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# Consumption of Added Sugar among Chinese Toddlers and Its Association with Picky Eating and Daily Screen Time

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**Abstract:** Objectives: This study aimed to examine the relationship between daily screen time, picky eating, and consumption frequency of sugared foods and sugar-sweetened beverages (SSBs). Methods: The research data came from the Young Investigation (YI) study conducted in 10 cities in China. This study used sociodemographic information, feeding behavior, picky eating reported by parents, and the consumption frequency of sugared foods and SSBs of 879 toddlers aged 1–3 years. The relationship between daily screen time and picky eating behavior was assessed using logistic regression. The zero-inflated negative binomial (ZINB) model was used to fit the consumption frequencies of sugared foods and SSBs. Results: In all, 13.1% ($n = 115$) of toddlers did not have sugared foods 1 month before the survey, while 73.3% ($n = 644$) of toddlers did not have SSBs 1 month before the survey. The consumption rate of sugared foods was relatively higher than SSBs ($\chi^2 = 661.25$, $p < 0.001$). After adjusting for social demographic information, no relationship was found between daily screen time and picky eating (OR = 1.437; 95% CI: 0.990,2.092). The ZINB model showed that, among children who ate sugared foods, children who were picky eaters ate them more often (IRR = 1.133; 95% CI: 1.095,1.172), but no association was found between picky eating and the chance of avoiding sugared foods (OR = 0.949; 95% CI: 0.613,1.471). Children who were picky eaters were less likely not to drink SSBs (OR = 0.664; 95% CI: 0.478,0.921). However, among children who consumed SSBs, picky eaters drank them less frequently (IRR = 0.599; 95% CI: 0.552,0.650). Children with a screen time of no less than 1 h/d ate sugared foods more frequently (IRR = 1.383; 95% CI: 1.164,1.644), and they were less likely to avoid sugared foods (OR = 0.223; 95% CI: 0.085,0.587). The longer the screen time per day was, the less likely children did not have SSBs (<1 h/d: OR = 0.272; 95% CI: 0.130, 0.569; ≥1 h/d: OR = 0.136; 95% CI: 0.057, 0.328). Conclusions: The consumption rate of sugared foods was higher than that of SSBs. Picky eating and daily screen time were related to the consumption frequency of added sugar among Chinese toddlers aged 1–3 years. Picky eaters consumed sugared foods more frequently and were more likely to drink SSBs. Children whose daily screen time reached 1 h/d were more likely to eat sugared foods and drink SSBs.

**Keywords:** key toddlers; added sugar; picky eating; screen time; zero-inflated negative binomial model

## 1. Introduction

The triple burden of malnutrition (undernutrition, hidden hunger, and overweight) threatens the growth and development of children. The phenomenon of the undernutrition

of infants has decreased significantly, and the incidence of overweight and obesity has increased rapidly [1], indicating that malnutrition has become the main nutritional problem of children all over the world. Toddlerhood is a key period for the establishment of eating behaviors and food preferences [2]. The nutritional status of infants and toddlers may have a long-term impact on health [3]. A healthy diet can effectively reduce the risk of malnutrition [4].

Studies on the psychological and physical traits of children have confirmed their preference for sweetness [5]. The early introduction of sweetened foods has been observed in various populations. Observational studies have also demonstrated that there is a high proportion of infants eating unhealthy foods and drinks, such as candy and juice [6]. A multicenter study conducted in Europe found that more than 95% of infants began to eat sweets by the age of 9 months [7]. The National Health and Nutrition Examination (NHANES) data from 2009–2012 showed that the energy percent contributed by added sugar was about 14.3% for children aged 2–8 years, exceeding the 10% guideline [8]. The intake of sugar-sweetened beverages (SSBs) has a strong correlation between 2 and 5 years of age [9]. Therefore, intervention measures to reduce the amount of added sugar should be started as soon as possible.

Sugared foods and SSBs are the main sources of added sugar [8,9]. The intake of sugared foods is one of the major reasons of developing overweight and obesity [10,11]. Chinese studies further identified that SSBs are independently associated with a high risk of abdominal obesity [12].

The quality of the diet of children is related to a variety of factors, such as sex, region, education levels of parents, socioeconomic status (SES), physical activity, and sleep duration [13,14]. What is more, children's screen time has increased significantly during the COVID-19 pandemic [15]. Screen time was found to be associated with increased intake frequencies of unhealthy foods [16–18]. In addition to the effects of increasing screen time, picky eating is also one reason for the poor dietary quality of toddlers [19,20]. Picky eating is an umbrella term describing the rejection of one or more food items, which might be accompanied by strong food preferences [21,22]. Previous studies have found that children with high picky eating levels have insufficient intakes of vitamins, minerals, and dietary fiber [23] but a higher intake of trans fatty acids [24]. In addition, it has been reported that children who use a screen for longer times were more likely to be picky about food [25], so there might be an interaction between picky eating, daily screen time, and diet quality.

Previous studies have mostly explored the impact of screen time and picky eating on diets separately, but few studies have examined the relationship between screen time, picky eating, and a sugary diet. This study aimed to explore the associations among screen time, picky eating, and intake of foods and drinks with added sugar in 10 cities in China.

## 2. Materials and Methods

### 2.1. Subjects

This study was based on the Young Investigation (YI) study, which was a cross-sectional survey focused on the nutrition and health of pregnant women, mother–infant pairs, and toddlers (aged 1–3 years). The YI study was conducted in 10 cities in China from 2019 to 2020. The 10 cities surveyed included two first-tier cities (Beijing and Guangzhou); three new first-tier cities (Suzhou, Chengdu, and Shenyang); three second-tier cities (Ningbo, Nanchang, and Lanzhou); one third-tier city (Hohhot); and one fourth-tier city (Xuchang). A general hospital or maternal and child health hospital was selected in each city to recruit the respondents. The inclusion criteria of toddlers included the following: (1) singleton, (2) term birth (gestational age $\geq$ 37 weeks), and (3) 12–35.9 months old. The exclusion criteria were as follows: (1) physical disabilities; (2) recently experienced infectious, metabolic, mental, and other major diseases; or (3) the guardian could not answer the questions. Finally, at least 90 children were selected in each city for the investigation. The original investigation included 924 individuals. After excluding those missing important information (sociodemographic information, outdoor activities, sleep duration, picky

eating behavior, daily screen time, and consumption frequency of sugared foods and SSBs), the data of 879 toddlers were finally used.

## 2.2. Data Collection

With a face-to-face survey, the uniformly trained investigators asked the main caregivers to convey the sociodemographic information (age, sex, delivery mode, parity, family income, mother's education level, mother's working state, place of residence, etc.); exact daily time of outdoor activities and sleep duration (daytime and nighttime); picky eating behavior; and daily screen time of their toddlers based on a self-developed questionnaire. For the evaluation of the children's daily screen time, the investigator asked the main caregivers of the toddler in detail about the specific time using the screen every day. The daily screen time was the sum of the time children spend watching TV or using computers, tablets, mobile phones, and other electronic products a day. Picky eating behavior was self-reported by the main feeders of the toddlers, which was mainly manifested in their rejection of eating one or more kinds of food, including milk, beans, cereals, vegetables, fruits, meat, etc. The intake frequency of sugared foods and SSBs over the past month were assessed using a food frequency questionnaire (FFQ). The foods with added sugar included cake, candy, chocolate, etc. SSBs included water with added sugar, flavored milk drinks, carbonated drinks, etc. Food and beverages that contained different kinds of sweeteners (besides sugar) were not included. Freshly squeezed fruit and vegetable juices were not counted as SSBs in this study.

## 2.3. Statistical Analysis

All of the statistical analyses were performed using R software (version 4.1.1). Descriptive statistics were presented as numbers (percentages). Children's screen time was converted to categorical variables (0 h/d; <1 h/d; ≥1 h/d). In the univariate analysis, the monthly consumption frequency of sugared foods and SSBs was divided into three levels, and the chi-square test was used to analyze the differences in the lifestyle and sociodemographic characteristics between different groups. Taking those children whose screen time was 0 h/d as the reference group, the associations between different screen times and picky eating groups were analyzed by multivariate logistic regression after adjusting for the age, sex, family income, mother's educational level, place of residence, outdoor activity time, and daytime and nighttime durations of the toddlers (the independent variable was daily screen time, and the dependent variable was picky eating behavior).

The distribution of the consumption frequency of foods and drinks with added sugar was non-normal count data, and the variance was greater than the mean presented. In the meantime, there were excess zero counts in the data (13.3% and 73.3% in the consumption frequency of sugared foods and SSBs, respectively), so we considered the consumption frequency as an over-dispersed and zero-inflated count variable. Therefore, taking picky eating and daily screen time as independent variables and the sugar-containing food and SSB consumption frequency as dependent variables, the zero-inflated negative binomial (ZINB) model was adopted to assess the associations among picky eating behavior, daily screen time, and the consumption frequency of sugared foods and SSBs, including intake frequency and the chance of not having any sugared food/drinks in the past month, such as a "sugar-free diet".

As described by Cheung [26], the ZINB model satisfies the over-discretization of the dependent variable data structure. Its application assumes that the data variance is greater than the mean, which is in line with the characteristics of the data structure in this paper. In addition, the ZINB model is more suitable to solve the problem of too many zero counts in the data. ZINB modeling generated two separate models: a logit model for the "sugar-free diet" samples predicting the chance of being in the "sugar-free" group and a negative binomial model analyzing the intake frequency for those children who had sugared foods/drinks. The model was sequentially adjusted for the demographic

features (age, sex, family income, mother's education level, and place of residence), then additionally for lifestyle behaviors (outdoor time, daytime sleep, and nighttime sleep).

To confirm the results of the ZINB model, the standard negative binomial (NB) regression model was also used with the same adjustment of variables. The ZINB and NB models were conducted using the "pscl" and "MASS" packages, respectively. The significance level for all the statistical tests was set at 0.05.

## 3. Results

### 3.1. Factors Associated with Consumption Frequency of Added Sugar

The consumption rate of sugared foods was 86.9%, which was higher than the consumption rate of SSBs ($\chi2$ = 661.25, *p* < 0.001). The sociodemographic characteristics, feeding-related characteristics, and daily screen times of children with different levels of monthly consumption frequencies of added sugar are summarized in Table 1. The frequency of consumption of sugared foods and beverages in children over 2 years old was higher. Additionally, a lower maternal educational level and picky eating were associated with a higher consumption frequency of drinks with added sugar. Children with longer daily screen times also consumed both drinks and foods with added sugar more often. However, the differences in sex, delivery mode, parity, mother's working state, family income, and the primary caregivers between the groups were not significant.

### 3.2. Association between Picky Eating and Daily Screen Time

The association between self-reported picky eating behavior from parents and screen time is shown in Table 2. Although, in the crude model without any adjustment (model 1) and the model only adjusting for age and sex (model 2), children who used a screen had a higher incidence of picky eating, an association between daily screen time and picky eating behaviors of children was not found after adjusting for the sociodemographic information (model 3) and lifestyle factors (model 4).

### 3.3. Association between Picky Eating and Consumption Frequency of Added Sugar

The results of the ZINB model are shown in Table 3, including the relationship between picky eating and the consumption frequency of added sugar, as well as the possibility of not eating a sugary diet, respectively. Among children who had a sugary diet in the negative binomial model part, we found that children who were picky eaters had a higher consumption frequency of foods with added sugar but a lower frequency of the consumption of SSBs. In the logit model, indicating the chance of being "sugar-free", no association was found between picky eating and sugared foods, but children who were picky eaters were less likely not to drink SSBs. On the other hand, when taking into consideration only the standard negative binomial regression model, picky eating behavior was not associated with the frequency of the consumption of foods and drinks with added sugar.

### 3.4. Association between Daily Screen Time and Consumption Frequency of Added Sugar

Table 4 presents the results of the relationship between daily screen time and the eating behavior of added sugar using the ZINB model and standard negative binomial regression.

Firstly, the analysis of sugared foods found that children whose screen time reached 1 h/d had a higher consumption frequency and lower possibility of not eating sugared foods than those whose screen time was 0 h/d. However, the added sugar consumption behavior of children with <1 h of screen time per day was not different from that of children in the reference group. The results of the standard negative binomial regression analysis also confirmed that the consumption frequency of sugared foods of children with a screen time of 1 h/d was significantly higher than that of children who did not use screens.

**Table 1.** Monthly consumption frequency of added sugar, *n* (%).

| Variables | | N (%) | Monthly Sugar-Added Food Consumption Frequency | | | | Monthly SSBs Consumption Frequency | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | 1~15 | 16~ | *p*-Value | 0 | 1~4 | 5~ | *p*-Value |
| Age | 1~ | 483 (54.9) | 82 (71.3) | 229 (54.4) | 172 (50.1) | **<0.001** | 393 (61.0) | 47 (38.8) | 43 (37.7) | **<0.001** |
| | 2~ | 396 (45.1) | 33 (28.7) | 192 (45.6) | 171 (49.9) | | 251 (39.0) | 74 (61.2) | 71 (62.3) | |
| Sex | female | 428 (48.7) | 59 (51.3) | 190 (45.1) | 179 (52.2) | 0.127 | 304 (47.2) | 63 (52.1) | 61 (53.5) | 0.336 |
| | male | 451 (51.3) | 56 (48.7) | 231 (54.9) | 164 (47.8) | | 340 (52.8) | 58 (47.9) | 53 (46.5) | |
| Delivery mode | vaginal | 493 (56.1) | 64 (55.7) | 233 (55.3) | 196 (57.1) | 0.879 | 352 (54.7) | 71 (58.7) | 70 (61.4) | 0.338 |
| | cesarean | 386 (43.9) | 51 (44.3) | 188 (44.7) | 147 (42.9) | | 292 (45.3) | 50 (41.3) | 44 (38.6) | |
| Parity | 1 | 545 (62.0) | 75 (65.2) | 253 (60.1) | 217 (63.3) | 0.500 | 392 (60.9) | 78 (64.5) | 75 (65.8) | 0.508 |
| | >1 | 334 (38.0) | 40 (34.8) | 168 (39.9) | 126 (36.7) | | 252 (39.1) | 43 (35.5) | 39 (34.2) | |
| Mother's working state | working | 561 (63.8) | 71 (61.7) | 263 (62.5) | 227 (66.2) | 0.503 | 420 (65.2) | 74 (61.2) | 67 (58.8) | 0.337 |
| | not working | 318 (36.2) | 44 (38.3) | 158 (37.5) | 116 (33.8) | | 224 (34.8) | 47 (38.8) | 47 (41.2) | |
| Mother's educational level (years) | 0~9 | 112 (12.7) | 12 (10.4) | 51 (12.1) | 49 (14.3) | 0.409 | 70 (10.9) | 21 (17.4) | 21 (18.4) | **0.013** |
| | 12 | 138 (15.7) | 17 (14.8) | 75 (17.8) | 46 (13.4) | | 95 (14.8) | 26 (21.5) | 17 (14.9) | |
| | 13~ | 629 (71.6) | 86 (74.8) | 295 (70.1) | 248 (72.3) | | 479 (74.4) | 74 (61.2) | 76 (66.7) | |
| Per capita monthly income (RMB: yuan) | 0~ | 402 (45.7) | 47 (40.9) | 201 (47.7) | 154 (44.9) | 0.333 | 290 (45.0) | 62 (51.2) | 50 (43.9) | 0.770 |
| | 5000~ | 315 (35.8) | 44 (38.3) | 138 (32.8) | 133 (38.8) | | 233 (36.2) | 39 (32.2) | 43 (37.7) | |
| | 10,000~ | 162 (18.4) | 24 (20.9) | 82 (19.5) | 56 (16.3) | | 121 (18.8) | 20 (16.5) | 21 (18.4) | |
| The primary caregivers | parents | 472 (53.7) | 64 (55.7) | 230 (54.6) | 178 (51.9) | 0.680 | 332 (51.6) | 69 (57.0) | 71 (62.3) | 0.078 |
| | others | 407 (46.3) | 51 (44.3) | 191 (45.4) | 165 (48.1) | | 312 (48.4) | 52 (43.0) | 43 (37.7) | |
| Picky eating | without | 565 (64.3) | 78 (67.8) | 273 (64.8) | 214 (62.4) | 0.543 | 437 (67.9) | 59 (48.8) | 69 (60.5) | **<0.001** |
| | with | 314 (35.7) | 37 (32.2) | 148 (35.2) | 129 (37.6) | | 207 (32.1) | 62 (51.2) | 45 (39.5) | |
| Daily screen time (h/d) | 0 | 275 (31.3) | 55 (47.8) | 138 (32.8) | 82 (23.9) | **<0.001** | 243 (37.7) | 15 (12.4) | 17 (14.9) | **<0.001** |
| | <1 | 242 (27.5) | 36 (31.3) | 111 (26.4) | 95 (27.7) | | 182 (28.3) | 37 (30.6) | 23 (20.2) | |
| | ≥1 | 362 (41.2) | 24 (20.9) | 172 (40.9) | 166 (48.4) | | 219 (34.0) | 69 (57.0) | 74 (64.9) | |
| Total | | 879 (100.0) | 115 (13.1) | 421 (47.9) | 343 (39.0) | | 644 (73.3) | 121 (13.8) | 114 (13.0) | |

Bold text represents a statistically significant difference (*p* < 0.05); *p*-values were obtained from the chi-square test. SSBs, sugar-sweetened beverages.

**Table 2.** Associations between picky eating and daily screen time.

| Daily Screen Time | OR | 95% CI | *p*-Value |
|---|---|---|---|
| Model 1 [a] | | | |
| 0 h | 1(Ref) | | |
| <1 h | 1.158 | (0.795, 1.687) | 0.445 |
| ≥1 h | 1.922 | (1.380, 2.691) | <0.001 |
| Model 2 [b] | | | |
| 0 h | 1(Ref) | | |
| <1 h | 1.017 | (0.690, 1.497) | 0.933 |
| ≥1 h | 1.555 | (1.084, 2.237) | 0.017 |
| Model 3 [c] | | | |
| 0 h | 1(Ref) | | |
| <1 h | 1.043 | (0.702, 1.547) | 0.835 |
| ≥1 h | 1.432 | (0.987, 2.084) | 0.059 |
| Model 4 [d] | | | |
| 0 h | 1(Ref) | | |
| <1 h | 1.040 | (0.700, 1.544) | 0.845 |
| ≥1 h | 1.437 | (0.990, 2.092) | 0.057 |

Daily screen time was represented by three levels (0 h, <1 h, and ≥1 h). The reference category is 0 h. Picky eating behavior is the dependent variable. OR, odds ratio. [a] unadjusted model; [b] adjusted for toddlers' age and sex; [c] adjusted for toddlers' age, sex, family income, mother's educational level, and place of residence; and [d] adjusted for toddlers' age, sex, family income, mother's educational level, place of residence, outdoor activity time, and sleep duration.

**Table 3.** Associations between picky eating and the consumption frequency of products with added sugar.

| | Monthly Sugar-Added Food Consumption Frequency | | | Monthly SSBs Consumption Frequency | | |
|---|---|---|---|---|---|---|
| | Zero-Inflated NB Model | | NB Regression Model | Zero-Inflated NB Model | | NB Regression Model |
| Picky Eating | Negative Binomial Part | Zero-Inflated Part | IRR (95% CI) | Negative Binomial Part | Zero-Inflated Part | IRR (95% CI) |
| | IRR (95% CI) | OR (95% CI) | | IRR (95% CI) | OR (95% CI) | |
| Model 1 [a] | | | | | | |
| without | 1(Ref) | | | 1(Ref) | | |
| with | 1.169(1.017, 1.343) * | 0.839(0.484, 1.456) | 1.189(1.015, 1.397) * | 0.571(0.371, 0.881) * | 0.348(0.172, 0.705) ** | 0.957(0.601, 1.555) |
| Model 2 [b] | | | | | | |
| without | 1(Ref) | | | 1(Ref) | | |
| with | 1.136(1.098, 1.175) *** | 0.953(0.616, 1.475) | 1.133(0.963, 1.334) | 0.609(0.561, 0.660) *** | 0.681(0.492, 0.941) * | 0.928(0.558, 1.563) |
| Model 3 [c] | | | | | | |
| without | 1(Ref) | | | 1(Ref) | | |
| with | 1.133(1.095, 1.172) *** | 0.949(0.613, 1.471) | 1.132(0.962, 1.334) | 0.599(0.552, 0.650) *** | 0.664(0.478, 0.921) * | 0.966(0.586, 1.608) |

The monthly consumption frequency of sugar-added foods and SSBs is the dependent variable (counting data). IRR, incidence rate ratio; OR, odds ratio. SSBs, sugar-sweetened beverages. NB, negative binomial. [a] unadjusted model; [b] adjusted for toddlers' age, sex, family income, mother's educational level, and place of residence; and [c] adjusted for toddlers' age, sex, family income, mother's educational level, place of residence, outdoor activity time, and sleep duration. * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

The negative binomial model of the ZINB model of SSBs indicated that children whose screen time was <1 h/d drank SSBs less frequently. On the other hand, the logit model of the ZINB model showed that children who used screens were less likely not to have SSBs. Additionally, the results of the standard negative binomial regression test were similar to those with sugared foods—namely, children whose screen time was ≥1 h/d drank SSBs more frequently.

**Table 4.** Associations between daily screen time and the consumption frequency of products with added sugar.

| Daily Screen Time | Monthly Sugar-Added Food Consumption Frequency | | | Monthly SSBs Consumption Frequency | | |
|---|---|---|---|---|---|---|
| | Zero-Inflated NB Model | | NB Regression Model IRR (95% CI) | Zero-Inflated NB Model | | NB Regression Model IRR (95% CI) |
| | Negative Binomial Part IRR (95% CI) | Zero-Inflated Part OR (95% CI) | | Negative Binomial Part IRR (95% CI) | Zero-Inflated Part OR (95% CI) | |
| Model 1 [a] | | | | | | |
| 0 h | 1(Ref) | | | 1(Ref) | | |
| <1 h | 1.104(0.923, 1.321) | 0.664(0.374, 1.180) | 1.170(0.959, 1.428) | 0.483(0.233, 1.002) | 0.263(0.131, 0.526) *** | 1.184(0.66, 2.137) |
| ≥1 h | 1.316(1.122, 1.544) *** | 0.199(0.088, 0.454) *** | 1.519(1.268, 1.818) *** | 0.787(0.408, 1.516) | 0.107(0.040, 0.282) *** | 2.785(1.63, 4.702) *** |
| Model 2 [b] | | | | | | |
| 0 h | 1(Ref) | | | 1(Ref) | | |
| <1 h | 1.135(0.946,1.361) | 0.720(0.393,1.317) | 1.181(0.965,1.445) | 0.411(0.188,0.899) * | 0.283(0.135,0.596) *** | 1.510(0.789,2.910) |
| ≥1 h | 1.366(1.147,1.627) *** | 0.172(0.043,0.695) * | 1.565(1.288,1.901) *** | 0.631(0.299,1.333) | 0.139(0.061,0.320) *** | 3.096(1.672,5.690) *** |
| Model 3 [c] | | | | | | |
| 0 h | 1(Ref) | | | 1(Ref) | | |
| <1 h | 1.131(0.945,1.354) | 0.723(0.401,1.304) | 1.182(0.966,1.448) | 0.370(0.167,0.822) * | 0.272(0.130,0.569) *** | 1.528(0.795,2.950) |
| ≥1 h | 1.383(1.164,1.644) *** | 0.223(0.085,0.587) ** | 1.577(1.296,1.916) *** | 0.505(0.230,1.106) | 0.136(0.057,0.328) *** | 2.637(1.396,4.963) *** |

The monthly consumption frequency of sugar-added foods and SSBs is the dependent variable (counting data). IRR, incidence rate ratio; OR, odds ratio. SSBs, sugar-sweetened beverages. NB, negative binomial [a] unadjusted model; [b] adjusted for toddlers' age, sex, family income, mother's educational level, and place of residence; and [c] adjusted for toddlers' age, sex, family income, mother's educational level, place of residence, outdoor activity time, and sleep duration. * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

## 4. Discussion

This study assessed the relationship between daily screen time, picky eating, and a sugary diet. We did not find a correlation between the total daily screen time and picky eating, and the results showed that both picky eating and screen time were related to children's consumption of sugared foods and SSBs (summarized in Figure 1).
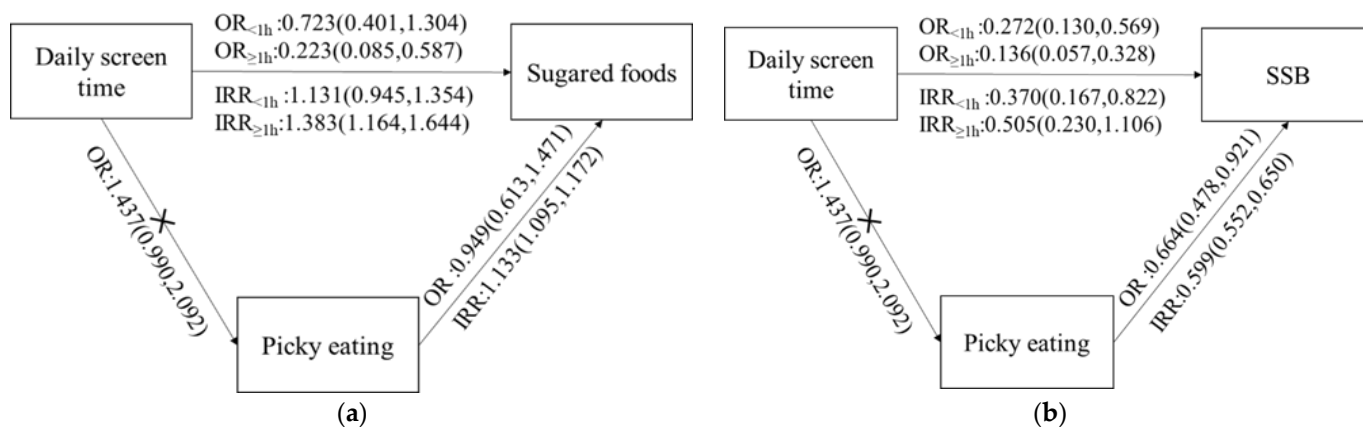


**Figure 1.** (**a**) Relationship between daily screen time, picky eating, and the consumption frequency of sugared foods. (**b**) Relationship between daily screen time, picky eating, and the consumption frequency of SSBs. IRR, incidence rate ratio; OR, odds ratio; SSBs, sugar-sweetened beverages.

### 4.1. Sugared Foods and Beverage Consumption and Its Associated Factors

In our study, the consumption rate of sugared foods was relatively higher than that of SSBs. The intake rates of sugared foods and SSBs were lower than previous studies. According to a cross-sectional survey in The Netherlands, 20.2% and 16.5% of 6-month-old infants consumed sugared foods and SSBs every day, respectively [27]. In the United States, more than a quarter of children under the age of 2 drank SSBs during their dietary recall [6]. The consumption rate of young children in developing countries has also reached a high level—60.0% of children aged 24–35 months in Indonesia ate snacks three or more times a day [28]. Previous studies have reported that an added sugar consumption increases significantly with age [29]. This study only focused on toddlers aged 1–3 years and found that the sugared foods intake was higher in children in the 24–36-month-old age group, and it might be increased alongside children's growth. This also suggested that Chinese parents might begin to control their children's intake of added sugar as early as possible. Additionally, an association between the mother's educational level and added sugar was not observed in this study, but some researchers pointed out that the mother's educational level is related to a sugary diet in children [28,30]. In addition, the participants in our study were recruited from cities, and most of their mothers were well-educated.

### 4.2. Association of Sugared Foods and SSBs with Picky Eating

Picky eating behavior has different effects on the consumption of sugared foods and SSBs. Children who were picky eaters consumed sugared foods more frequently. Although children who are picky eaters are more likely to consume SSBs, their consumption frequency was lower, which is contrary to previous studies. A cohort study carried out in the United Kingdom found that, among older children who were picky eaters, the intake of sugared foods and SSBs was higher [22].

### 4.3. Association of Sugared Foods and SSBs with Screen Time

Our study proved that children whose screen time reached 1 h/d were more likely to eat sugared foods and SSBs, and sugared foods were eaten more frequently. However, the negative binomial part of the ZINB model showed that the consumption frequency of

SSBs of children with <1 h/d of screen time per day was lower than those who did not use screens.

### 4.4. Association among Screen Time, Picky Eating, and Intake of Sugared Foods and SSBs

The reason for the inconsistent results of the consumption frequency of SSBs might be because those children who drank SSBs were only a small part of the respondents, which is bound to have an impact on the results. The results of this study are basically consistent with previous studies. A cross-sectional study on Chinese children and adolescents showed that those who were non-consumers of SSBs were less likely to have ≥2 h/d of screen time [31]. Similar research on Greek schoolchildren aged 8–17 years also pointed out that a longer screen time increased the possibility of unhealthy eating habits, such as skipping breakfast, often eating fast food, and often eating sweets [32]. A prospective European study found that the odds ratio of having increased consumption of SSBs was 1.19 for each hour per day watching TV [33].

The WHO suggested that screen time is not recommended for infants and children less than 2 years of age, and for those aged 2 to 3 years, screen time should be no more than 1 h/d; less is better [34]. In addition to the effect on a sugary diet, screen exposure is associated with the increasing prevalence of overweight and obesity [33,35,36]. Meanwhile, the overuse of digital media is harmful for the development of physical and cognitive abilities, sleeping, and the emotions of children [35,37,38]. Randomized controlled trials of reducing screen time in a community reduced the weight gains of children [39].

Children's picky eating behavior, screen use time, and dessert intake are closely related to the living environment provided by their parents [40,41]. Research on Chinese teenagers found that the attitudes of parents toward sweets will affect the intake of sweets by children by affecting the availability of sweets in the family [42]. Parental and family-based interventions that support the development of healthy eating rules for children have the potential to improve their children's diet quality, such as changing feeding methods or helping infants to identify unhealthy foods [43,44].

The effect of screen time on a diet may be related to advertising [45,46]. Children are exposed to foods and beverages in the advertisements they watch, as well as during children-specific programs. The proportion of ultra-processed foods in a diet was positively correlated with the intake of leisure foods and added sugar, and this was particularly evident among younger children [28,47].

### 4.5. Strengths and Limitations

There were several strengths in this study. The participants were recruited from 10 cities in China, and the relationships among sugared food intake, picky eating, and screen time were fully evaluated. However, as with a cross-sectional design, recall bias may exist, and we could only detect associations but were not able to infer or establish any causality. For the methodology, although we tried our best to ensure that the child's primary caregiver answered all questions in the survey, the evaluations of picky eating behavior and daily screen time were based on self-reported questions instead of standardized tools, which may have led to a misclassification bias. In addition, although we adjusted for confounders that may have influenced the results, residual confounders may have still existed. Further retrospective studies are still needed to examine the effects of screen exposure on the diets and picky eating behaviors of toddlers.

### 5. Conclusions

The consumption rate of sugared foods was higher than that of SSBs. Picky eating and daily screen time were related to the consumption frequency of added sugar among Chinese toddlers. Picky eaters consumed sugared foods more frequently and were more likely to drink SSBs. Children whose screen times reached ≥1 h/d were more likely to eat sugared foods and SSBs.

This study highlighted the importance of early intervention on reducing the consumption frequency of sugared foods. The toddler period is a critical window for building healthy eating behaviors. A comprehensive strategy, including reducing screen times and avoiding picky eating behaviors, may benefit by reducing the consumption frequency of sugared foods and bring about a lifelong health effect.

## References

1. Gonçalves, H.; Barros, F.C.; Buffarini, R.; Horta, B.L.; Menezes, A.M.B.; Barros, A.J.D.; Domingues, M.R.; Victora, C.G.; Matijasevich, A.; Bertoldi, A.D.; et al. Infant nutrition and growth: Trends and inequalities in four population-based birth cohorts in Pelotas, Brazil, 1982–2015. *Int. J. Epidemiol.* **2019**, *48*, i80–i88. [CrossRef] [PubMed]

2. Penha, S.D.C.; Norde, M.M.; Carioca, A.A.F. Childhood eating practices are relevant to ultra-processed food consumption in adulthood: Results from the Nutritionists' Health Study. *J. Dev. Orig. Health Dis.* **2021**, *10*, 1–10. [CrossRef] [PubMed]

3. Ley, D.; Desseyn, J.-L.; Gouyer, V.; Plet, S.; Tims, S.; Renes, I.; Mischke, M.; Gottrand, F. Early life nutrition influences susceptibility to chronic inflammatory colitis in later life. *Sci. Rep.* **2019**, *9*, 1–15. [CrossRef] [PubMed]

4. U.S. Department of Agriculture and U.S and U.S. Department of Health and Human Services. *Dietary Guildlines for America 2020–2025*; 2020. Available online: https://www.dietaryguidelines.gov/sites/default/files/2021-03/Dietary_Guidelines_for_Americans-2020-2025.pdf (accessed on 15 February 2021).

5. A Mennella, J. Ontogeny of taste preferences: Basic biology and implications for health. *Am. J. Clin. Nutr.* **2014**, *99*, 704S–711S. [CrossRef]

6. A Roess, A.; Jacquier, E.F.; Catellier, D.J.; Carvalho, R.; Lutes, A.C.; Anater, A.S.; Dietz, W.H. Food Consumption Patterns of Infants and Toddlers: Findings from the Feeding Infants and Toddlers Study (FITS) 2016. *J. Nutr.* **2018**, *148*, 1525S–1535S. [CrossRef]

7. Theurich, M.A.; Zaragoza-Jordana, M.; Luque, V.; Gruszfeld, D.; Gradowska, K.; Xhonneux, A.; Riva, E.; Verduci, E.; Poncelet, P.; Damianidi, L.; et al. Commercial complementary food use amongst European infants and children: Results from the EU Childhood Obesity Project. *Eur. J. Nutr.* **2019**, *59*, 1679–1692. [CrossRef]

8. Bailey, R.L.; Fulgoni, V.L.; Cowan, A.E.; Gaine, P.C. Sources of Added Sugars in Young Children, Adolescents, and Adults with Low and High Intakes of Added Sugars. *Nutrients* **2018**, *10*, 102. [CrossRef]

9. Azais-Braesco, V.; Sluik, D.; Maillot, M.; Kok, F.; Moreno, L.A. A review of total & added sugar intakes and dietary sources in Europe. *Nutr. J.* **2017**, *16*, 6. [CrossRef]

10. Charvet, A.; Huffman, F.G. Beverage Intake and Its Effect on Body Weight Status among WIC Preschool-Age Children. *J. Obes.* **2019**, *2019*, 1–8. [CrossRef]

11. Thurber, K.A.; Dobbins, T.; Neeman, T.; Banwell, C.; Banks, E. Body mass index trajectories of Indigenous Australian children and relation to screen time, diet, and demographic factors. *Obesity* **2017**, *25*, 747–756. [CrossRef]

12. Shang, X.W.; Liu, A.L.; Zhang, Q.; Hu, X.Q.; Du, S.M.; Ma, J.; Xu, G.F.; Li, Y.; Guo, H.W.; Du, L.; et al. Report on childhood obesity in China (9): Sugar-sweetened beverages consumption and obesity. *Biomed. Environ. Sci.* **2012**, *25*, 125–132. [PubMed]

13. Janmohamed, A.; Luvsanjamba, M.; Norov, B.; Batsaikhan, E.; Jamiyan, B.; Blankenship, J.L. Complementary feeding practices and associated factors among Mongolian children 6–23 months of age. *Matern. Child Nutr.* **2020**, *16*, 12838. [CrossRef] [PubMed]

14. Sağlam, N.Ö.; Bülbül, L.; Kazancı, S.Y.; Hatipoğlu, S.S. Yaro Factors Affecting Breastfeeding and Complementary Feeding Choices for Children Aged 24 to 48 Months. *SiSli Etfal Hast. Tip Bulteni Med Bull. Sisli Hosp.* **2018**, *53*, 165–171. [CrossRef]

15. Kołota, A.; Głąbska, D. COVID-19 Pandemic and Remote Education Contributes to Improved Nutritional Behaviors and Increased Screen Time in a Polish Population-Based Sample of Primary School Adolescents: Diet and Activity of Youth during COVID-19 (DAY-19) Study. *Nutrients* **2021**, *13*, 1596. [CrossRef] [PubMed]

16. Stiglic, N.; Viner, R.M. Effects of screentime on the health and well-being of children and adolescents: A systematic review of reviews. *BMJ Open* **2019**, *9*, e023191. [CrossRef] [PubMed]

17. Pérez-Fariñós, N.; Villar-Villalba, C.; Sobaler, A.M.L.; Saavedra, M.; Ángeles, D.R.; Aparicio, A.; Sanz, S.S.; de Dios, T.R.; Castrodeza-Sanz, J.J.; Anta, R.M.O. The relationship between hours of sleep, screen time and frequency of food and drink consumption in Spain in the 2011 and 2013 ALADINO: A cross-sectional study. *BMC Public Health* **2017**, *17*, 33. [CrossRef]

18. Shqair, A.Q.; Pauli, L.A.; Costa, V.P.P.; Cenci, M.; Goettems, M.L. Screen time, dietary patterns and intake of potentially cariogenic food in children: A systematic review. *J. Dent.* **2019**, *86*, 17–26. [CrossRef]

19. Taylor, C.M.; Northstone, K.; Wernimont, S.M.; Emmett, P.M. Picky eating in preschool children: Associations with dietary fibre intakes and stool hardness. *Appetite* **2016**, *100*, 263–271. [CrossRef]

20. Brown, C.L.; Perrin, E.M.; Peterson, K.E.; Herb, H.E.B.; Horodynski, M.A.; Contreras, D.; Miller, A.; Appugliese, D.P.; Ball, S.C.; Lumeng, J.C. Association of Picky Eating With Weight Status and Dietary Quality Among Low-Income Preschoolers. *Acad. Pediatr.* **2018**, *18*, 334–341. [CrossRef]

21. Wolstenholme, H.; Kelly, C.; Hennessy, M.; Heary, C. Childhood fussy/picky eating behaviours: A systematic review and synthesis of qualitative studies. *Int. J. Behav. Nutr. Phys. Act.* **2020**, *17*, 2–22. [CrossRef]

22. Taylor, C.M.; Northstone, K.; Wernimont, S.M.; Emmett, P.M. Macro- and micronutrient intakes in picky eaters: A cause for concern? *Am. J. Clin. Nutr.* **2016**, *104*, 1647–1656. [CrossRef] [PubMed]

23. Gan, K.; Tithecott, C.; Neilson, L.; Seabrook, J.; Dworatzek, P. Picky Eating Is Associated with Lower Nutrient Intakes from Children's Home-Packed School Lunches. *Nutrients* **2021**, *13*, 1759. [CrossRef] [PubMed]

24. Kutbi, H. Picky Eating in School-Aged Children: Sociodemographic Determinants and the Associations with Dietary Intake. *Nutrients* **2021**, *13*, 2518. [CrossRef]

25. Sandvik, P.; Ek, A.; Somaraki, M.; Hammar, U.; Eli, K.; Nowicka, P. Picky eating in Swedish preschoolers of different weight status: Application of two new screening cut-offs. *Int. J. Behav. Nutr. Phys. Act.* **2018**, *15*, 74. [CrossRef] [PubMed]

26. Bin Cheung, Y. Zero-inflated models for regression analysis of count data: A study of growth and development. *Stat. Med.* **2002**, *21*, 1461–1469. [CrossRef] [PubMed]

27. Wang, L.; Van Grieken, A.; Van Der Velde, L.A.; Vlasblom, E.; Beltman, M.; L'Hoir, M.P.; Boere-Boonekamp, M.M.; Raat, H. Factors associated with early introduction of complementary feeding and consumption of non-recommended foods among Dutch infants: The BeeBOFT study. *BMC Public Health* **2019**, *19*, 1–12. [CrossRef] [PubMed]

28. Green, M.; Hadihardjono, D.N.; Pries, A.M.; Izwardy, D.; Zehner, E.; Huffman, S.L. High proportions of children under 3 years of age consume commercially produced snack foods and sugar-sweetened beverages in Bandung City, Indonesia. *Matern. Child Nutr.* **2019**, *15*, e12764. [CrossRef] [PubMed]

29. Demmer, E.; Cifelli, C.J.; Houchins, J.A.; Fulgoni, V.L. Ethnic disparities of beverage consumption in infants and children 0–5 years of age; National Health and Nutrition Examination Survey 2011 to 2014. *Nutr. J.* **2018**, *17*, 1–9. [CrossRef]

30. Ford, C.N.; Ng, S.W.; Popkin, B.M. Are Food and Beverage Purchases in Households with Preschoolers Changing? *Am. J. Prev. Med.* **2014**, *47*, 275–282. [CrossRef]

31. Gui, Z.-H.; Zhu, Y.-N.; Cai, L.; Sun, F.-H.; Ma, Y.-H.; Jing, J.; Chen, Y.-J. Sugar-Sweetened Beverage Consumption and Risks of Obesity and Hypertension in Chinese Children and Adolescents: A National Cross-Sectional Analysis. *Nutrients* **2017**, *9*, 1302. [CrossRef]

32. Tambalis, K.D.; Panagiotakos, D.B.; Psarra, G.; Sidossis, L.S. Screen time and its effect on dietary habits and lifestyle among schoolchildren. *Central Eur. J. Public Health* **2020**, *28*, 260–266. [CrossRef] [PubMed]

33. Olafsdottir, S.; Berg, C.; Eiben, G.; Lanfer, A.; Reisch, L.; Ahrens, W.; Kourides, Y.; Molnár, D.; A Moreno, L.; Siani, A.; et al. Young children's screen activities, sweet drink consumption and anthropometry: Results from a prospective European study. *Eur. J. Clin. Nutr.* **2013**, *68*, 223–228. [CrossRef] [PubMed]

34. World Health Organization. *Guidelines on Physical Activity, Sedentary Behaviour and Sleep for Children under 5 Years of Age*; World Health Organization: Geneva, Switzerland, 2019.

35. Robinson, T.N.; Banda, J.A.; Hale, L.; Lu, A.S.; Fleming-Milici, F.; Calvert, S.L.; Wartella, E. Screen Media Exposure and Obesity in Children and Adolescents. *Pediatrics* **2017**, *140* (Suppl. S2), S97–S101. [CrossRef] [PubMed]

36. Taylor, A.W.; Winefield, H.; Kettler, L.; Roberts, R.; Gill, T. A Population Study of 5 to 15 Year Olds: Full Time Maternal Employment not Associated with High BMI. The Importance of Screen-Based Activity, Reading for Pleasure and Sleep Duration in Children's BMI. *Matern. Child Health J.* **2012**, *16*, 587–599. [CrossRef]

37. Zhang, Y.; Wu, X.; Tao, S.; Li, S.; Ma, L.; Yu, Y.; Sun, G.; Li, T.; Tao, F. Associations between screen time, physical activity, and depressive symptoms during the 2019 coronavirus disease (COVID-19) outbreak among Chinese college students. *Environ. Health Prev. Med.* **2021**, *26*, 1–12. [CrossRef]

38. Domingues-Montanari, S. Clinical and psychological effects of excessive screen time on children. *J. Paediatr. Child Health* **2017**, *53*, 333–338. [CrossRef]

39. Epstein, L.H.; Roemmich, J.N.; Robinson, J.L.; Paluch, R.A.; Winiewicz, D.D.; Fuerch, J.H.; Robinson, T.N. A Randomized Trial of the Effects of Reducing Television Viewing and Computer Use on Body Mass Index in Young Children. *Arch. Pediatr. Adolesc. Med.* **2008**, *162*, 239–245. [CrossRef]

40. Dong, F.; Howard, A.G.; Herring, A.H.; Thompson, A.L.; Adair, L.S.; Popkin, B.M.; Aiello, A.E.; Zhang, B.; Gordon-Larsen, P. Parent–child associations for changes in diet, screen time, and physical activity across two decades in modernizing China: China Health and Nutrition Survey 1991–2009. *Int. J. Behav. Nutr. Phys. Act.* **2016**, *13*, 1–11. [CrossRef]

41. Lloyd, A.B.; Lubans, D.; Plotnikoff, R.C.; Collins, C.E.; Morgan, P.J. Maternal and paternal parenting practices and their influence on children's adiposity, screen-time, diet and physical activity. *Appetite* **2014**, *79*, 149–157. [CrossRef]

42. Qiu, N.; Moore, J.B.; Wang, Y.; Fu, J.; Ding, K.; Li, R. Perceived Parental Attitudes Are Indirectly Associated with Consumption of Junk Foods and Sugar-Sweetened Beverages among Chinese Adolescents through Home Food Environment and Autonomous Motivation: A Path Analysis. *Nutrients* **2021**, *13*, 3403. [CrossRef]

43. Fries, L.R.; van der Horst, K. Parental Feeding Practices and Associations with Children's Food Acceptance and Picky Eating. In *Nurturing a Healthy Generation of Children: Research Gaps and Opportunities*; Karger Publishers: Basel, Switzerland, 2019; Volume 91, pp. 31–39.

44. Shonkoff, E.T.; Dunton, G.F.; Chou, C.-P.; Leventhal, A.M.; Bluthenthal, R.; Pentz, M.A. Direct and indirect effects of parent stress on child obesity risk and added sugar intake in a sample of Southern California adolescents. *Public Health Nutr.* **2017**, *20*, 3285–3294. [CrossRef] [PubMed]

45. Harris, J.L.; LoDolce, M.; Dembek, C.; Schwartz, M.B. Sweet promises: Candy advertising to children and implications for industry self-regulation. *Appetite* **2015**, *95*, 585–592. [CrossRef] [PubMed]

46. Scully, P.; Reid, O.; Macken, A.; Healy, M.; Saunders, J.; Leddin, D.; Cullen, W.; Dunne, C.; O'Gorman, C.S. Food and beverage cues in children's television programmes: The influence of programme genre. *Public Health Nutr.* **2015**, *19*, 616–624. [CrossRef] [PubMed]

47. Neri, D.; Martinez-Steele, E.; Monteiro, C.A.; Levy, R.B. Consumption of ultra-processed foods and its association with added sugar content in the diets of US children, NHANES 2009–2014. *Pediatr. Obes.* **2019**, *14*, e12563. [CrossRef] [PubMed]