Diet has a critical role in human health improvement. Large nutritional epidemiology studies have led to important improvements in our understanding of the relationship between nutrition and diseases. Previous studies inferred that the bias of representative dietary intake were mainly attributed to intra-individual variation either using methods of 24-h dietary recall or food frequency questionnaires (FFQs) (1, 2). As a matter of fact, studies that analyze dietary intake usually ignore the possibility of seasonal variation. If seasonality does matter in dietary intake, researchers should take the seasonal bias into consideration and adjust their results across all seasons if data collection was only conducted during a period of one season. There were some evidences that season could affect the health conditions (3, 4). Some studies revealed that season should be regarded as an important risk factor in the incidence of nutrient deficiency or other disorders (5). The realization of seasonal variance in dietary intakes may also facilitate the season-related strategy making to improve the health in a more evidence-based way (4).

International literatures were inconsistent in seasonal variation of energy, macronutrient and micronutrient intakes in industrialized regions. Many investigators have reported seasonality in macronutrient intakes, even after adjusting for total energy intake (6–11). Studies have also demonstrated seasonal changes in the consumption of various food groups (6, 7, 9–13). Nevertheless, no differences found in dietary intakes across seasons were also reported (5, 6, 8–11, 13–17). Moreover, a recent study caught our interest which analyzed no seasonality of dietary intake in metropolitan area of America and proved that there was a more limited effect of season on access to food (14).

Traditional Chinese dietary pattern is known as plant-based which is more linked with seasonal supply. Quite different with western custom, it is common for Chinese people to prepare meals from raw materials which rely on cyclical availability. But few study analyzed seasonal variation of energy, macronutrient and micronutrient intakes in China. Our study was to assess seasonal variation in the absolute dietary intake among general population in a metropolis, Shanghai, China. A representative sample of general population aged 15 and older (n = 1,704) were randomly stratified-sampled from communities in Shanghai. Dietary survey included consecutive 3-day-24-hour diet record recall and household condiments weighing. Data was collected across four seasons during 2012–2014. Most of food and condiments consumption differed across seasons in Shanghai. Intakes of grains, legumes and cooking oil were highest in spring; vegetables, fruit and non-alcoholic beverage highest, but cooking oil and cooking salt lowest in summer; red meat, nuts and cooking salt highest in winter. Seasonality existed in the intakes of energy and energy contributed from macronutrients that fat contributed more in winter but less in summer. Seasonal variations were also found in beta-carotene, vitamin E, vitamin K, thiamin, folate and sodium intakes. Seasonal changes of dietary intake were extensively observed in Shanghai, a highly-developed metropolis in China. Given the seasonal differences and their features described in current article, the estimation methods of the average dietary intake across whole year by just conducting dietary survey in one single season warrants further study.

**Key Words** seasonal variation in dietary intake, food consumption, energy intake, macronutrients, micronutrients

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**Summary** Chinese diet pattern known as plant-based is more linked with seasonal supply, but it is lack of study on seasonal difference in dietary intakes in China. Diet has a critical role in human health improvement. Large nutritional epidemiology studies have led to important improvements in our understanding of the relationship between nutrition and diseases. Previous studies inferred that the bias of representative dietary intake were mainly attributed to intra-individual variation either using methods of 24-h dietary recall or food frequency questionnaires (FFQs) (1, 2). As a matter of fact, studies that analyze dietary intake usually ignore the possibility of seasonal variation. If seasonality does matter in dietary intake, researchers should take the seasonal bias into consideration and adjust their results across all seasons if data collection was only conducted during a period of one season. There were some evidences that season could affect the health conditions (3, 4). Some studies revealed that season should be regarded as an important risk factor in the incidence of nutrient deficiency or other disorders (5). The realization of seasonal variance in dietary intakes may also facilitate the season-related strategy making to improve the health in a more evidence-based way (4).

International literatures were inconsistent in seasonal variation of energy, macronutrient and micronutrient intakes in industrialized regions. Many investigators have reported seasonality in macronutrient intakes, even after adjusting for total energy intake (6–11). Studies have also demonstrated seasonal changes in the consumption of various food groups (6, 7, 9–13). Nevertheless, no differences found in dietary intakes across seasons were also reported (5, 6, 8–11, 13–17). Moreover, a recent study caught our interest which analyzed no seasonality of dietary intake in metropolitan area of America and proved that there was a more limited effect of season on access to food (14).
Dietary Intake Patterns Fluctuate across Four Seasons

China. Though two publications mentioned seasonal variance of nutrients intake in China, there was no further description of specific seasonality in each season (18, 19). We have published an article on the seasonal difference of dietary quality using an index (20). It is more practical to report the absolute amount of dietary intake across four seasons for future studies to estimate the average intake across whole year by just conduct dietary survey in one single season. The objective of this observational study was to assess the seasonal variation in absolute food consumption and energy and nutrients intake among general population in Shanghai, a well-developed metropolis in China.

MATERIALS AND METHODS

Subjects. Subjects were from Shanghai Diet and Health Survey (SDHS) which was an ongoing open cohort. The SDHS was conducted by Shanghai Municipal Center for Diseases Control and Prevention since 2012 in order to access the nutritional statuses and food chemical contaminants exposure of local population and examine how these factors affect human health in long term. The cohort subjects initially comprised a representative sample of local population aged 15 and above. It was excluded who was living no more than 6 months in Shanghai during last year of survey.

Subjects were randomly stratified-sampled. The sampling included four stratifications. First, all communities were classified into central urban, suburb or outer suburb, and total 54 communities were randomly selected by Probability Proportionate to Size Sampling (PPS) method; second, three smaller residential areas were randomly selected from each communities; third, 1 residential quarter was randomly selected from each residential area; at last, in each residential quarter, 2 subjects were randomly selected from each age group (15–44 y/45–59 y/60 y–) and gender (male/female) group, totally 12 subjects in each residential quarter. The total sample size was 1,944.

The survey was approved by the Shanghai Municipal Center for Diseases Control and Prevention’s Institutional Review Board (the ethical approval number: 2012-01); an informed consent was obtained by each subject before the survey. The study complied with the code of ethics of the World Medical Association (Declaration of Helsinki).

Dietary survey. Dietary survey included consecutive 3-day-24-hour diet record (including 2 weekdays and 1 weekend day), and household condiments weighing before and after 3 survey days. All interviewers were public health doctors from 54 local community health care centers and received a standard training course to record diet information. Each subject was interviewed by interviewers at home. Subjects were instructed not to change their typical diet or physical activity during the interview period. Food records were reviewed by nutrition specialists from local center of disease control and prevention.

Subjects were interviewed four times across four seasons during 2012–2014. It was no disastrous seasons which might affect normal food supply in this duration. Data from spring, the baseline, was collected during April and May 2012, data from fall during September and October 2012, data from summer during July and August 2013 and data from winter during December 2013 and January 2014. Seasons were defined as spring (March 1st to May 31st), summer (June 1st to August 31st), fall (September 1st to November 30th) and winter (December 1st to February 28th).

Dietary assessment. Daily food consumption was calculated from 3-day-24-hour diet recall record. The 3-day condiments consumption from condiments weighing in household was divided to individual intake according to times of eating at home and individual’s energy proportion among family members. Individual condiments consumption out of home was estimated by those consumption at home.

Chinese food composition database (21, 22) was used to define food groups. Food groups were classified as grains (rice and wheat), potatoes and tubes, soybeans and products, other legumes (soybeans and products were widely consumed in terms of food source of protein), vegetables (excluding legumes), fruits (including citrus), red meat (pork, mutton and beef), poultry, eggs, seafood, dairy, nuts, dessert (including pastry, cake, etc.), fast-food (including Western and Chinese styles), non-alcoholic beverages (including brewed tea, sweetened beverages, ice cream, etc. and excluding 100% fruit juice, dairy, and water), alcohol, cooking oil salt, monosodium glutamate and soy sauce. The weights of food in categories of grains were adjusted to the equivalent weight of raw rice or wheat; in categories of soybeans and products into soybeans; in categories of dairy into milk; in categories of alcohol into pure alcohol.

All food including condiments were analyzed for energy, macronutrient, mineral and vitamin intake. Dietary supplements and medications were excluded from energy and nutrients intake.

Food consumption, energy and nutrient intake were described in absolute amount and adjusted to the equivalent consumption or intake of a Chinese male adult with light physical activity level whose energy requirement was 2,250 kcal.

Statistical analyses. Data sampling and analyzing were conducted using SAS 9.3 (SAS Institute Inc., Cary, NC, USA). Sampling was conducted using PROC SURVEYSELECT of survey analysis procedures in SAS. Subjects demographic data were obtained at first interview. Demographic profile of the sample was described without weighting. Mean and standard errors (SE) of food consumption, energy and nutrients intake from each season were determined using PROC SURVEYMEANS. Appropriate weights including sampling weight and post stratification weight were used to adjust for the complex sample design to ensure the representative results. Multivariate linear regression models were run in analysis of the difference between seasons by using PROC SURVEYREG, with food consumption, energy and nutrients intake taken as dependent variables and sea-
son as a categorical independent variable. Those models also included age, gender, region, income, years of education, physical exercises and weight status as covariates. Significance was determined if $p<0.05$.

RESULTS

Demographic characteristics

One thousand seven hundred and four subjects in the cohort were visited during the survey. One thousand five hundred and twenty-six subjects were visited in the survey season of spring, 1,621 of summer, 1,631 of fall and 1,605 of winter (Table 1).

Food and condiments consumption

Table 2 shows the weighted average daily food consumption and its 95% confidence interval in different four seasons in Shanghai. The average consumption of grains, soybeans and products, other legumes, vegetables, fruit, red meat, poultry, eggs, nuts, fast-food, non-alcoholic beverage, cooking oil and cooking salt were significantly different across four seasons (Table 2). It showed inclination that intake of grains, legumes and cooking oil were higher in spring; vegetables, fruit and non-alcoholic beverage higher; but cooking oil and cooking salt lower in summer; red meat, nuts and cooking salt higher in winter.

Energy and nutrients intake

Table 3 demonstrates average daily energy and nutrients intake and its 95% confidence interval across seasons in Shanghai. It showed the intakes of energy and the proportion of energy contribution from macronutrients were significantly different across seasons. Energy intake was highest in spring and lowest in summer. Energy contribution from fat was higher during fall and winter but lower in spring and summer. Energy contribution from protein was at its lowest in spring and highest in summer. Energy contribution from carbohydrate was significantly higher in spring compared to other seasons. It indicated that the dietary pattern fluctuated by energy contribution from fat increasing and carbohydrate decreasing from spring to winter.

It also shows seasonal variation in the intake of vitamins such as beta-carotene, vitamin E, vitamin K, thiamin and folate. Beta-carotene intake was at its highest in fall. Vitamin E and vitamin K intake were higher in spring compared to other seasons. Folate intake was highest in spring and lowest in winter. Among minerals, only seasonality of sodium intake was observed. Sodium intake was highest in winter and lowest in fall. The intake of cholesterol exhibited seasonal difference with significantly higher intakes in summer. Intakes of other nutrients were found no seasonal fluctuations.

In addition, higher consumption of vegetable and fruit was associated with a higher intake of vitamin C. Higher consumption of cooking oil resulted in a higher intake of vitamin E and vitamin K on the basis of food composition. A higher intake of sodium was probably contributed by higher consumption of cooking salt.

DISCUSSION

Epidemiologic studies that analyze dietary intake utilizing food records usually don’t consider the possibility of seasonal variation. Researches performed internationally regarding the impact of season on dietary intake showed conflicting results. Inconsistencies in study design and analysis were impeding to form a common understanding in seasonality on dietary intake. Most of the studies looked at differences in dietary intake across all four seasons (5, 6, 9, 10, 12, 14–18, 23–27), and a few just analyzed difference between two seasons (7, 8, 11, 13, 28). Sample size in most studies was less than 300 (5–8, 11, 13, 16–18, 23–25), that might restrain further explanations in general population. The inconsistencies reported in studies globally and the lack of research in China raised concerns about the accuracy of dietary intake data in studies spanning different seasons. To our literature review, this was the first cohort study of general population to perform a broad analysis of seasonality in dietary intake in a well-developed metropolitan area of China, including not only analyzing food consumption, energy and nutrients intake but processing condiments consumption and their contributions to energy and nutrients intake as well.

Shanghai has a northern subtropical maritime monsoon climate and four distinct seasons, serving as China’s largest commercial and financial center. Seasonal
## Table 2: Average daily food consumption in different four seasons in Shanghai (g).

| Food groups          | Whole year | Mean (95%CI) | Spring | Mean (95%CI) | Summer | Mean (95%CI) | Fall | Mean (95%CI) | Winter | Mean (95%CI) | $p^1$ |
|----------------------|------------|--------------|--------|--------------|--------|--------------|------|--------------|--------|--------------|------|
| Grains               | 82.9 (81.0, 84.8) | 95.0 (90.0, 100.0) | 83.7 (80.5, 87.0) | 81.0 (77.2, 84.8) | 80.0 (76.3, 83.8) | NS  |
| Potatoes             | 6.4 (6.0, 6.8) | 6.6 (5.8, 7.4) | 6.5 (5.6, 7.3) | 5.6 (4.8, 6.5) | 7.2 (6.2, 8.1) | NS  |
| Soybean and products | 4.9 (4.6, 5.2) | 5.4 (4.8, 6.1) | 4.2 (3.7, 4.6) | 4.8 (4.3, 5.4) | 5.5 (4.8, 6.1) | <0.01 |
| Other legumes        | 4.7 (4.1, 5.2) | 16.9 (14.2, 19.5) | 4.4 (3.4, 5.3) | 1.3 (1.0, 1.7) | 0.5 (0.3, 0.7) | <0.01 |
| Vegetables           | 109.6 (107.0, 112.1) | 110.7 (105.9, 115.6) | 121.0 (115.6, 126.4) | 102.8 (97.9, 107.6) | 110.9 (105.7, 116.1) | <0.01 |
| Fruit                | 47.7 (45.3, 50.1) | 33.2 (30.4, 35.9) | 80.8 (73.7, 87.9) | 36.9 (33.7, 40.1) | 39.6 (36.0, 43.2) | <0.01 |
| Red meat             | 43.0 (41.7, 44.2) | 38.4 (35.4, 41.4) | 41.3 (39.0, 43.6) | 43.8 (40.9, 46.7) | 47.8 (45.4, 50.2) | <0.01 |
| Poultry              | 11.1 (10.5, 11.8) | 11.6 (10.3, 12.9) | 9.8 (8.6, 10.9) | 11.7 (10.3, 13.2) | 11.2 (10.0, 12.4) | NS  |
| Eggs                 | 17.8 (17.3, 18.4) | 18.5 (17.5, 19.5) | 20.5 (19.3, 21.7) | 16.4 (15.4, 17.4) | 16.7 (15.6, 17.8) | <0.01 |
| Seafood              | 26.7 (25.6, 27.8) | 24.9 (23.0, 26.8) | 28.4 (26.3, 30.6) | 27.4 (25.5, 29.4) | 26.8 (24.4, 29.1) | NS  |
| Dairy                | 42.7 (40.3, 45.2) | 38.7 (35.1, 42.3) | 44.3 (39.7, 48.8) | 43.9 (38.3, 49.5) | 44.4 (39.1, 49.6) | NS  |
| Nuts                 | 1.4 (1.1, 1.6) | 1.6 (1.3, 1.9) | 0.5 (0.3, 0.6) | 1.4 (1.1, 1.8) | 2.2 (1.4, 3.1) | <0.01 |
| Dessert              | 4.6 (4.1, 5.1) | 4.8 (3.8, 5.7) | 3.8 (3.0, 4.6) | 4.5 (3.6, 5.5) | 5.2 (3.9, 6.4) | NS  |
| Fast-food            | 18.6 (17.4, 19.7) | 13.7 (12.2, 15.3) | 16.8 (14.6, 19.0) | 20.1 (17.5, 22.7) | 21.6 (19.4, 23.8) | <0.01 |
| Non-alcoholic beverage | 101.2 (93.2, 109.2) | 121.5 (104.1, 138.8) | 131.4 (112.6, 150.3) | 67.2 (55.9, 78.5) | 88.5 (74.5, 102.4) | <0.01 |
| Alcohol              | 0.6 (0.5, 0.8) | 1.0 (0.5, 1.5) | 0.6 (0.4, 0.7) | 0.5 (0.4, 0.7) | 0.6 (0.4, 0.8) | NS  |
| Cooking oil          | 16.1 (15.5, 16.7) | 17.4 (16.4, 18.3) | 14.8 (13.9, 15.8) | 16.6 (15.1, 18.2) | 16.1 (15.0, 17.3) | 0.03 |
| Cooking salt         | 3.3 (3.2, 3.4) | 3.4 (3.3, 3.6) | 3.3 (3.0, 3.5) | 3.2 (3.0, 3.4) | 3.6 (3.4, 3.8) | 0.04 |
| Monosodium glutamate | 1.1 (1.0, 1.1) | 1.1 (1.1, 1.2) | 1.1 (1.0, 1.2) | 0.7 (0.1, 1.4) | 1.1 (1.0, 1.2) | NS  |
| Soy sauce            | 5.1 (4.9, 5.3) | 5.4 (4.9, 6.0) | 4.9 (4.5, 5.3) | 4.9 (4.5, 5.3) | 5.4 (4.9, 6.0) | NS  |

NS, non significant difference.

$^1$Difference between seasons was tested with multivariate linear regression models for complex survey sample designs adjusted by age, gender, region, income, years of education, physical exercises and weight status.
| Items                        | Whole year | Spring       | Summer       | Fall            | Winter       | \( p \) |
|-----------------------------|------------|--------------|--------------|-----------------|--------------|--------|
| Energy (kcal)               | 2,036.7 (2,002.3, 2,071.1) | 2,138.2 (2,065.7, 2,210.7) | 1,964.1 (1,905.4, 2,022.7) | 2,084.6 (2,000.3, 2,168.9) | 2,008.0 (1,946.6, 2,069.3) | 0.02   |
| Total fat (E%)              | 38.3 (37.9, 38.7) | 36.9 (36.1, 37.6) | 36.7 (35.9, 37.5) | 39.5 (38.6, 40.3) | 39.3 (38.5, 40.2) | <0.01  |
| Protein (E%)                | 15.9 (15.7, 16.0) | 15.2 (15.0, 15.5) | 16.5 (16.2, 16.8) | 15.5 (15.2, 15.8) | 16.2 (15.8, 16.5) | <0.01  |
| Carbohydrate (E%)           | 45.9 (45.5, 46.2) | 47.9 (47.2, 48.6) | 46.8 (46.0, 47.6) | 45.0 (44.3, 45.8) | 44.5 (43.7, 45.2) | <0.01  |
| Retinol (\( \mu \)g)        | 206.0 (194.7, 217.3) | 205.2 (184.7, 225.8) | 194.9 (182.9, 206.9) | 214.3 (189.8, 238.9) | 200.5 (181.5, 219.5) | NS     |
| Beta-carotene (\( \mu \)g)  | 2,802.8 (2,508.7, 3,097.0) | 2,008.6 (1,801.0, 2,216.2) | 2,734.4 (2,201.2, 3,267.6) | 3,548.7 (2,634.7, 4,462.7) | 2,973.6 (2,569.3, 3,377.9) | <0.01  |
| Vitamin E (mg)              | 34.0 (32.9, 35.1) | 36.8 (35.2, 38.4) | 31.8 (29.9, 33.7) | 35.1 (32.4, 37.9) | 32.9 (31.0, 34.9) | <0.01  |
| Vitamin K (\( \mu \)g)      | 35.6 (32.3, 39.0) | 60.4 (50.4, 70.4) | 30.4 (24.4, 36.5) | 48.6 (41.8, 55.3) | 8.0 (5.6, 10.3) | <0.01  |
| Vitamin C (mg)              | 95.6 (88.4, 102.9) | 89.9 (78.3, 101.6) | 97.3 (75.3, 119.2) | 92.7 (84.7, 100.8) | 9.3 (89.2, 98.1) | <0.01  |
| Riboflavin (mg)             | 1.1 (1.0, 1.1) | 1.0 (1.0, 1.1) | 1.1 (1.0, 1.1) | 1.1 (1.0, 1.2) | 1.1 (1.1, 1.1) | NS     |
| Thiamin (mg)                | 0.9 (0.9, 0.9) | 0.9 (0.9, 1.0) | 0.9 (0.9, 1.0) | 0.9 (0.9, 1.0) | 0.9 (0.9, 1.0) | NS     |
| Folate (\( \mu \)g)         | 26.9 (24.8, 28.9) | 38.5 (33.2, 43.8) | 23.7 (20.3, 27.1) | 35.3 (30.5, 40.1) | 11.8 (10.1, 13.5) | <0.01  |
| Sodium (mg)                 | 4,899.1 (4,761.5, 5,036.7) | 5,017.9 (4,806.0, 5,229.8) | 4,886.4 (4,648.5, 5,124.2) | 4,585.7 (4,233.5, 4,937.8) | 5,218.9 (4,973.7, 5,464.1) | 0.01   |
| Potassium (mg)              | 2,301.1 (2,204.5, 2,397.6) | 2,298.9 (2,181.8, 2,415.9) | 2,316.0 (2,134.8, 2,497.2) | 2,426.3 (2,145.6, 2,707.0) | 2,235.0 (2,091.5, 2,378.6) | NS     |
| Calcium (mg)                | 594.5 (573.9, 615.2) | 546.8 (522.9, 570.7) | 584.8 (547.0, 622.5) | 629.4 (572.0, 686.9) | 627.1 (592.4, 661.8) | NS     |
| Magnesium (mg)              | 322.4 (310.9, 333.9) | 336.6 (322.2, 351.1) | 318.8 (296.8, 340.8) | 344.5 (311.2, 377.8) | 307.9 (291.1, 324.7) | NS     |
| Iron (mg)                   | 24.2 (23.3, 25.1) | 23.2 (22.2, 24.2) | 24.1 (22.5, 25.8) | 26.5 (23.7, 29.4) | 24.2 (22.9, 25.6) | NS     |
| Dietary fiber (g)           | 11.8 (11.0, 12.6) | 12.2 (11.3, 13.1) | 11.5 (9.9, 13.0) | 13.3 (10.8, 15.8) | 11.2 (10.1, 12.3) | NS     |
| Cholesterol (mg)            | 461.8 (451.5, 472.0) | 432.5 (413.7, 451.3) | 508.1 (487.1, 529.1) | 442.5 (421.6, 463.4) | 457.6 (437.9, 477.3) | <0.01  |

NS, non significant difference.

1 Difference between seasons was tested with multivariate linear regression models for complex survey sample designs adjusted by age, gender, region, income, years of education, physical exercises and weight status.
variation of dietary intake in Chinese population was only mentioned in the studies about comparisons of within- and between-individual variances in Shanghai but not specifically measured between seasons (18, 19). A recent study by Bernstein and colleagues implied that cyclical availability of food had limit effect on seasonality of dietary intake in developed areas (14). But our results were on the contrary that indicated people living in Shanghai, one of the largest metropolises in China, exhibited seasonal variations in food consumption, as well as energy and nutrients intake. Seasonality in dietary intake pattern was broadly discovered in our data.

We found seasonal difference in the consumption of most food groups and condiments in Shanghai. Our findings were consistent with those reporting variations in grains, meat, fruits and vegetables intake across seasons (7, 9–11). We observed vegetables intake was highest in summer, while another research studying females reported a contrary result (9). This research differed from ours in gender-specific differences, use of FFQs to assess dietary intake and data collection earlier one decade. Although a few studies reported no seasonality in the intake of oil/fat (6, 7, 10, 14), we found higher oil intake in spring and lower in summer, as well as higher salt intake in winter and lower in summer/fall. Nevertheless, we didn’t observe seasonal difference in dairy intake which was contrast to several western studies (7, 11). Though it was reported legumes intake was higher in winter (7), our analysis found legumes (excluding soybean and products) intake highest in spring. Those inconsistencies might be attributable to diet habit, cultural practices and seasonal supply. When compared with China’s National Nutrition Survey (29), average daily consumption of grains, soybeans and products, meat, eggs and dairy were consistent with our study’s, but consumption of fruit, vegetables, legumes, cooking oil and cooking salt were not. The inconsistency was partially attributable to the seasonal fluctuation of those food consumption as China’s National Nutrition Survey collected data during a period of fall or winter.

We observed seasonal variations in the intakes of energy and the proportion of energy contribution from macronutrients across seasons in our study population. We took cooking oil contribution into consideration of total energy intake for it was a main source of dietary fat in Chinese diet. Our findings were consistent with the results from several studies (5–7, 9, 15, 16, 23). In one of those studies, of which the population was in the same location as ours (9), the seasonal variation of energy across seasons was different from our results. That study differed from ours in use of FFQs to assess energy and macronutrients intake, lack of condiments contribution to energy intake and different study samples. Meanwhile, other studies reported no difference in energy or macronutrients intake (6, 8, 10, 11, 13, 15–17). The difference between their results and what we obtained in this study could be partially explained by lack of condiments contribution to energy and macronutrients intake, different cultural practices, study population and dietary assessment instruments.

Our analysis showed seasonal differences in vitamin intakes in Shanghai. Although some studies found no seasonality in vitamin intakes (5, 9, 14), the majority of reviewed literatures aligned with our findings (7, 8, 10, 11, 17, 23, 25, 30). Those reported no differences in vitamins intakes which were different from ours in use FFQs to assess vitamin intakes and different cultural dietary pattern. But the trend of vitamin intakes across seasons was not consistent within studies of positive findings. Some found certain vitamin intake higher in summer, however, others showed the same vitamin intake lower in summer. The inconsistency might partially attribute to differences in ethnic groups, food sources and cultural practices. In our data, only seasonality of sodium intake was observed among eight studied minerals. Some studies found seasonal variations in mineral intakes in their studies as well (7, 8, 10, 11, 17, 25).

We found no seasonal variation of dietary fiber intake in our population. While the study focusing on females in Shanghai showed high seasonal variation of fiber intake (18). A few investigators measured dietary fiber intake across seasons (5–8, 10, 14, 17, 25). Most of them reported higher consumption in winter, spring or fall (6–8, 10, 25). We observed seasonality of cholesterol intake in our study which was highest in summer in Shanghai. Only six of reviewed studies reported cholesterol intake across seasons and two of them reported higher intake in winter (7, 11) while others showed no differences (5, 8, 14, 17). The differences between those findings and ours might once again result from different populations studied, cultural practices taken and/or diet assessment method used.

This study was strengthened by use of repeated dietary intake reports that were collected using 3-day-24-hour food records recall interviewed by public health doctors from community health care centers. Our study had an average of 3-d food records (consecutive 2 weekdays and 1 weekend day), which was a balanced representation of weekdays and weekend days of usual intake than a random single day (1, 31). Moreover, a larger sample size ensured us to detect differences across seasons in our survey while a study conducted in metropolis with a small sample size found nothing statistically significant (14). Our sample was randomly selected in Shanghai and an appropriate weighting method for complex sample design was utilized to provide local representative dietary intakes, which enhanced reliability of our results representing general population in metropolis areas of China (32). Our results of energy and nutrients intake were more validated by taking condiments contribution into consideration.

However, food records recall do have limitations, including underreporting and potential for subjects to alter dietary intake while recording (2). Dietary intake in free-living persons differs from day to day and seasonally (33). In our study, the variances of the dietary intakes were attributed to seasonal difference whereas it would be more convinced if clarifying other sources.
of the variations. The condiments consumption out of home in our analysis was estimated by that at home. A decade ago, Chinese family used to cook meals from raw materials at home, but with increasing frequency of dining out in metropolis, which implies a higher intake of condiments than that from food prepared at home. The condiments consumption might be underestimated in our study.

Results in the present study has given detailed information of the seasonality of absolute food and condiments consumption, energy and nutrients intake in Shanghai, a highly-developed metropolis in China. Given the seasonality of absolute food and condiments intake across whole year by just conducting dietary survey in one single season warrants further study.

Source of funding
This study was supported by the Three-year Action Plan on Public Health, Phase IV (15GWZK0801), Foundation of Shanghai Municipal Commission of Health and Family Planning (201740073), National Nature Science Foundation of China (81602851), Municipal Human Resources Development Program for Outstanding Young Talents in Medical and Health Science in Shanghai (2017YQ043), the Fourth three year public health program (GWIV-27.1), the National Key Research and Development Program of China (2016YFD0400602).

Acknowledgments
We are grateful to all participants in the study. We also thank our colleagues in local district Centers for Diseases Control and Prevention and local Community Health Centers for their assistance with data collection.

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