Trends and Disparities of Energy Intake and Macronutrient Composition in China: a series of national surveys, 1982-2012

ZHENNI ZHU (zhuzhenni@scdc.sh.cn)
Shanghai Municipal Center for Disease Control and Prevention

Xiaoguang Yang
Chinese Center for Disease Control and Prevention National Institute for Nutrition and Health

Yuehui Fang
Chinese Center for Disease Control and Prevention National Institute for Nutrition and Health

Jian Zhang
Chinese Center for Disease Control and Prevention National Institute for Nutrition and Health

Zhenyu Yang
Chinese Center for Disease Control and Prevention National Institute for Nutrition and Health

Zhu Wang
Chinese Center for Disease Control and Prevention National Institute for Nutrition and Health

Ailing Liu
Chinese Center for Disease Control and Prevention National Institute for Nutrition and Health

Li He
Chinese Center for Disease Control and Prevention National Institute for Nutrition and Health

Jing Sun
Chinese Center for Disease Control and Prevention National Institute for Nutrition and Health

Yiyao Lian
Chinese Center for Disease Control and Prevention National Institute for Nutrition and Health

Gangqiang Ding
Chinese Center for Disease Control and Prevention National Institute for Nutrition and Health

Yuna He
Chinese Center for Disease Control and Prevention National Institute for Nutrition and Health

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Abstract

Background

China’s diets transition might give references for the undeveloped countries on the way to prosperity. This report describes the trends and disparities in energy and macronutrient composition among Chinese adults and by subpopulations.

Methods

Data for the current study were obtained from the 1982, 1992, 2002, and 2010-12 CNNS rounds, which were nationally representative cross-sectional surveys. 24-h dietary recall and food weighing were applied to assess dietary intake.

Results

There were 204 877 participants aged 20 years or older included in the current analysis. From 1982 to 2012, the estimated energy intake declined from 2614.7 kcal to 2063.9 kcal. The trends of the estimated percentage of energy intake from fat showed a spike. It increased from 16.3–33.1% (1992 vs 1982 difference, 7.6%; 95% CI 7.4–7.7%; 2002 vs 1992 difference, 7.7%; 95% CI 7.6–7.9%; 2012 vs 2002 difference, 1.6%; 95% CI 1.4–1.7%; \( P < 0.01 \) for trend). The trends coincided in the subgroups (all \( P < 0.01 \) for trend) except the subgroup of those educated over 15 years whose percentage of energy intake from fat declined from 37.4–36.6% (2012 vs 2002 difference, -0.8%; 95% CI -1.6–0.0%). The estimated percentage of energy intake from carbohydrates declined from 74.0–55.0%. The ranges of the estimated percentage of energy intake from fat within population subgroups stratified by education level, area, and Gross national product (GNP) level were narrowed.

Conclusions

Quick improvements in society and economy effectively curbed undernutrition but easily triggered overnutrition. Disparities persistently existed in different subpopulations while the gaps would narrow if comprehensive efforts put on. Education might be a promising way to preventing overnutrition during the prosperous progress. Low social profile population required specific interventions to avoid further disease burden.

Background

China has been one of the fastest-growing countries over the past three decades. It implemented major social and economic reforms since 1979 and achieved tremendous economy and agricultural productivity improvement.[1] Changes in the economy, food supply, and nutrition-related policies can
affect diet quality at the population level. The mass Chinese population experienced diets from scarcity to prosperity within only one decade or two but it cost a lot in the health outcomes that burden of diet-related non-communicable disease turned out extremely heavy.[2] Malnutrition covers two broad groups of conditions: undernutrition and overnutrition.[3] Many developing countries were working on the problem of undernutrition while overnutrition emerged soon.[4] China's diets transition might give references for the developing countries on the way to prosperity. We try to get a close look on its dietary transition during the extraordinary time in China. This report describes data from 4 rounds of China National Nutrition Survey (CNNS) from 1982 to 2012. We examined the trends in energy and macronutrient composition among Chinese population, as well as determined the disparities of dietary quality within subpopulation in terms of area, education level, and economic background.

**Materials And Methods**

**Study population and sampling**

Data for the current study were obtained from the 1982, 1992, 2002, and 2010-12 CNNS rounds, which were nationally representative cross-sectional surveys conducted by the Chinese Center for Disease Control and Prevention to assess the health and nutrition among Chinese population.[5] The design, sampling and dietary data collection methods of each round were in homogeneity. The survey design and methods have been presented in detail previously.[5] A stratified and multistage cluster randomized sampling method was applied. There were initially 238 124, 100 201; 247 464, and 188 622 participants recruited in the series of survey from 1982 to 2012, respectively. The response rate was 87.9% in 2002 and 76.5% in 2010-12 survey round. Response rates were not recorded in the 1982 and 1992 surveys. For this analysis, we restricted the study sample to adults aged 20 years or older with dietary intake data.

Education level was defined as years the participants had ever received education. Area was defined as urban and rural because China is a two-class society with rural-urban distinctions in many aspects. The urban sector has shared more benefits from social and economic reforms than the rural sector has. The life style and dietary pattern were distinguishing between the two sectors. Gross national product (GNP) level was classified in provincial level according to the GNP quartiles across provinces. In 1982, the first class to fourth class were classified as ≥ 284, (244, 284), (194, 244), and < 194 in United States dollars sequentially; in 1992, the first class to fourth class were classified as ≥ 482, (354, 482), (268, 354), and < 268 in United States dollars sequentially; in 2002, the first class to fourth class were classified as ≥ 1569, (958, 1569), (743, 958), and < 743 in United States dollars sequentially; in 2012, the first class to fourth class were classified as ≥ 8510, (5761, 8510), (4670, 5761), and < 4670 in United States dollars, respectively.

**Dietary Assessment**

Field work of each round was launched in autumn considering the comparability between survey rounds. Dietary information was collected for 5 days in 1982 by trained investigators who weighed all available foods in participants' homes at the beginning of the first day, recorded (and weighed if necessary) all new
foods brought into the homes during the 5 days and weighed all leftover at the end of the survey day to calculate the total amount of food consumed by participants during those 5 days. In the 1992, 2002, and 2010-12 surveys, diet was assessed during 3 consecutive days (including two weekdays and one weekend) of 24-h dietary recall in addition to weighing household cooking oil and condiments. For each dietary recall day, investigators went to participants’ homes and helped to record food intake during the past 24 h. Investigators also weighed the household cooking oil and condiments at the beginning and end of each 24 h dietary survey. Nutrient intakes were calculated with the China Food Composition tables (FCTs),[6–8] which are continuously updated with commonly consumed foods and changes in nutrient composition. FCT-1981[8] was used for dietary data from the 1982 round, FCT-2002[6] for those from the 1992 and 2002 round, and FCT-2009[7] for those from the 2010-12 round.

Statistical Analyses

The post-stratification population sampling weights were applied to estimated nationally representative population levels for intakes of energy and macronutrient. In order to compare the dietary intake across years, the weights were derived from the sampling probability of the 2010 Chinese population aged 20 years or older (based on census data) and applied to estimate the representative dietary intake in each survey round. Means and 95% confidence intervals (CIs) of energy and the percentages of macronutrient contributed to energy were determined by adjustment for the sample weights. General linear regression models were used to determine the dietary trends across the survey rounds and the dietary differences between and within years. The regression models included the year of each survey as a ordinal variable. A two-sided P < .05 was considered to indicate statistical significance. Statistical analyses were conducted using SAS statistical software (v. 9.4; SAS Institute, Cary, NC, USA).

Results

Participant Characteristics

There were 204,877 participants aged 20 years or older included in the current analysis. In survey rounds of 1982, 1992, 2002 and 2010-12, dietary intake data were available for 39,084, 58,316, 52,426, and 55,051 participants, respectively. The age structure of the participants was aging across the survey rounds in accordance with that of actual changing among Chinese population. The sex ratios were balanced in the samples. More participants had higher education level than the former round. Urban participants gradually accounted for more percentage of samples in survey rounds due to urbanization progress in China. (Table 1)
|                | 1982       | 1992       | 2002       | 2012       |
|----------------|------------|------------|------------|------------|
| n              | 39084      | 58316      | 52426      | 55051      |
| Age Group, year|            |            |            |            |
| 20–29          | 12642(32.4)| 16116(27.6)| 7531(14.4) | 5310(9.7)  |
| 30–39          | 8729(22.3) | 13840(23.7)| 12959(24.7)| 7894(14.3) |
| 40–49          | 6540(16.7) | 11440(19.6)| 11745(22.4)| 12420(22.6)|
| 50–59          | 5533(14.2) | 8429(14.5) | 10201(19.5)| 12828(23.3)|
| 60–69          | 3662(9.4)  | 5598(9.6)  | 6630(12.7) | 10308(18.7)|
| ≥ 70           | 1978(5.1)  | 2893(5.0)  | 3360(6.4)  | 6291(11.4) |
| Sex            |            |            |            |            |
| Male           | 19432(49.7)| 28010(48.0)| 24709(47.1)| 25278(45.9)|
| Female         | 19652(50.3)| 30306(52.0)| 27717(52.9)| 29773(54.1)|
| Education Level|            |            |            |            |
| under 6 years  | ..         | 23479(40.3)| 6567(12.5)| 6901(12.5) |
| 6 years        | ..         | 8477(14.5) | 15686(29.9)| 15866(28.8)|
| 9 years        | ..         | 15620(26.8)| 18075(34.5)| 19064(34.6)|
| 12 years       | ..         | 7766(13.3) | 8433(16.1) | 8454(15.4) |
| 15 years       | ..         | 1514(2.6)  | 2452(4.7)  | 2740(5.0)  |
| over 15 years  | ..         | 1148(2.0)  | 1115(2.1)  | 2026(3.7)  |

CNNS, China National Nutrition Survey; GNP, gross national product

Data are numbers of participants (%), unless otherwise indicated.

\(^a\) GNP level was classified in provincial level according to the GNP quartiles across provinces. In 1982, the first class to fourth class were classified as \(\geq 284\), (244, 284), (194, 244), and \(< 194\) in United States dollars sequentially; in 1992, the first class to fourth class were classified as \(\geq 482\), (354, 482), (268, 354), and \(< 268\) in United States dollars sequentially; in 2002, the first class to fourth class were classified as \(\geq 1569\), (958, 1569), (743, 958), and \(< 743\) in United States dollars sequentially; in 2012, the first class to fourth class were classified as \(\geq 8510\), (5761, 8510), (4670, 5761), and \(< 4670\) in United States dollars, respectively.
### Trends of Energy and Macronutrient Composition

From 1982 to 2012, the estimated energy intake declined from 2614.7 kcal to 2063.9 kcal (1992 vs 1982 difference, -82.6; 95% CI -92.5 to -72.7; 2002 vs 1992 difference, -335.4; 95% CI -344.2 to -326.7; 2012 vs 2002 difference, -132.7; 95% CI -141.5 to -123.9; \( P < 0.01 \) for trend). So as the trends in population subgroups. (Table 2)
Table 2
Trends and Disparities of Daily Energy Intake of Adults Aged 18 Years or Older by CNNS Rounds, 1982-2012a

| Daily Energy Intake-Survey-Weighted Mean, kcal (95% CI) | P Value for Trend | Difference between Rounds, kcal (95% CI) |
|--------------------------------------------------------|-------------------|-----------------------------------------|
| 1982                                                   | 1992              | 2002                                    | 2012                                    | 1992 vs 1982 | 2002 vs 1992 | 2012 vs 2002 |
| All                                                    |                   |                                         |                                         |              |              |              |
| 2614.7 (2606.5-2622.8)                                 |                   | 2196.6 (2190.4-2202.8)                  | 2063.9 (2057.7-2070.2)                  | <0.01         | -82.6 (-92.5 to -72.7) | -335.4 (-344.2 to -326.7) | -132.7 (-141.5 to -123.9) |
| Education level                                         |                   |                                         |                                         |              |              |              |
| under 6 years                                          | 2488.7 (2478.3-2499.1) | 2055.7 (2038.5-2072.8)                  | 1882.0 (1865.7-1898.4)                  | <0.01         | ..            | -433.0 (-454.2 to -411.8) | -173.6 (-197.4 to -149.9) |
| 6 years                                                | 2618.8 (2602.5-2635.1) | 2288.5 (2277.2-2299.8)                  | 2126.4 (2114.4-2138.3)                  | <0.01         | ..            | -330.3 (-349.9 to -310.8) | -162.1 (-178.5 to -145.6) |
| 9 years                                                | 2589.0 (2577.4-2600.6) | 2269.2 (2258.6-2279.9)                  | 2155.5 (2144.5-2166.5)                  | <0.01         | ..            | -319.8 (-335.6 to -303.9) | -113.8 (-129.1 to -98.4) |
| 12 years                                               | 2494.3 (2479.0-2509.6) | 2123.3 (2108.2-2138.4)                  | 2015.2 (2000.3-2030.2)                  | <0.01         | ..            | -371.0 (-392.6 to -349.5) | -108.1 (-129.4 to -86.7) |
| 15 years                                               | 2500.7 (2467.0-2534.4) | 2052.3 (2025.4-2079.2)                  | 1911.1 (1886.9-1935.3)                  | <0.01         | ..            | -448.4 (-491.6 to -405.1) | -141.2 (-177.3 to -105.2) |

CNNS, China National Nutrition Survey; GNP, gross national product

a Data were adjusted for CNNS weights to be nationally representative. Values may not equal the difference between two years’ or the highest and lowest subgroups’ estimates because of rounding.
|                          | Daily Energy Intake-Survey-Weighted Mean, kcal (95% CI) | P Value for Trend | Difference between Rounds, kcal (95% CI) |
|--------------------------|--------------------------------------------------------|-------------------|----------------------------------------|
|                          | 1982         | 1992         | 2002         | 2012         | 1992 vs 1982 | 2002 vs 1992 | 2012 vs 2002 |
| over 15 years            | ..           | 2472.2       | 2035.2       | 1883.3       | < 0.01       | ..           | -437.0       | -151.9       |
|                          | (2436.3-     | (1996.9-     | (2073.5-     | (1855.6-     | to -1911.1) | to -384.5)   | to -105.2)   |
|                          | 2508.0)      | 2073.5)      | 1911.1)      |               |              |              |              |
| Range within subgroups   | ..           | 146.6        | 253.3        | 273.4        | < 0.01       | ..           | -107.4       | -439.7       |
|                          | (109.8-     | (220.9-     | (250.7-     |               | to -221.1) |              | (-123.5 to -198.6) |
|                          | 183.4)       | 285.6)       | 296.2)       |               |              |              | (-213.3 to -169.9) |
| Area                     |              |              |              |              |              |              |              |
| Urban                    | 2531.0       | 2423.6       | 1983.9       | 1897.2       | < 0.01       | -107.4       | -439.7       | -86.7        |
|                          | (2518.1-     | (2413.5-     | (1974.2-     | (1889.4-     | to -91.2)   | (-123.5 to -453.8) | to -74.6)   |
|                          | 2543.9)      | 1993.7)      | 1905.0)      |               |              |              |              |
| Rural                    | 2703.9       | 2647.7       | 2423.5       | 2241.8       | < 0.01       | -56.2        | -224.2       | -181.7       |
|                          | (2693.3-     | (2639.8-     | (2416.0-     | (2232.5-     | to -43.4)   | (-68.9 to -235.1) | to -169.9) |
|                          | 2714.5)      | 2655.6)      | 2431.0)      | 2251.1)      |              |              |              |
| Range within subgroups   | 172.9        | 224.1        | 439.6        | 344.6        | < 0.01       | -180.8       | -269.7       | -209.7       |
|                          | (156.7-     | (211.9-     | (427.8-     | (332.5-     | to -161.6) | (-200.0 to -284.7) | to -194.5) |
|                          | 189.1)       | 236.2)       | 451.4)       | 356.7)       |              |              |              |
| GNP level                |              |              |              |              |              |              |              |
| First class              | 2624.2       | 2443.4       | 2173.6       | 1963.9       | < 0.01       | -180.8       | -269.7       | -209.7       |
|                          | (2605.9-     | (2432.9-     | (2162.9-     | (1953.2-     | to -161.6) | (-200.0 to -284.7) | to -194.5) |
|                          | 2642.5)      | 2184.3)      | 1974.6)      |               |              |              |              |
| Second class             | 2555.3       | 2514.8       | 2140.9       | 1936.6       | < 0.01       | -40.5        | -373.9       | -204.3       |
|                          | (2540.6-     | (2502.3-     | (2127.7-     | (1925.8-     | to -21.1)   | (-59.8 to -392.1) | to -187.4) |
|                          | 2570.0)      | 2154.2)      | 1947.5)      |               |              |              |              |
| CNNS, China National Nutrition Survey; GNP, gross national product | | | | | | | |
| a Data were adjusted for CNNS weights to be nationally representative. Values may not equal the difference between two years’ or the highest and lowest subgroups’ estimates because of rounding. |
| Daily Energy Intake-Survey-Weighted Mean, kcal (95% CI) | 1982 | 1992 | 2002 | 2012 | $P$ Value for Trend | Difference between Rounds, kcal (95% CI) |
|-------------------------------------------------------|------|------|------|------|----------------------|----------------------------------------|
|                                                       |      |      |      |      | for Trend            | 1992 vs 1982 | 2002 vs 1992 | 2012 vs 2002 |
| Third class                                           |      |      |      |      | < 0.01               | -90.7 (-111.3 to -70.1) | -346.9 (-363.9 to -329.9) | -49.9 (-67.3 to -32.5) |
| Third class                                           | 2629.1 (2611.2-2647.1) | 2538.4 (2526.3-2550.5) | 2191.5 (2179.7-2203.4) | 2141.6 (2128.8-2154.4) |
|                                                       |      |      |      |      |                     | -27.0 (6.1 to 48.0) | -382.3 (-402.7 to -361.9) | -39.0 (-59.9 to -18.1) |
| Fourth class                                          | 2654.6 (2639.7-2669.6) | 2681.6 (2667.2-2696.0) | 2299.3 (2285.0-2313.6) | 2260.3 (2245.1-2275.6) | < 0.01 | -27.0 (6.1 to 48.0) | -382.3 (-402.7 to -361.9) | -39.0 (-59.9 to -18.1) |
| Fourth class                                          |      |      |      |      |                     | -27.0 (6.1 to 48.0) | -382.3 (-402.7 to -361.9) | -39.0 (-59.9 to -18.1) |
| Range within subgroups                                 | 99.3 (78.4-120.3) | 238.3 (220.7-255.8) | 158.4 (138.9-177.9) | 323.7 (305.5-342.0) |
|                                                       |      |      |      |      |                     | -27.0 (6.1 to 48.0) | -382.3 (-402.7 to -361.9) | -39.0 (-59.9 to -18.1) |

CNNS, China National Nutrition Survey; GNP, gross national product

Data were adjusted for CNNS weights to be nationally representative. Values may not equal the difference between two years or the highest and lowest subgroups’ estimates because of rounding.

The trends of the estimated percentage of energy intake from fat showed a spike. It increased from 16.3–33.1% (1992 vs 1982 difference, 7.6%; 95% CI 7.4–7.7%; 2002 vs 1992 difference, 7.7%; 95% CI 7.6–7.9%; 2012 vs 2002 difference, 1.6%; 95% CI 1.4–1.7%; $p < 0.01$ for trend). The trends coincided in the subgroups (all $P < 0.01$ for trend) except the subgroup of those educated over 15 years. In the recent two survey rounds, the estimated percentage of energy intake from fat among the well-educated population declined from 37.4–36.6% (2012 vs 2002 difference, -0.8%; 95% CI -1.6–0.0%). (Table 3)
Table 3
Trends and Disparities of Estimated Percentage of Energy Intake from Fat of Adults Aged 18 Years or Older by CNNS Rounds, 1982-2012\(^a\)

| Population | Estimated Percentage of Energy Intake from Fat, Survey-Weighted % (95% CI) | \(P\) Value for Trend | Difference between Rounds, % (95% CI) |
|------------|---------------------------------------------------------------------|----------------------|------------------------------------|
|            | 1982 | 1992 | 2002 | 2012 | 1992 vs 1982 | 2002 vs 1992 | 2012 vs 2002 |
| All        | 16.3 (16.2–16.4) | 23.8 (23.7–23.9) | 31.6 (31.5–31.7) | 33.1 (33.0–33.2) | <0.01 | 7.6 (7.4 to 7.7) | 7.7 (7.6 to 7.9) | 1.6 (1.4 to 1.7) |
| Education level |           |        |      |      |                |        |        |
| under 6 years | 19.9 (19.8–20.0) | 28.0 (27.7–28.3) | 30.4 (30.1–30.7) | <0.01 | .. | 8.1 (7.8 to 8.4) | 2.5 (2.0 to 2.9) |
| 6 years | 22.2 (22.0–22.5) | 28.9 (28.7–29.1) | 31.1 (31.0–31.3) | <0.01 | .. | 6.6 (6.3 to 6.9) | 2.3 (2.0 to 2.5) |
| 9 years | 25.2 (25.0–25.3) | 31.0 (30.8–31.2) | 32.9 (32.7–33.1) | <0.01 | .. | 5.8 (5.6 to 6.1) | 1.9 (1.7 to 2.1) |
| 12 years | 28.2 (28.0–28.4) | 34.8 (34.6–35.1) | 35.1 (34.8–35.3) | <0.01 | .. | 6.6 (6.2 to 6.9) | 0.3 (-0.1 to 0.6) |
| 15 years | 30.3 (29.8–30.8) | 36.5 (36.1–37.0) | 36.7 (36.3–37.1) | <0.01 | .. | 6.2 (5.5 to 6.9) | 0.1 (-0.5 to 0.7) |
| over 15 years | 30.5 (30.0–31.0) | 37.4 (36.8–38.0) | 36.6 (36.2–37.1) | <0.01 | .. | 6.9 (6.1 to 7.7) | -0.8 (-1.6 to 0.0) |
| Range within subgroups | 10.6 (10.1–11.1) | 9.5 (8.8–10.1) | 6.3 (5.8–6.7) | <0.01 | .. | 9.5 (9.3 to 9.7) | 6.8 (6.6 to 7.0) | 0.9 (0.7 to 1.1) |

Area

| Urban | 19.6 (19.4–19.7) | 29.0 (28.9–29.2) | 35.8 (35.7–36.0) | 36.7 (36.6–36.8) | <0.01 | 9.5 (9.3 to 9.7) | 6.8 (6.6 to 7.0) | 0.9 (0.7 to 1.1) |

CNNS, China National Nutrition Survey; GNP, gross national product

\(^a\) Data were adjusted for CNNS weights to be nationally representative. Values may not equal the difference between two years’ or the highest and lowest subgroups’ estimates because of rounding.
|                              | Estimated Percentage of Energy Intake from Fat, Survey-Weighted % (95% CI) | P Value for Trend | Difference between Rounds, % (95% CI) |
|------------------------------|--------------------------------------------------------------------------|------------------|--------------------------------------|
|                              | 1982       | 1992       | 2002       | 2012       | 1992 vs 1982 | 2002 vs 1992 | 2012 vs 2002 |
| Rural                        | 12.7 (12.6–12.8) | 18.3 (18.2–18.4) | 27.0 (26.9–27.1) | 29.3 (29.2–29.4) | < 0.01 | 5.5 (5.4 to 5.7) | 8.7 (8.6 to 8.9) | 2.3 (2.1 to 2.5) |
| Range within subgroups       | 6.8 (6.7–7.0) | 10.8 (10.6–10.9) | 8.9 (8.7–9.1) | 7.4 (7.2–7.6) |
| GNP level                    |                              |                              |                              |                              |
| First class                  | 17.0 (16.8–17.2) | 27.5 (27.4–27.7) | 33.0 (32.8–33.1) | 35.0 (34.9–35.2) | < 0.01 | 10.5 (10.3 to 10.8) | 5.4 (5.2 to 5.7) | 2.1 (1.8 to 2.3) |
| Second class                 | 15.8 (15.6–15.9) | 23.7 (23.5–23.9) | 31.2 (31.0–31.4) | 33.3 (33.1–33.5) | < 0.01 | 8.0 (7.7 to 8.2) | 7.5 (7.2 to 7.7) | 2.1 (1.8 to 2.4) |
| Third class                  | 15.1 (14.9–15.3) | 20.2 (20.0–20.4) | 31.3 (31.1–31.5) | 31.3 (31.1–31.5) | < 0.01 | 5.1 (4.8 to 5.3) | 11.1 (10.8 to 11.4) | 0.0 (-0.3 to 0.3) |
| Fourth class                 | 17.1 (17.0–17.3) | 21.9 (21.7–22.1) | 30.1 (29.9–30.3) | 32.5 (32.3–32.7) | < 0.01 | 4.8 (4.5 to 5.1) | 8.2 (7.9 to 8.5) | 2.4 (2.1 to 2.7) |
| Range within subgroups       | 2.0 (1.8–2.3) | 7.3 (7.1–7.6) | 2.9 (2.6–3.1) | 3.7 (3.5–4.0) |

CNNS, China National Nutrition Survey; GNP, gross national product

Data were adjusted for CNNS weights to be nationally representative. Values may not equal the difference between two years’ or the highest and lowest subgroups’ estimates because of rounding.

The estimated percentage of energy intake from carbohydrates declined from 74.0–55.0% (1992 vs 1982 difference, -10.5%; 95% CI -10.7% to -10.4%; 2002 vs 1992 difference, -7.4%; 95% CI -7.5% to -7.2%; 2012 vs 2002 difference, -1.0%; 95% CI -1.2% to -0.9%; P < 0.01 for trend). The trends in subgroups were in the same.
Table 4
Trends and Disparities of Estimated Percentage of Energy Intake from Carbohydrates of Adults Aged 18 Years or Older by CNNS Rounds, 1982-2012a

| Estimated Percentage of Energy Intake from Carbohydrates, Survey-Weighted % (95% CI) | P Value | Difference between Rounds, % (95% CI) |
|---|---|---|
| | 1982 | 1992 | 2002 | 2012 | vs 1982 | vs 1992 | vs 2002 |
| All | 74.0 (73.8–74.1) | 63.4 (63.3–63.5) | 56.0 (55.9–56.1) | 55.0 (54.9–55.1) | < 0.01 | -10.5 (-10.7 to -10.4) | -7.4 (-7.5 to -7.2) | -1.0 (-1.2 to -0.9) |
| Education level | | | | | | | | |
| under 6 years | 68.1 (67.9–68.2) | 60.5 (60.2–60.8) | 59.1 (58.8–59.4) | < 0.01 | | -7.6 (-7.9 to -7.3) | -1.4 (-1.8 to -1.0) | |
| 6 years | 65.4 (65.2–65.6) | 59.5 (59.3–59.7) | 57.7 (57.5–57.9) | < 0.01 | | -5.9 (-6.2 to -5.6) | -1.8 (-2.0 to -1.5) | |
| 9 years | 61.9 (61.8–62.1) | 56.8 (56.6–57.0) | 55.4 (55.2–55.6) | < 0.01 | | -5.1 (-5.4 to -4.9) | -1.4 (-1.7 to -1.2) | |
| 12 years | 58.1 (57.9–58.4) | 51.9 (51.7–52.2) | 52.4 (52.1–52.6) | < 0.01 | | -6.2 (-6.5 to -5.8) | 0.4 (0.1 to 0.8) | |
| 15 years | 55.4 (54.9–55.9) | 49.6 (49.2–50.0) | 50.0 (49.6–50.4) | < 0.01 | | -5.8 (-6.5 to -5.1) | 0.4 (-0.2 to 1.0) | |
| over 15 years | 55.0 (54.4–55.5) | 48.1 (47.5–48.7) | 49.6 (49.2–50.1) | < 0.01 | | -6.9 (-7.7 to -6.1) | 1.5 (0.8 to 2.3) | |
| Range within subgroups | 13.1 (12.6–13.6) | 12.4 (11.8–13.0) | 9.5 (9.0–10.0) | | | | | |

CNNS, China National Nutrition Survey; GNP, gross national product

a Data were adjusted for CNNS weights to be nationally representative. Values may not equal the difference between two years’ or the highest and lowest subgroups’ estimates because of rounding.
|                        | Estimated Percentage of Energy Intake from Carbohydrates, Survey-Weighted % (95% CI) | Difference between Rounds, % (95% CI) | \(P\) Value for Trend |
|------------------------|--------------------------------------------------------------------------------------|----------------------------------------|------------------------|
|                        | 1982 | 1992 | 2002 | 2012 | 1992 vs 1982 | 2002 vs 1992 | 2012 vs 2002 |                                  |
| **Urban**              |      |      |      |      |              |                    |                  |                       |
|                        | 70.0 | 57.2 | 50.8 | 50.4 | -12.8 (-13.0 to -12.6) | -6.4 (-6.6 to -6.2) | -0.4 (-0.6 to -0.2) | < 0.01 |
|                        | (69.8–70.2) | (57.0–57.3) | (50.6–51.0) | (50.2–50.5) |                                  |                      |                      |                        |
| **Rural**              |      |      |      |      |              |                    |                  |                       |
|                        | 78.2 | 70.1 | 61.6 | 60.0 | -8.1 (-8.2 to -7.9) | -8.4 (-8.6 to -8.3) | -1.7 (-1.8 to -1.5) | < 0.01 |
|                        | (78.0–78.3) | (70.0–70.2) | (61.5–61.7) | (59.8–60.1) |                                  |                      |                      |                        |
| **Range within subgroups** | 8.2 | 12.9 | 10.8 | 9.6 | -8.1 (-8.2 to -7.9) | -8.4 (-8.6 to -8.3) | -1.7 (-1.8 to -1.5) |                       |
|                        | (8.0–8.3) | (12.7–13.0) | (10.7–11.0) | (9.4–9.8) |                                  |                      |                      |                        |
| **GNP level**          |      |      |      |      |              |                    |                  |                       |
| **First class**        |      |      |      |      |              |                    |                  |                       |
|                        | 72.7 | 58.7 | 53.6 | 51.6 | -14.1 (-14.3 to -13.8) | -5.1 (-5.3 to -4.9) | -1.9 (-2.2 to -1.7) | < 0.01 |
|                        | (72.5–73.0) | (58.5–58.8) | (53.4–53.7) | (51.4–51.8) |                                  |                      |                      |                        |
| **Second class**       |      |      |      |      |              |                    |                  |                       |
|                        | 74.5 | 63.7 | 56.5 | 55.4 | -10.8 (-11.0 to -10.5) | -7.2 (-7.5 to -6.9) | -1.1 (-1.4 to -0.8) | < 0.01 |
|                        | (74.3–74.7) | (63.5–63.9) | (56.3–56.8) | (55.2–55.6) |                                  |                      |                      |                        |
| **Third class**        |      |      |      |      |              |                    |                  |                       |
|                        | 75.6 | 67.9 | 56.8 | 57.4 | -7.8 (-8.0 to -7.5) | -11.1 (-11.3 to -10.8) | 0.6 (0.3 to 0.9) | < 0.01 |
|                        | (75.4–75.8) | (67.7–68.0) | (56.6–57.0) | (57.2–57.6) |                                  |                      |                      |                        |
| **Fourth class**       |      |      |      |      |              |                    |                  |                       |
|                        | 72.9 | 65.9 | 58.4 | 56.3 | -7.0 (-7.3 to -6.7) | -7.6 (-7.9 to -7.2) | -2.1 (-2.4 to -1.8) | < 0.01 |
|                        | (72.7–73.1) | (65.7–66.1) | (58.1–58.6) | (56.0–56.5) |                                  |                      |                      |                        |
| **Range within subgroups** | 2.9 | 9.2 | 4.8 | 5.8 | 2.9 (2.6–3.2) | 4.5 (4.5–5.1) | 5.5 (5.5–6.1) |                  |
|                        | (9.0–9.5) | (4.5–5.1) | (5.5–6.1) |                  |                                  |                      |                      |                        |

CNNS, China National Nutrition Survey; GNP, gross national product

Data were adjusted for CNNS weights to be nationally representative. Values may not equal the difference between two years’ or the highest and lowest subgroups’ estimates because of rounding.

The estimated percentage of energy intake from protein increased between the first and second rounds from 10.9–12.8% and slightly declined to 12.3% in the successive two rounds (1992 vs 1982 difference,
1.9%; 95% CI 1.9–1.9%; 2002 vs 1992 difference, -0.3%; 95% CI -0.4% to -0.3%; 2012 vs 2002 difference, -0.1%; 95% CI -0.1–0.0%). (Table 5)
### Table 5
Trends and Disparities of Estimated Percentage of Energy Intake from Protein of Adults Aged 18 Years or Older by CNNS Rounds, 1982-2012

| Estimated Percentage of Energy Intake from Protein, Survey-Weighted % (95% CI) | P Value for Trend | Difference between Rounds, % (95% CI) |  |
|---|---|---|---|
| | 1982 | 1992 | 2002 | 2012 | 1992 vs 1982 | 2002 vs 1992 | 2012 vs 2002 |
| All | 10.9 (10.8–10.9) | 12.8 (12.7–12.8) | 12.4 (12.4–12.4) | 12.3 (12.3–12.4) | <0.01 | 1.9 (1.9 to 1.9) | -0.3 (-0.4 to -0.3) | -0.1 (-0.1 to 0.0) |
| Education level | | | | | | | | |
| under 6 years | .. | 12.0 (12.0–12.0) | 11.5 (11.5–11.6) | 11.2 (11.2–11.3) | <0.01 | .. | -0.7 (-0.8 to -0.6) | -0.2 (-0.2 to -0.1) |
| 6 years | .. | 12.4 (12.3–12.4) | 11.7 (11.6–11.7) | 11.5 (11.4–11.5) | <0.01 | .. | -0.7 (-0.8 to -0.6) | -0.2 (-0.2 to -0.1) |
| 9 years | .. | 12.9 (12.9–13.0) | 12.2 (12.2–12.2) | 12.1 (12.0–12.1) | <0.01 | .. | -0.7 (-0.8 to -0.6) | -0.1 (-0.2 to -0.1) |
| 12 years | .. | 13.7 (13.6–13.7) | 13.2 (13.2–13.3) | 13.2 (13.1–13.2) | <0.01 | .. | -0.4 (-0.5 to -0.3) | -0.1 (-0.2 to 0.0) |
| 15 years | .. | 14.2 (14.0–14.4) | 13.8 (13.7–14.0) | 14.1 (14.0–14.3) | 0.83 | .. | -0.4 (-0.6 to -0.2) | 0.3 (0.1 to 0.5) |
| over 15 years | .. | 14.5 (14.3–14.7) | 14.5 (14.3–14.7) | 14.6 (14.4–14.8) | 0.40 | .. | 0.0 (-0.3 to 0.2) | 0.1 (-0.1 to 0.4) |
| Range within subgroups | .. | 2.5 (2.4–2.6) | 3.0 (2.8–3.1) | 3.4 (3.3–3.5) | | | | |
| Area | | | | | | | | |
| Urban | 11.2 (11.2–11.3) | 13.8 (13.7–13.8) | 13.4 (13.3–13.4) | 13.5 (13.4–13.5) | <0.01 | 2.6 (2.5 to 2.6) | -0.4 (-0.5 to -0.3) | 0.1 (0.0 to 0.2) |

CNNS, China National Nutrition Survey; GNP, gross national product

aData were adjusted for CNNS weights to be nationally representative. Values may not equal the difference between two years’ or the highest and lowest subgroups’ estimates because of rounding.
| Estimated Percentage of Energy Intake from Protein, Survey-Weighted % (95% CI) | P Value for Trend | Difference between Rounds, % (95% CI) |
|---|---|---|
| | 1982 | 1992 | 2002 | 2012 | 1992 vs 1982 | 2002 vs 1992 | 2012 vs 2002 |
| Rural | 10.5 (10.5–10.5) | 11.7 (11.6–11.7) | 11.4 (11.4–11.4) | 11.2 (11.1–11.2) | <0.01 | 1.2 (1.1 to 1.2) | -0.3 (-0.3 to -0.2) | -0.2 (-0.3 to -0.2) |
| Range within subgroups | 0.7 (0.7–0.8) | 2.1 (2.1–2.1) | 2.0 (1.9–2.0) | 2.3 (2.3–2.4) | |
| GNP level | | | | | | | |
| First class | 11.0 (10.9–11.0) | 13.8 (13.8–13.9) | 13.5 (13.4–13.5) | 13.6 (13.5–13.7) | <0.01 | 2.8 (2.8 to 2.9) | -0.3 (-0.4 to -0.3) | 0.1 (0.0 to 0.2) |
| Second class | 11.2 (11.2–11.2) | 12.5 (12.5–12.6) | 12.3 (12.2–12.3) | 12.0 (12.0–12.1) | <0.01 | 1.3 (1.3 to 1.4) | -0.3 (-0.3 to -0.2) | -0.3 (-0.3 to -0.2) |
| Third class | 10.6 (10.5–10.6) | 12.0 (11.9–12.0) | 11.9 (11.9–12.0) | 11.8 (11.8–11.9) | <0.01 | 1.4 (1.3 to 1.4) | 0.0 (-0.1 to 0.0) | -0.1 (-0.2 to 0.0) |
| Fourth class | 10.7 (10.7–10.7) | 12.1 (12.1–12.2) | 11.5 (11.5–11.6) | 11.7 (11.6–11.8) | <0.01 | 1.4 (1.4 to 1.5) | -0.6 (-0.7 to -0.5) | 0.2 (0.1 to 0.2) |
| Range within subgroups | 0.6 (0.5–0.7) | 1.9 (1.8–1.9) | 1.9 (1.9–2.0) | 1.9 (1.8–2.0) | |

CNNS, China National Nutrition Survey; GNP, gross national product

* Data were adjusted for CNNS weights to be nationally representative. Values may not equal the difference between two years’ or the highest and lowest subgroups’ estimates because of rounding.

Disparities of Macronutrient Composition in Population Subgroups

The ranges of the estimated percentage of energy intake from fat within population subgroups stratified by education level were 10.6% (95% CI 10.1%-11.1%) in 1992, 9.5% (95% CI 8.8%-10.1%) in 2002, and 6.3% (95% CI 5.8%-6.7%) in 2010-12. Those stratified by area were 6.8% (95% CI 6.7%-7.0%) in 1982, 10.8% (95% CI 10.6%-10.9%) in 1992, 8.9% (95% CI 8.7%-9.1%) in 2002, and 7.4% (95% CI 7.2%-7.6%) in 2010-12. Those stratified by GNP level were 2.0% (95% CI 1.8%-2.3%) in 1982, 7.3% (95% CI 7.1%-7.6%) in...
1992, 2.9% (95% CI 2.6%-3.1%) in 2002, and 3.7% (95% CI 3.5%-4.0%) in 2010-12. The ranges of the estimated percentage of energy intake from carbohydrates within population subgroups stratified by education level were 13.1% (95% CI 12.6%-13.6%) in 1992, 12.4% (95% CI 11.8%-13.0%) in 2002, and 9.5% (95% CI 9.0%-10.0%) in 2010-12. Those stratified by area were 8.2% (95% CI 8.0%-8.3%) in 1982, 12.9% (95% CI 12.7%-13.0%) in 1992, 10.8% (95% CI 10.7%-11.0%) in 2002, and 9.6% (95% CI 9.4%-9.8%) in 2010-12. Those stratified by GNP level were 2.9% (95% CI 2.6%-3.2%) in 1982, 9.2% (95% CI 9.0%-9.5%) in 1992, 4.8% (95% CI 4.5%-5.1%) in 2002, and 5.8% (95% CI 5.5%-6.1%) in 2010-12. (Table 2–5 and Fig. 1)

(The trends and disparities stratified by age and sex were given in the Supplement Table 1–4.)

Discussion

China has made substantial progress in improving nutrition. The diet quality was improved remarkably from 1982 to 2012 in China. The trends of energy intake was constantly going down in the survey rounds due to the fast pace of modernization and urbanization. The percentage of fat contributed to energy spiked, that of carbohydrates fell all the way, and that of protein stabilized within a small range. The macronutrient composition was going through poor to ideal and far away from ideal again. Though the composition was not satisfying at the beginning round of CNNS in1982 which featured full of carbohydrates and lack of fat, it turned to more ideal in the 1992 survey round. The macronutrient composition was within the national recommendations among most subpopulations around that period. [9] But in the recent two surveys, the macronutrient composition had dropped out of the ideal ranges which led health condition to the other part of malnutrition, overnutrition, potentially contributing the prevalence of nutrition-related NCDs national wide.[10] We considered different fat composition at the same level of energy intake could have diverse impacts in the development of obesity. It seemed a paradox in China that overweight and obesity were dramatically increasing since 1980s despite of energy intake constantly decreasing.[1, 11] Reduced physical activity could explain the uprising prevalence of obesity, but most developed countries, like America, Korea, also experienced both obesity prevalent and energy intake uprising.[12–15] Indeed, very less countries, like Japan, had the similar situation with ours that obesity rate went up along with energy intake decreasing.[16] New studies suggested that the percentage of fat contributed to energy could be the cause of adiposity but not carbohydrates or protein. [17] In fact, the proportion of fat in diet kept going up worldwide as well as the prevalence of obesity.[13, 16, 18, 19] The current findings were based on massive samples and from observation in a long term which might provide new thoughts to the causality of obesity.

The great achievements from social and economic shifts after 1979 had tremendous impact on the diet of Chinese population.[20] It took no more than one decade for Chinese people from lack of various food to plenty of every food. There was a big leap in nutrition improvement and the diet patterns changed most in 1980s and 1990s. The macronutrient composition rapidly reached the ideal ranges at that time. The pace of the change in the macronutrient composition got slow down but it was off satisfying in recent years. The promoter of the diet has shifted. Economy and food supply were still continuing improved but it had yet added little credit on the diet improvement recently in China. Other things like
nutrition policy retargeting or availabilities of nutrition education and knowledge might be the key to promote the current diet quality in China.

The disparities persistently existed in different subpopulations across China, but the gaps were narrowed in the recent years. The Chinese government has put huge efforts on poverty reduction, transportation system construction, and agricultural yield raising which all potentially increased equity of access to various food by people with different background. Especially in the most recent survey round, the percentages of fat and carbohydrates contributed to energy were getting closer between the two ends within subpopulations in the aspects of area, education level, and economic background. It was obvious that the subpopulations with better social profile (living in urban, well-educated, and wealthy economic background) were leading the diet trends and the rest followed in next one decade or two. Nevertheless, the macronutrient composition of those with better social profile had been going toward the overnutrition pattern since years around 2002 which was probably a major cause of nutrition-related NCDs prevailing in China.[3, 10, 21] If people with low social profile continues following the diet trend, there might be another surge of nutrition-related NCDs in China. Moreover, inequalities of health resources had existed for some time in China.[22] It would deepen the social contradictions if those who suffered from diseases could not be able to access necessary health resources. More governmental interventions should be launched on the subpopulation with low social profile in order to slow down or even curb their following paces to overnutrition.

One promising trend was discovered in the well-educated subpopulation. In the survey round of 2012, the macronutrient composition distinctively retuned to the recommended ranges among these people. “Eat well” was linked to “live well” in Chinese culture but people always confused “eat well” with “eat whatever one wants”. Actually, “eat well” means “eat properly” in the modern nutritional theory and it leads to “live well”. It is convinced some risks of nutrition-related NCDs can be modified though education improvement.[23] Well-educated people have more wills and abilities to acquire health information which might help them regulate dietary behaviors rather than follow the instinct appetite or preference. Health education would probably be a useful tool to help China get through the possible dilemma of further potential surge of NCDs in the subpopulations with low social profile.

This study has several limitations. First, 3-day 24-h dietary recalls were used to obtain food consumption information, the accuracy of dietary intake was mostly dependent on the participants’ recall and estimation. Second, for the individual income information varied in different survey rounds, the classification of GNP level was applied. It was based on each province’s GNP in the survey year which might not classify the each participant meticulously. Third, a recent study mentioned the quality or food sources of macronutrients might lead to different health outcomes [24]. The diet quality in the current study was determined based on the macronutrient composition which might cause bias without taking food composition into consideration. Fourth, the inference of macronutrient composition and later health outcome in the discussion was only derived from reports on the national level in ecological way rather than the relationship among CNNS participants.
Conclusions

Quick improvements in society and economy effectively curbed undernutrition but easily triggered larger-scaled overnutrition soon after in China. Disparities persistently existed in different subpopulations while the gaps would narrow if major efforts put on. Education might be a promising way to preventing overnutrition during the prosperous progress in developing country. Low social profile population required specific interventions to avoid further burden of diet-related non-communicable disease in order to maintain social stability.

Abbreviations

CNNS: China National Nutrition Survey; GNP: Gross national product;

Declarations

Ethics approval and consent to participate

The series of national surveys were approved by the ethics committee of the National Institute for Nutrition and Health at the Chinese Center for Disease Control and Prevention.

Consent for publication

Not applicable.

Availability of data and materials

Open access to the CNNS data is not yet available. However, we welcome ideas and proposals for potential collaborations. Any enquiries should be sent to Dr Yuna He (heyn@ninh.chinacdc.cn).

Competing interests

None reported.

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Authors' contributions
Drs Y He had full access to all of the data in the study and took responsibility for the integrity of the data and the accuracy of the data analysis. Z Zhu and Y He designed the study. X Yang, Y Fang, J Zhang, Z Yang, Z Wang, A Liu, L He, J Sun, Y Lian, and G Ding were responsible for the data collection, curation, and interpretation. Z Zhu finished statistical analysis and draft paper preparation. Y He supervised the study. All other authors reviewed the paper.

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Figures

The two polygonal lines in each graph represented the two ends of subgroups. (A, B, C) showed percentages of energy intake from fat across survey rounds. (D, E, F) showed percentages of energy intake from carbohydrates across survey rounds. (G, H, I) showed percentages of energy intake from protein across survey rounds.

Figure 1

Trends and Disparities between Two Ends of Subgroups in Estimated Energy Intake from Macronutrients of Adults Aged 18 Years or Older by CNNS Rounds, 1982-2012, Stratified by Area, Education Level, and GNP Level
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