RESEARCH ARTICLE

Sociodemographic, lifestyle, behavioral, and parental factors associated with sugar-sweetened beverage consumption in children in China

Haijun Guo*, Dung Phung, Cordia Chu
Centre for Environment and Population Health, Griffith University, Nathan, Australia

* hajun.guo@griffithuni.edu.au

Abstract

Objective

Evidence shows sugar-sweetened beverage (SSB) consumption is a risk factor for obesity and non-communicable diseases (NCDs) in children. Investigating the influential profiles, which have been examined insufficiently, will help to inform the reduction of SSB consumption. The present research examines the current trend in SSB consumption and associated factors among children in China, in order to inform policy development.

Methods

Secondary data was extracted from China’s Health and Nutrition Survey (CHNS; 2004, 2006, 2009, and 2011), a repeated cross-sectional research, and a Chi-squared test was applied to compare SSB consumption in the last year, queried by social demographic, environmental, behavioral, and parental factors. Multilevel mixed-effects logistic regression was employed to examine the trend and effects of the multiple factors.

Results

A total of 6015 Chinese children aged 6–17 years were investigated. From 2004 to 2011, the percentage of SSB consumption in children increased from 72.6% to 90.3%. The prevalence in urban areas was higher than the prevalence in rural areas, higher in high schools than primary and middle schools, higher in east coast affluent provinces than other provinces, and higher in high-income households than low-income households. Other associated factors include children’s fast food and salty snacks preference, level of physical activity, sedentariness, and parental education. The strongest association with SSB consumption in children was the mother’s SSB consumption (adjusted odds ratio: 5.54, 95% CI: 3.17–9.67).

Conclusion

Children’s SSB consumption has increased significantly in China, and is associated with socio-economic, demographic, level of physical activity, food preference, and parental
factors. Future strategies aimed at reducing SSB consumption among children need to consider these factors.

Introduction

Obesity plays a key role in the pandemic of non-communicable diseases (NCDs), with the highest mortality and morbidity worldwide, and imposes a heavy burden on healthcare systems [1, 2]. Research shows the prevalence of childhood obesity has increased by 8.3% annually from 1981 to 2010 [3–5], causing a higher likelihood of obesity in adulthood. Accumulating research illustrates childhood obesity is increasing dramatically in developing countries: For example, China has seen a significant increase in overweight and obesity in children [6–10]. The soaring prevalence of obesity and NCDs is recognized as a consequence of an interaction of multiple factors, such as diet shifting, eating out more frequently, increased intake of cooking oils, reduced physical activity, and increased sedentary behavior. Among these, an excess of free sugar in the diet has been identified as one of the most significant factors [3]. The main source of dietary free sugar is SSBs, especially in children [11, 12].

Research has shown that SSB sales have increased during the last two decades, particularly in low- and middle-income countries: The figures increased from 43.4 liters per person in 2001 to 65.3 liters per person in 2014 [13]. China has experienced a sharp increase in SSB sales [14], but evidence regarding the frequency of SSB consumption in the population remains lacking, in particular the trend of SSB consumption by children during the last two decades is missing.

Researchers have claimed that social and environmental factors affect SSB consumption, such as economic status, water fountains in the community, advertising, marketing, in addition to the dietary behaviors and physical activities, and parental influence has been found to be highly associated with SSB consumption in children [15–19]. These findings are mainly drawn from cross-sectional studies [20], and the historical influence of these previously examined factors remains unclear, especially in countries such as China that are undergoing rapid socio-economic change. Moreover, previous studies have examined the effects of associated factors in small-scale studies, focusing only on sex, age, and residency while ignoring a wide range of socio-economic and lifestyle factors. This information gap presents a challenge for policy makers in developing effective strategies to reduce SSB consumption in children. Thus, this research aims to examine the trend and various associated factors of SSB consumption among children in China.

Methods

Setting and participants

We extracted the data from the CHNS, which was a population-based, multistage, cluster-random sampling survey. From 1989 to 2015, nine rounds of nutrition, health behavior, health status, and sociodemographic data was collected. Households were the basic sample units from rural and urban areas in nine provinces, including Heilongjiang, Liaoning, Shandong, Henan, Jiangsu, Hubei, Hunan, Guizhou, and Guangxi. All members of each household were investigated. A detailed description of the survey design and procedures has been published elsewhere [21, 22].

We selected participants aged 6–17 years to analyse their SSB consumption in 2004, 2006, 2009, and 2011 [22]. The data was openly accessed on the CHNS official website. The ethical clearance of CHNS was approved by the IRB of the National Institute for Nutrition and Food
Safety, China Center for Disease Control and Prevention, and University of North Carolina at Chapel Hill [21, 22]. The current research was fully approved by the Griffith University Human Research Ethics Committee. Written informed consent was obtained from all participants, data was fully anonymized, and no identifiable information was collected.

Variables measured
Questionnaires were developed and adapted by CHNS to measure the frequency of beverage consumption and the potential associated factors. All these questionnaires had been documented and described on the CHNS website [22].

Beverage consumption. SSB consumption was measured through two questions that were included in the CNHS: “In the last year, did you drink soft drinks or sugared fruit drinks?” and “How often did you drink soft drinks or sugared fruit drinks?” For the first question, the potential answers were ‘No’, ‘Yes’, and ‘Unknown’. The children who answered ‘Yes’ were required to answer the second question, and the potential answers were: ‘almost every day’, ‘3–4 times a week’, ‘1–2 times a week’, ‘1–2 times a month’, ‘no more than once a month’, and ‘unknown’. Because SSB consumption showed a highly skewed distributed and was largely reported as zero in previous research [23], we defined the answer ‘No’ for the first questions as ‘0 times a week’ in the final variable; ‘1–2 times a week’, ‘1–2 times a month’, and ‘no more than once a month’ for the second question as ‘0–2 times a week’; ‘almost every day’, ‘3–4 times a week’ for the second question as ‘>2 times a week’. The ‘unknown’ for the first and second questions were defined as missing in the final variable, because they did not provide enough information to assess SSB consumption in this research.

Associated factors. We selected the potential associated factors according to literature and theoretical plausibility. Age, sex, residency, education level, and provincial categories were demographic factors frequently used by previous research [24]. We selected household income to evaluate the influence of economic status on SSB consumption [24], preference for fast food, salty snack, vegetable and fruit indicating to evaluate the influence of dietary habit [25–27], physical exercise and sedentary activity to evaluate the influence of lifestyle [19, 28], and parental education and SSB consumption to evaluate the parental influence [29].

We defined those associated factors as age (categorized into two age groups: 6–11 years or 12–17 years), sex (boy or girl), education (primary school, middle school, or high school), residency (rural or urban), and provincial categories (northeast, east coastal, central, south, or municipality). Household income per year was categorized into three groups by quartile (low: 0 to quartile 25, medium: quartile 25 to quartile 75, high: over quartile 75). Food preferences were binary variables (yes or no). Performing physical exercises out of school and in school were respectively classified into two groups (yes or no). Sedentary activity was defined as low, medium, and high according to the homework plus screen time (less than 2 hours, 2 to 4 hours, and more than 4 hours). Father and mother’s highest education level were classified into three groups: primary and below, middle school, and graduate and postgraduate. Whether or not father and mother reported SSB consumption in the last year was also analyzed as two dichotomous factors.

Statistical analysis
We used a Chi-square test to compare the percentages of reported SSB consumption queried by factors among children. The Mantel-Haenszel chi-square was used if the factors were in ordinal scales.

Given that participants might be repeatedly investigated across the four survey years, the multilevel mixed-effects logistic regression were applied to determine the adjusted odds ratios
(AOR) and 95% confidence intervals (CI) of the occurrence of SSB consumption as the dependent variable (Y) and dummy variables for children’s factors referring to demographic, economic, food preferences, physical activity, sedentary activity, and parental influences as independent variables. We chose participants as the random-effect intercept in the regression model. The full model was provided, and the goodness-of-fit was illustrated with Akaike information criterion (AIC). All analyses were conducted in SAS, version 9.4 (SAS Institute Inc., Cary, NC, United States). The statistical significance level was set at 0.05.

Results

Characteristics of participants

In total, 6015 children aged 6–17 years, including 3198 boys and 2817 girls, were involved. Four rounds of survey were used with sample sizes of 1725 (2004), 1385 (2006), 1241 (2009), and 1663 (2011) respectively (Table 1). Younger children aged 6–11 years had a similar sample size (51.0%) compared with those aged 12–17 years (49.0%), while the sample size of rural children (69.6%) was more than twice the urban sample size (30.4%), and boys (53.2%) outnumbered girls (46.8%).

Sugar-sweetened beverage consumption among children in China from 2004 to 2011

In total, 81.2% of children reported they had consumed SSBs in the last year during 2004–2011, and 16.8% of them consumed SSBs more than twice a week in the same period. The prevalence of SSB consumption among children increased significantly during the research period (Mantel-Haenszel $\chi^2 = 185.6$, $P<0.01$). In 2004, 14.2% of children consumed SSBs two times a week, which increased to 21.8% in 2011, while 27.4% of the children who did not consume SSBs decreased to only 9.7% during the same period.

The result of bivariate analysis (Table 2) shows that differences of the SSB consumption between age groups in each survey year was not significant ($P>0.05$). A higher percentage of boys (92.0%) consumed SSBs than girls (88.5%) in 2011 ($P<0.01$), while a higher percentage of urban children consumed SSBs than rural children in 2004 (84.0% vs. 68.1%), 2006 (83.0% vs. 72.1%) and 2009 (89.9% vs. 86.0%), and the differences were statistically significant. High school students tended to consume more SSBs, in particular 32.0% of high school students consumed SSBs more than twice per week, which is significantly higher than that of primary

| Table 1. Characteristics of participants stratified by age, sex and residency. |
|-----------------|-------|-------|-------|-------|
|                 | 2004  | 2006  | 2009  | 2011  |
| Age             |       |       |       |       |
| 6–11            | 732   | 715   | 656   | 966*  |
| 12–17           | 993   | 671   | 585   | 697   |
| Sex             |       |       |       |       |
| Boys            | 919   | 735   | 690   | 854   |
| Girls           | 806   | 651   | 551   | 809   |
| Residency       |       |       |       |       |
| Urban           | 484   | 398   | 341   | 608** |
| Rural           | 1241  | 988   | 900   | 1055  |

* Chi-Square test: $p<0.05$;
** Chi-Square test: $p<0.01$.

https://doi.org/10.1371/journal.pone.0261199.t001
|                        | 2004 | 2006 | 2009 | 2011 | 2011 |
|------------------------|------|------|------|------|------|
|                        | 0/w  | 0–2/w| >2/w | 0/w  | 0–2/w| >2/w | 0/w  | 0–2/w| >2/w |
| Total                  | 27.4 | 58.4 | 14.2 | 24.7 | 61.9 | 13.4 | 12.9 | 69.4 | 17.7 |
| Age                    | 9.7  | 68.3 | 21.8 |
| 6–11                   | 26.5 | 58.8 | 14.7 | 23.9 | 62.7 | 13.4 | 12.5 | 68.8 | 18.7 |
| 12–17                  | 28.1 | 58.1 | 13.8 | 25.5 | 61.1 | 13.4 | 13.3 | 70.1 | 16.6 |
| Sex                    | 9.5  | 70.6 | 19.9 |
| Boys                   | 25.3 | 59.1 | 15.6 | 24.5 | 61.6 | 13.9 | 11.1 | 70.1 | 18.8 |
| Girls                  | 29.8 | 57.6 | 12.6 | 25.0 | 62.3 | 12.7 | 15.1 | 68.6 | 16.3 |
| Residency              | 8.0  | 67.3 | 24.7 ** |
| Urban                  | 16.0 | 60.4 | 23.6** | 17.0 | 63.3 | 19.7** | 10.1 | 63.7 | 26.2** |
| Rural                  | 31.9 | 57.6 | 10.5 | 27.9 | 61.4 | 10.7 | 14.0 | 71.6 | 14.4 |
| Education              | 9.4  | 71.2 | 19.4** |
| Primary school         | 30.8 | 57.5 | 11.7** | 25.8 | 62.0 | 12.2 | 12.9 | 71.3 | 15.8 |
| Middle school          | 26.4 | 58.3 | 15.3 | 25.0 | 59.7 | 15.3 | 11.1 | 70.2 | 18.7 |
| High school            | 15.4 | 67.7 | 16.9 | 15.9 | 65.1 | 19.0 | 13.5 | 75.7 | 10.8 |
| Provincio categories   | 9.2  | 63.7 | 24.3 |
| Municipality           | 10.7 | 63.2 | 26.1** |
| Northeast              | 27.8 | 56.1 | 16.1** | 23.0 | 59.2 | 17.8** | 13.7 | 60.6 | 25.7** |
| East coast             | 23.4 | 58.2 | 18.4 | 13.3 | 61.7 | 25.0 | 15.9 | 59.5 | 24.6 |
| Central                | 28.1 | 56.9 | 15.0 | 30.6 | 60.4 | 9.0  | 10.9 | 69.5 | 19.5 |
| South                  | 28.5 | 61.1 | 10.4 | 26.4 | 64.1 | 9.5  | 12.5 | 75.8 | 11.7 |
| Household income       | 8.1  | 76.3 | 15.6 |
| Low                    | 38.2 | 51.1 | 10.7** | 35.3 | 56.3 | 8.4** | 15.0 | 72.6 | 12.4** |
| Medium                 | 25.0 | 62.9 | 12.1 | 23.5 | 65.6 | 10.9 | 13.4 | 72.4 | 14.2 |
| High                   | 18.5 | 60.7 | 20.8 | 17.8 | 59.7 | 22.5 | 10.2 | 62.8 | 27.0 |
| Like fast food         | 9.4  | 60.3 | 30.3** |
| Yes                    | 11.8 | 59.8 | 28.4** | 14.9 | 66.5 | 18.6** | 6.8  | 73.6 | 19.6** |
| No                     | 31.7 | 57.9 | 10.4 | 33.7 | 57.7 | 8.6  | 19.2 | 66.9 | 13.9 |
| Like salty snack food  | 11.3 | 70.4 | 19.3 |
| Yes                    | 13.7 | 60.6 | 25.7** | 19.1 | 65.4 | 15.5** | 8.6  | 72.9 | 18.5** |
| No                     | 31.4 | 57.7 | 10.9 | 32.9 | 57.2 | 9.9  | 19.6 | 66.4 | 14.0 |
| Like vegetables        | 9.8  | 66.6 | 23.6 |
| Yes                    | 29.3 | 58.6 | 12.1 | 29.2 | 59.7 | 11.1** | 15.5 | 69.6 | 14.9* |
| No                     | 27.3 | 58.0 | 14.7 | 17.4 | 65.9 | 16.7 | 7.8  | 71.1 | 21.1 |
| Like fruit             | 9.8  | 63.6 | 26.6 |
| Yes                    | 26.9 | 59.0 | 14.1 | 26.2 | 61.3 | 12.5 | 12.8 | 70.4 | 16.8 |
| No                     | 29.4 | 57.4 | 13.2 | 24.3 | 61.4 | 14.3 | 16.7 | 67.8 | 15.5 |
| Physical exercise outside of school | 11.3 | 69.6 | 19.1 |
| Yes                    | 20.8 | 60.1 | 19.0** | 18.4 | 64.2 | 17.4** | 9.9  | 70.6 | 19.6 |
| No                     | 30.5 | 57.6 | 11.8 | 28.1 | 60.5 | 11.4 | 14.2 | 69.1 | 16.7 |
| Physical exercise in school | 7.9  | 69.9 | 22.2** |
| Yes                    | 24.3 | 60.8 | 14.9 | 23.3 | 63.9 | 12.8** | 12.0 | 70.2 | 17.8 |
| No                     | 48.3 | 41.4 | 10.3 | 33.5 | 57.9 | 8.6  | 18.0 | 60.9 | 21.1 |
| Sedentary activity     | 19.1 | 68.9 | 24.1 |
| low                    | 39.1 | 55.2 | 5.7** | 26.6 | 63.3 | 10.1** | 25.3 | 59.9 | 14.8** |
| Medium                 | 24.6 | 60.0 | 15.4 | 26.2 | 62.1 | 11.7 | 11.4 | 71.7 | 16.9 |
| High                   | 19.0 | 62.2 | 18.8 | 21.1 | 62.1 | 16.8 | 10.4 | 69.1 | 20.5 |
school students (19.4%) and middle school students (27.1%) (Mantel-Haenszel p < 0.01) in 2011. The children living in east coast provinces had a higher prevalence of SSB consumption than for other provinces in 2004, 2006, and 2011 (P < 0.01). As the household income increased so did the consumption of SSB in children: more children consumed SSBs in all survey years, especially in the highest consumption groups (>2 times a week). The children who enjoyed eating fast food and salty snacks tended to show higher SSB consumption (>2 times a week) compared with the children who did not enjoy eating fast food and salty snacks (28.4% vs. 10.4% and 25.7% vs. 10.9% in 2004, 18.6% vs. 8.6% and 15.5% vs. 9.9% in 2006, 19.6% vs. 13.9% and 18.5% vs. 14.0% in 2009, and 30.3% vs. 21.3% and 27.1% vs. 21.3% in 2011). Meanwhile, children who spent more time on sedentary activities consumed more SSBs, particularly in the group ‘>2 times a week’. For sedentary time increasing from low to high, SSB consumption increased from 5.7% to 18.8% in 2004, from 10.1% to 16.8% in 2006, and from 14.8% to 20.5% in 2009, (Mantel-Haenszel p < 0.01, for all three). Father and mother’s low education levels were associated with children’s higher SSB consumption (Mantel-Haenszel p < 0.01). Moreover, the children whose parents consumed SSBs were inclined to have higher SSB consumption, P < 0.01.

### The effects of multiple factors on sugar-sweetened beverage consumption in children

The result of the multilevel mixed-effects logistic regression (Table 3) shows SSB consumption in children increased significantly from 2004 to 2011. The AOR increased from 0.96 (95% CI: 0.60–1.52) in 2006 to 2.32 (95% CI: 1.22–4.41) in 2011 compared with 2004. The model also shows during the same period, AOR for girls’ SSB consumption compared with boys was 0.83 (95% CI: 0.58–1.18), and for the consumption in rural areas compared with in urban was 0.79 (95% CI: 0.53–1.17). The SSB consumption of high school students was more than that of...
The children in high- and medium-income households had higher AOR of SSB consumption (1.62, 95% CI: 1.08–2.44 and 2.15, 95% CI: 1.26–3.68) than low-income households. The children who enjoyed eating fast food and salty snacks held the AOR: 1.52 (95% CI: 0.96–2.40) and 1.49 (95% CI: 0.96–2.31). Children performing exercise out of school and in school consumed SSBs with AOR 1.22 (95% CI: 0.85–1.75) and 1.24 (95% CI: 0.67–2.27), respectively. Compared with low level of sedentarily activity, AORs for medium and high levels were 1.57 (95% CI: 0.99–2.49) and 1.89 (95% CI: 1.15–3.11). After adjusting for the factors involved in the logistic model, father and mother’s education and SSB consumption were significantly associated with SSB consumption.

Table 3. Multilevel mixed-effects logistic regression on SSB consumption and associated factors in children in China from 2004 to 2011.

|                          | OR    | 95% CI         | P      |
|--------------------------|-------|----------------|--------|
| Wave (ref. = 2004)       |       |                |        |
| 2006                     | 0.96  | (0.60–1.52)    | 0.8512 |
| 2009                     | 1.29  | (0.76–2.17)    | 0.3441 |
| 2011                     | 2.32  | (1.22–4.41)    | 0.0101 |
| Age (ref. = 6–11)        | 0.31  | (0.03–3.30)    | 0.3328 |
| Sex (ref. = boy)         | 0.83  | (0.58–1.18)    | 0.2967 |
| Residency (ref. = urban) | 0.79  | (0.53–1.17)    | 0.2346 |
| Education (ref. = primary school) |   |                |        |
| Middle school            | 1.16  | (0.81–1.65)    | 0.4262 |
| High school              | 2.13  | (1.06–4.28)    | 0.0345 |
| Provincial categories (ref. = central) |       |                |        |
| East coast               | 0.97  | (0.55–1.70)    | 0.9017 |
| Municipality             | 1.02  | (0.35–2.97)    | 0.9742 |
| Northeast                | 0.86  | (0.53–1.40)    | 0.5416 |
| South                    | 0.94  | (0.59–1.50)    | 0.7926 |
| Household income (ref. = low) |       |                |        |
| Medium                   | 1.62  | (1.08–2.44)    | 0.0198 |
| High                     | 2.15  | (1.26–3.68)    | 0.0053 |
| Like fast food (ref. = no) | 1.52  | (0.96–2.40)    | 0.0758 |
| Like salty snack food (ref. = no) | 1.49  | (0.96–2.31)    | 0.0728 |
| Like Vegetable (ref. = no) | 0.68  | (0.44–1.04)    | 0.0754 |
| Like Fruit (ref. = no)   | 1.19  | (0.76–1.88)    | 0.4490 |
| Physical exercise off school (ref. = no) | 1.22  | (0.85–1.75)    | 0.2848 |
| Physical exercise in school (ref. = no) | 1.24  | (0.67–2.27)    | 0.4944 |
| Sedentary activity (ref. = low) |       |                |        |
| Medium                   | 1.57  | (0.99–2.49)    | 0.0560 |
| High                     | 1.89  | (1.15–3.11)    | 0.0119 |
| Father’s education (ref. = primary and below) |       |                |        |
| Middle school            | 0.90  | (0.59–1.39)    | 0.6400 |
| University and higher    | 0.60  | (0.24–1.49)    | 0.2704 |
| Father’s SSB consumption (ref. = no) | 3.83  | (1.98–7.39)    | <0.0001 |
| Mother’s education (ref. = primary and below) |       |                |        |
| Middle school            | 1.06  | (0.72–1.54)    | 0.7827 |
| University and higher    | 0.89  | (0.32–2.46)    | 0.8136 |
| Mother’s SSB consumption (ref. = no) | 5.54  | (3.17–9.67)    | <0.0001 |

Ref, reference category. AIC, 1141.91.

https://doi.org/10.1371/journal.pone.0261199.t003

primary school students, AOR 2.13 (95% CI: 1.06–4.28). The children in high- and medium-income households had higher AOR of SSB consumption (1.62, 95% CI: 1.08–2.44 and 2.15, 95% CI: 1.26–3.68) than low-income households. The children who enjoyed eating fast food and salty snacks held the AOR: 1.52 (95% CI: 0.96–2.40) and 1.49 (95% CI: 0.96–2.31). Children performing exercise out of school and in school consumed SSBs with AOR 1.22 (95% CI: 0.85–1.75) and 1.24 (95% CI: 0.67–2.27), respectively. Compared with low level of sedentarily activity, AORs for medium and high levels were 1.57 (95% CI: 0.99–2.49) and 1.89 (95% CI: 1.15–3.11). After adjusting for the factors involved in the logistic model, father and mother’s education and SSB consumption were significantly associated with SSB consumption.
highest education levels were not statistically relevant to SSB consumption by their children, but parents’ SSB consumption was significantly linked to increased children’s consumption, AOR 3.83 (95% CI: 1.98–7.39) for father and AOR 5.54 (95% CI: 3.17–9.67) for mother.

Discussion

Main findings

We found more than 80% of children in China reported consuming SSBs and the prevalence increased significantly from 2004 to 2011. The boys and the children who resided in urban areas, studied in high school, and lived in higher-income families tended to consume more SSBs than their respective counterparts. Children who enjoyed eating unhealthy food consumed more SSBs. Furthermore, physical activity and increased sedentary time, and parental SSB consumption were associated with raised prevalence of SSB consumption among children.

We found a high percentage of children in China reported SSB consumption, but the consumption frequency in this population was not high: approximately 83.2% of children consumed SSBs less than two times every week between 2004 and 2011. This finding was in accordance with previous research [23]. Compared with other countries, Chinese residents consumed a relatively low level of SSBs, but the increasing trend, particularly in children, was dramatic [30, 31]. This change mirrored the SSB sales in China issued by Euromonitor Passport International [14].

Multi-domain of factors related to the upward trend of SSB consumption

We hypothesized that a multi-domain of factors related to the upward trend of SSB consumption in children in China. We found that girls consumed less SSBs than boys in the bivariate analysis. This difference can be attributed to the possibility that girls may care more about their body shape and were willing to keep fit by avoiding high energy-dense food and beverages [23, 32].

With the economy continuing to expand, China saw a significant lifestyle change among its residents. More and more people accepted highly processed food and beverages. Our research showed children who lived in urban areas consumed more SSBs in the bivariate analysis. One reason was that these areas had increasing emerging retailers, which boosted the dissemination of beverages to customers [33]. People with high accessibility to beverages would consume more than their counterparts [34, 35]. The other reason may be that these areas were socially and economically more developed than rural areas. The residents of these areas had high purchasing capability, and the beverage companies targeted their products to these people to earn more profit [36]. Furthermore, the beverage companies and retailers placed more importance on the high-income families, who had higher purchasing capability to consume SSBs [18, 37, 38].

Our research also showed children who preferred eating unhealthy food had a higher prevalence of SSB consumption. One of the reasons was those ultra-processed food providers expanded in the Chinese market, because of high profits attained from food industries. Those unhealthy foods also were targeted at the population with similar social economic background as SSBs. The food and beverage combination consumed by children led to increased health risks more than any one type of unhealthy food intake [26]. Research found that beverages were less likely than solid food to satisfy people’s appetite, even though these people had already consumed significant calories from SSBs [39, 40]. As a result, SSBs were less likely to reduce solid food consumption to maintain energy balance. People still can consume much
processed food, such as fast food or salty food, after consuming a lot of SSBs. This increased the risk of obesity and related non-communicable diseases [30, 41].

Schools are the main living places where children’s health behavior and dietary pattern are cultivated. High school students usually had higher weekly allowances than middle and primary school students, and a major proportion of allowances were used to purchase beverages, so more high school students consumed SSBs [15, 42]. We also found that higher percentage of student consumed SSBs after physical activity both in school and out of school. Active children were inclined to consume beverages more frequently [19]. Also, peers influenced children’s dietary behaviors. The children who participate in physical activity together tended to share SSBs during exercise sessions [43, 44]. The availability of SSBs in corner stores or vending machines in schools and nearby neighborhoods increased SSB consumption [34].

In our research, sedentary activities were classified by time spent on homework plus screen activities. The children who spent more time performing sedentary activities consumed more SSBs. In China, approximately 80% of advertising on TV was for food and beverages [38], and so children with access to TV were exposed to these advertisements tempting them to purchase and consume more SSBs [16]. In addition, children were likely to consume SSBs when they were watching TV, as a way of lifting spirits, or a reward after completing their homework. Our research supported previous research that showed a positive association between sedentary activities and SSB consumption [28], although several other studies failed to find a significant relationship [38]. Our research demonstrated that parents had strong influence on SSB consumption by children. We found that children whose parents consumed SSBs had a higher incidence of consuming SSBs [45], and mothers showed the strongest impact (AOR 5.54) in this research [15, 44]. Besides parental dietary behavior, parental education levels were examined by previous researchers with regard to their impact on SSB consumption by children, but the results were conflicted. Some research conducted in western countries showed that lower parental education levels were related to increased SSB consumption by children, and higher parental education levels contributed to a reduction. One reason was that parents with higher education levels controlled their children’s access to beverages and limited the intake [33, 46]. Nevertheless, the percentages of reported SSB consumption in our research showed the inverse association that the parents with high education level may increase their children’s exposure to SSBs. These results were also agreed to by several other research studies [15, 29, 47]. The conflicted conclusion should be attributed to the different social environment. In western and high-income countries, SSBs were usually more affordable than in low- and middle-income countries [48], and parents with low education level tended to choose lower-priced SSBs to feed their children [17, 49–51]. While in China, SSBs actually are more expensive than bottled water. Parents with higher education status usually had good economic status [24] and were capable of buying SSBs for their children.

**Implications for decision making and practice**

Implicated in our research, raising beverage prices may not be a sensitive and efficient measure to curb the increase of SSB consumption by children in China, because the majority of consumers actually had a high socio-economic background. This situation differs from that in western countries. Instead, prohibiting social marketing in urban and advanced areas, and communicating the associated health risks of SSBs to high income families, may potentially bring about improved health behavior and outcomes.

We used the data extracted from the CHNS, a national cohort study on nutrition and social economic development. The sample population was selected from the main Chinese territories where the majority of Chinese live. So, our research provided an overview of SSB consumption...
Prevalence of and associated factors with sugar-sweetened beverage consumption in children in China

by children in China, which can inform health decision making. Our research comprehensively examined the trend of SSB consumption among children in China for eight years, when China experienced a swift change of lifestyle and dietary patterns, which boosted the knowledge body of this health issue. We also comprehensively explored several domains of factors linked to SSB consumption in children, including children’s demographics, economic background, residency, food preferences, physical activities, and parental influences. Resulting from more factors in the multilevel mixed-effects logistic regression, we accurately identified the odds ratio of these factors for the SSB consumption by children in China. Because larger AORs demonstrate a stronger relationship between SSB consumption and factors, we can prioritize factors that may strongly influence SSB consumption and target them when making health strategies.

Limitations

This research used the data from self-reported food frequency questionnaires. The amounts of SSB consumption by children cannot be accurately measured and, as a result, we did not examine the dose-response effects between SSB consumption and those factors. Furthermore, as a descriptive quantitative research, our research was limited to deeply narrate the mechanism and pathway of the factors affecting SSB consumption in children.

Further studies are needed to employ precise measures on the amount of SSB consumption and the factors among children. In addition, mixed methodology combining quantitative survey and qualitative investigation may enhance the validity of this health research. Moreover, by conducting qualitative research, in-depth insights into occurrence, development, and consequence of SSB consumption by children can be gained.

Conclusions

In conclusion, our research illustrates that SSB consumption in children in China increased significantly from 2004 to 2011. Promising measures to reduce SSB consumption are urgently needed. By combining the efforts from parents, neighborhoods, and the community, a planned reduction of SSB consumption aimed at the children with high economic background, increased sedentary time, and high parental SSB consumption will help to curb the increase of obesity and NCDs among children in China.

Acknowledgments

We thank staff associated with the CHNS who allowed us to openly access their data.

Author Contributions

Conceptualization: Haijun Guo, Cordia Chu.
Formal analysis: Haijun Guo.
Methodology: Haijun Guo, Dung Phung, Cordia Chu.
Supervision: Dung Phung, Cordia Chu.
Validation: Dung Phung, Cordia Chu.
Writing – original draft: Haijun Guo.
Writing – review & editing: Dung Phung, Cordia Chu.
References

1. Popkin BM. Will China’s nutrition transition overwhelm its health care system and slow economic growth? Health affairs (Project Hope). 2008; 27(4):1064–76. Epub 2008/07/09. https://doi.org/10.1377/hlthaff.27.4.1064 PMID: 18607042.

2. Pan X-B, Wang H-J, Zhang B, Liu Y-L, Qi S-F, Tian Q-B. Plain water intake and association with the risk of overweight in the Chinese adult population: China Health and Nutrition Survey 2006–2011. Journal of Epidemiology. 2019; 30(3):128–35. https://doi.org/10.2188/jea.JE20180223 PMID: 30880306.

3. Yu P, Chen Y, Zhao A, Bai Y, Zheng Y, Zhao W, et al. Consumption of sugar-sweetened beverages and its association with overweight among young children from China. Public health nutrition. 2016; 19(13):2336–46. Epub 2016/06/07. https://doi.org/10.1017/S1368946516001373 PMID: 27265445.

4. Popkin BM, Adair LS, Ng SW. Global nutrition transition and the pandemic of obesity in developing countries. Nutrition reviews. 2012; 70(1):3–21. Epub 2012/01/10. https://doi.org/10.1111/j.1753-4887.2011.00456.x PMID: 22221213.

5. Yu Z, Han S, Chu J, Xu Z, Zhu C, Guo X. Trends in overweight and obesity among children and adolescents in China from 1981 to 2010: a meta-analysis. PLoS One. 2012; 7(12):e51949. https://doi.org/10.1371/journal.pone.0051949 PMID: 23284829.

6. Chen Y, Yang Y, Jiang H, Liang X, Lu W. Associations of BMI and waist circumference with all-cause mortality: a 22-year cohort study. Obesity. 2019; 27:662–9. https://doi.org/10.1002/oby.22423 PMID: 30861324.

7. Abdel Rahman A, Jomaa L, Kahale LA, Adair P, Pine C. Effectiveness of behavioral interventions to reduce the intake of sugar-sweetened beverages in children and adolescents: a systematic review and meta-analysis. Nutrition reviews. 2018; 76(2):88–107. Epub 2017/12/28. https://doi.org/10.1093/nutrit/nux061 PMID: 29281069.

8. Guo Q, Song P, Guo Y, Luo Q, Que C, Zhao R. Logistic regression of factors associated with caries among children aged 2–6. China Medical Herald. 2013;22:128–30.

9. Chen F, Wang Y, Shan X, Cheng H, Hou D, Zhao X, et al. Association between childhood obesity and metabolic syndrome: evidence from a large sample of Chinese children and adolescents. PLoS One. 2012; 7(10):e47380. Epub 2012/10/20. https://doi.org/10.1371/journal.pone.0047380 PMID: 23082159.

10. Attard SM, Herring AH, Zhang B, Du S, Popkin BM, Gordon-Larsen P. Associations between age, cohort, and urbanization with SBP and DBP in China: a population-based study across 18 years. Journal of hypertension. 2015; 33(5):948–56. Epub 2015/02/11. https://doi.org/10.1097/HTJ.0000000000000522 PMID: 25668349.

11. Hafekost K, Mitrou F, Lawrence D, Zubrick SR. Sugar sweetened beverage consumption by Australian children: implications for public health strategy. BMC public health. 2011; 11:950. https://doi.org/10.1186/1471-2458-11-950 PMID: 22192774.

12. Sanchez-Pimienta TG, Batis C, Lutter CK, Rivera JA. Sugar-sweetened beverages are the main sources of added sugar intake in the Mexican population. The Journal of nutrition. 2016; 146(9):1888s–96s. Epub 2016/08/12. https://doi.org/10.3945/jn.115.220301 PMID: 27511931.

13. Mendez Lopez A, Loopstra R, McKee M, Stuckler D. Is trade liberalisation a vector for the spread of sugar-sweetened beverages? A cross-national longitudinal analysis of 44 low- and middle-income countries. Social science & medicine (1982). 2017; 172:21–7. Epub 2016/11/22. https://doi.org/10.1016/j.socscimed.2016.11.001 PMID: 27871042.

14. Popkin BM, Hawkes C. Sweetening of the global diet, particularly beverages: patterns, trends, and policy responses. The lancet Diabetes & endocrinology. 2016; 4(2):174–86. Epub 2015/12/15. https://doi.org/10.1016/s2213-8587(15)00419-2 PMID: 26654575.

15. Sim E, Sohn W, Choi ES, Noh H. Sugar-sweetened beverage consumption frequency in Korean adolescents: based on the 2015 Youth Risk Behavior Web-Based Survey. International dental journal. 2019. Epub 2019/05/12. https://doi.org/10.1111/idj.12485 PMID: 31077367.

16. Kelly B, J C.G, Boyland EJ, Chapman K, Bautista-Castañol Immaculada, Berg C, et al. Television food advertising to children: a global perspective. Research and Practice. 2010; 100(9):1730–6. https://doi.org/10.2105/AJPH.2009.179267 PMID: 20634464.

17. Totland TH, Lien N, Bergh IH, Bjelland M, Gebremariam MK, Klepp KI, et al. The relationship between parental education and adolescents’ soft drink intake from the age of 11–13 years, and possible mediating effects of availability and accessibility. The British journal of nutrition. 2013; 110(5):926–33. Epub 2013/02/05. https://doi.org/10.1017/S0007114512005946 PMID: 23375110.

18. Zhou Y, Du S, Su C, Zhang B, Wang H, Popkin BM. The food retail revolution in China and its association with diet and health. Food policy. 2015; 55:92–100. Epub 2015/07/29. https://doi.org/10.1016/j.foodpol.2015.07.001 PMID: 26217068.
19. Bibiloni Mdel M, Ozen AE, Pons A, Gonzalez-Gross M, Tur JA. Physical activity and beverage consumption among adolescents. Nutrients. 2016; 8(7). Epub 2016/06/28. https://doi.org/10.3390/nu8070389 PMID: 27347993.

20. Yang L, Bovet P, Liu Y, Zhao M, Ma C, Liang Y, et al. Consumption of Carbonated Soft Drinks Among Young Adolescents Aged 12 to 15 Years in 53 Low- and Middle-Income Countries. American journal of public health. 2017; 107(7):1095–100. https://doi.org/10.2105/AJPH.2017.303762 PMID: 28520485.

21. Popkin BM, Du S, Zhao BM, Zhang B. Cohort profile: the China Health and Nutrition Survey—monitoring and understanding socio-economic and health change in China, 1989–2011. Int J Epidemiol. 2010; 39 (6):1435–40. Epub 2009/11/06. https://doi.org/10.1093/ije/dyp322 PMID: 19887509.

22. The University of North Carolina at Chapel Hill. China Health and Nutrition Survey. 123 West Franklin Street, Chapel Hill, NC 27516, USA: The University of North Carolina at Chapel Hill; 2020.

23. Gui ZH, Zhu YN, Cai L, Sun FH, Ma YH, Jing J, et al. Sugar-sweetened beverage consumption and risks of obesity and hypertension in Chinese children and adolescents: a national cross-sectional analysis. Nutrients. 2017; 9(12). Epub 2017/12/01. https://doi.org/10.3390/nu9121302 PMID: 29189729.

24. Irwin BR, Speelney MR, Gilliland JA. Assessing the relationship between water and nutrition knowledge and beverage consumption habits in children. Public health nutrition. 2019; 22(16):3035–48. Epub 2019/05/16. https://doi.org/10.1017/S1368980019000715 PMID: 31084651.

25. Tasevska N, DeLia D, Lorts C, Yedidia M, Ohri-Vachaspati P. Determinants of sugar-sweetened beverage consumption among low-income children: are there differences by race/ethnicity, age, and sex? Journal of the Academy of Nutrition and Dietetics. 2017; 117(12):1900–20. Epub 2017/05/13. https://doi.org/10.1016/j.jand.2017.03.013 PMID: 28495478.

26. Grimes CA, Riddell LJ, Campbell KJ, Nowson CA. Dietary salt intake, sugar-sweetened beverage consumption, and obesity risk. Pediatrics. 2013; 131(1):14–21. Epub 2012/12/12. https://doi.org/10.1542/peds.2012-1628 PMID: 23230077.

27. Frank SM, Webster J, McKenzie B, Geldsetzer P, Manne-Goehler J, Andall-Brereton G, et al. Consumption of fruits and vegetables among individuals 15 years and older in 28 low and middle-income countries. Journal of Nutrition. 2019; 149:1252–9. https://doi.org/10.1093/jn/nxz040 PMID: 31152660.

28. Ashdown-Franks G, Vancampfort D, Firth J, Smith L, Stubbs B, et al. Association of leisure-time sedentary behavior with fast food and carbonated soft drink consumption among 133,555 adolescents aged 12–15 years in 44 low- and middle-income countries. The international journal of behavioral nutrition and physical activity. 2019; 16(1):35. Epub 2019/04/25. https://doi.org/10.1186/s12966-019-0796-3 PMID: 31043859.

29. Zahid A, Davey C, Reicks M. Beverage intake among children: associations with parent and home-related factors. International journal of environmental research and public health. 2017; 14(8). Epub 2017/08/19. https://doi.org/10.3390/ijerph14080929 PMID: 28920455.

30. Singh GM, Micha R, Khatibzadeh S, Shi P, Lim S, Andrews KG, et al. Global, regional, and national consumption of sugar-sweetened beverages, fruit juices, and milk: a systematic assessment of beverage intake in 187 countries. PLoS One. 2015; 10(8):e0124845. https://doi.org/10.1371/journal.pone.0124845 PMID: 26244332.

31. Brand-Miller JC, Barclay AW. Declining consumption of added sugars and sugar-sweetened beverages in Australia: a challenge for obesity prevention. Am J Clin Nutr. 2017; 105(4):854–63. Epub 2017/03/10. https://doi.org/10.3945/ajcn.116.145318 PMID: 28275129.

32. Feng Y, Ding L, Tang X, Wang Y, Zhou C. Association between maternal education and school-age children weight status: a study from the China Health Nutrition Survey, 2011. International journal of environmental research and public health. 2019; 16:2543. https://doi.org/10.3390/ijerph16122543 PMID: 31315303

33. Mazarello Paes V, Hesketh K, O’Malley C, Moore H, Summerbell C, Griffin S, et al. Determinants of sugar-sweetened beverage consumption in young children: a systematic review. Obesity reviews: an official journal of the International Association for the Study of Obesity. 2015; 16(11):903–13. Epub 2015/08/08. https://doi.org/10.1111/obr.12310 PMID: 26252417.

34. Godin KM, Chaurasia A, Hammond D, Leatherdale ST. Examining associations between school food environment characteristics and sugar-sweetened beverage consumption among Canadian secondary-school students in the COMPASS study. Public health nutrition. 2018;1–13. Epub 2018/05/22. https://doi.org/10.1017/S1368980018001246 PMID: 29779507.

35. Bere E, Giommes ES, te Velde SJ, Klepp KI. Determinants of adolescents’ soft drink consumption. Public health nutrition. 2008; 11(1):49–56. Epub 2007/06/22. https://doi.org/10.1017/S1368980007000122 PMID: 17582242.

36. Watts AW, Lovato CY, Barr SI, Hanning RM, Masse LC. A qualitative study exploring how school and community environments shape the food choices of adolescents with overweight/obesity. Appetite. 2015; 95:360–7. Epub 2015/07/28. https://doi.org/10.1016/j.appet.2015.07.022 PMID: 26212268.
37. Lee YH, Wang Z, Chiang TC, Liu CT. Beverage intake, smoking behavior, and alcohol consumption in contemporary China—a cross-sectional analysis from the 2011 China Health and Nutrition Survey. International journal of environmental research and public health. 2017; 14(5). Epub 2017/05/10. https://doi.org/10.3390/ijerph14050493 PMID: 28481283.

38. Parvanta SA, Brown JD, Du S, Zimmer CR, Zhao X, Zhai F. Television use and snacking behaviors among children and adolescents in China. The Journal of adolescent health: official publication of the Society for Adolescent Medicine. 2010; 46(4):339–45. Epub 2010/03/24. https://doi.org/10.1016/j.jadohealth.2009.08.002 PMID: 20307822.

39. Luke A, Cooper RS. Physical activity does not influence obesity risk: time to clarify the public health message. Int J Epidemiol. 2013; 42(6):1831–6. https://doi.org/10.1093/ije/dyt159 PMID: 24415616.

40. Rippe JM, Saltzman E. Sweetened beverages and health: current state of scientific understandings. Advances in nutrition. 2013; 4(5):527–9. Epub 2013/09/17. https://doi.org/10.3945/ajn.113.004143 PMID: 24038246.

41. Wolf A, Bray GA, Popkin BM. A short history of beverages and how our body treats them. Obesity reviews: an official journal of the International Association for the Study of Obesity. 2008; 9(2):151–64. Epub 2008/02/09. https://doi.org/10.1111/j.1467-789x.2007.00389.x PMID: 18257753.

42. McNeal JU, Yeh C-H. Development of consumer behavior patterns among Chinese children. JOURNAL OF CONSUMER MARKETING. 1997; 14(1):45–59.

43. Chung SJ, Ersig AL, McCarthy AM. The Influence of Peers on Diet and Exercise Among Adolescents: A Systematic Review. Journal of pediatric nursing. 2017; 36:44–56. Epub 2017/09/11. https://doi.org/10.1016/j.pedn.2017.04.010 PMID: 2888511.

44. Watts AW, Miller J, Larson NI, Eisenberg ME, Story MT, Neumark-Sztainer D. Multicontextual correlates of adolescent sugar-sweetened beverage intake. Eating behaviors. 2018; 30:42–8. Epub 2018/05/20. https://doi.org/10.1016/j.eatbeh.2018.04.003 PMID: 29777969.

45. Lundeen EA, Park S, OnufraK S, Cunninghan S, Blanck HM. Adolescent sugar-sweetened beverage intake is associated with parent intake, not knowledge of health risks. American journal of health promotion: AJHP. 2018; 32(8):1661–70. Epub 2018/04/06. https://doi.org/10.1177/0890171718763008 PMID: 29618222.

46. Cockburn N, Laloo R, Schubert L, Ford PJ. Beverage consumption in Australian children. European journal of clinical nutrition. 2018; 72(3):401–9. Epub 2017/12/01. https://doi.org/10.1038/s41430-017-0021-x PMID: 29187750.

47. Inhulsen MM, Merelle SY, Renders CM. Parental feeding styles, young children’s fruit, vegetable, water and sugar-sweetened beverage consumption, and the moderating role of maternal education and ethnic background. Public health nutrition. 2017; 20(12):2124–33. Epub 2017/07/18. https://doi.org/10.1017/S1368980017001409 PMID: 28712381.

48. Blecher E, Liber AC, Drope JM, Nguyen B, Stoklosa M. Global Trends in the Affordability of Sugar-Sweetened Beverages, 1990–2016. Prev Chronic Dis. 2017; 14:E37. Epub 2017/05/05. https://doi.org/10.5888/pcd14.160406 PMID: 28472607.

49. van Ansem WJ, van Lenthe FJ, Schrijvers CT, Rodenburg G, van de Mheen D. Socio-economic inequalities in children’s snack consumption and sugar-sweetened beverage consumption: the contribution of home environmental factors. The British journal of nutrition. 2014; 112(3):467–75. Epub 2014/05/17. https://doi.org/10.1017/S0007114514001007 PMID: 24833428.

50. Saldiva SRDM, Venancio SI, Santana ACd, Castro AldS, Escudé MML, Giugliani EJU. The consumption of unhealthy foods by Brazilian children is influenced by their mother’s educational level. Nutrition journal. 2014; 13(33):1–8. https://doi.org/10.1186/1475-2891-13-33 PMID: 24708610.

51. Gebremariam MK, Chinapaw MJ, Brinolf-Iser B, Bere E, Kovacs E, Verloigne M, et al. Screen-based sedentary time: Association with soft drink consumption and the moderating effect of parental education in European children: The ENERGY study. PLoS One. 2017; 12(2):e0171537. Epub 2017/02/10. https://doi.org/10.1371/journal.pone.0171537 PMID: 28182671.