript; KR contributed to the conception and design of the study, interpretation of the data and critical revision of the manuscript; YZ contributed to the conception and design of the study and data collection; PW contributed to the conception and design of the study. All authors read and approved the final manuscript.

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