# Food Label Literacy, Ultra-Processed Food, and Sugar-Sweetened Beverages in Childhood Obesity: A Case-Control Study

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**Abstract**: *Introduction:* Childhood obesity is a worldwide health issue. The consumption of ultra-processed foods (UPF) and sugar-sweetened beverages (SSB) is suspected to be a major risk factor. Food labels can help protect consumers from unhealthy foods, but their effectiveness among young people is limited. This study examines whether food label literacy functions as a potential effect modifier of the association between UPF or SSB consumption and childhood obesity.

*Methods:* A case-control study involving 402 elementary school children aged 8–12 years in Makassar City (201 obese, 201 normal) with matching (age, gender, and school) was conducted. Food label knowledge and use were measured using structured questionnaires, and consumption was assessed with the Semi-Quantitative Food Frequency Questionnaire (SQ-FFQ).

*Results:* Food label knowledge was significantly lower in obese children ($p < 0.001$), though food label use did not differ significantly between groups ($p = 0.190$). UPF contributed 51% of daily energy needs in obese children, showing a significant association with childhood obesity (aOR = 1.018, 95% CI: 1.003–1.034, $p = 0.021$), whereas SSB showed no association (aOR = 1.012, 95% CI: 0.987–1.037, $p = 0.361$). Interaction tests indicated that neither food label knowledge nor use significantly modified these associations ($p > 0.050$).

*Conclusion:* UPF consumption was associated with childhood obesity, while food label literacy did not function as an effect modifier in the relationship between UPF or SSB consumption and obesity among school-aged children. Rather than relying solely on children's knowledge, comprehensive strategies including regulations, interventions, and parental empowerment are essential to address obesity.

**Keywords:** Food label, childhood obesity, school-aged children, sugar-sweetened beverage, ultra-processed food.

## INTRODUCTION

Childhood obesity has become one of the most serious public health issues of the 21st century, with its prevalence steadily increasing globally in the past three decades [1]. About 390 million children and adolescents aged 5–19 years are overweight, and as many as 18% of them are obese [2]. The prevalence of overweight and obesity in children has increased globally and is an urgent public health challenge. This condition is particularly worrying considering childhood obesity not only impacts short-term health, such as metabolic, cardiovascular, and psychosocial disorders, but also increases the risk of obesity, type 2 diabetes mellitus, coronary heart disease, and various chronic diseases in adulthood [3].

The shifting consumption patterns from traditional foods based on fresh ingredients to processed foods such as UPF and SSB have been identified as one of the main drivers of the global obesity epidemic [4]. UPF is defined as an industrially formulated product made from substances extracted or derived from food with the addition of various additives to enhance taste and shelf life, now dominating modern food systems. These products generally have high energy density, a high level of sugar, sodium, and saturated fat, and a low fiber and essential micronutrient content [5]. Scientific evidence suggests that UPF consumption is strongly associated with an increased risk of obesity, not only through excessive calorie intake but also through various biological mechanisms, such as altered satiety signals, a disrupted gut microbiome, and increased inflammatory markers [6, 7]. SSB is a category that also significantly contributes to the epidemic of childhood obesity. Unlike solid foods, the liquid calories from SSBs provide less satiety and incomplete energy compensation, leading to higher total daily energy intake [8], weight gain, and increased obesity risk in children [9]. In Indonesia, children consume SSB at a very high rate and find them easily accessible, both at school and at home, with various products being aggressively marketed to children [10].

Given global concerns about the roles of UPF and SSB in driving the risk of obesity and non-communicable diseases from an early age, children's ability to understand food labels has emerged as a relevant factor in fostering their autonomy to make

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healthier dietary choices [11, 12]. Food labels are recognized as an important public health strategy to inform choices and encourage product reformulation [13], with recent evidence demonstrating that interdisciplinary educational interventions utilizing game-based and theoretical methods effectively improve school-aged children's attitudes and knowledge toward front-of-pack labels [11], and warning labels significantly assist children in identifying healthy and unhealthy products [12]. However, a gap remains regarding Indonesian children, whose food environment and labeling context differ substantially from those studied in existing literature [14].

Children with higher food label literacy may be better positioned to critically evaluate and compare the nutritional composition of their food choices, including UPF and SSB products, enabling more informed purchasing decisions that reduce exposure to nutritionally unfavorable products and potentially attenuating the strength of the association between UPF or SSB consumption and obesity risk [11, 15]. Yet this moderating capacity may be substantially constrained in obesogenic environments where UPF products are widespread, affordable, and aggressively marketed to children, rendering individual-level label literacy insufficient to override structural determinants of dietary behavior regardless of knowledge level [10, 16].

Whether food label knowledge and use meaningfully modify the magnitude of the association between UPF and SSB consumption and obesity risk, therefore, remains an empirical question warranting direct examination in the Indonesian school food context, where previous studies often focused on adults or adolescents under the assumption that labels have minimal influence on children's food choices [16]. Therefore, this study aims to analyze the association between UPF and SSB consumption and obesity risk in school-aged children, and to examine whether knowledge and use of food labels function as potential effect modifiers that moderate the association between UPF or SSB consumption and childhood obesity. We hope the findings can inform the development of evidence-based interventions to prevent and control obesity.

## METHOD

### Research Design

This study employed a case-control design to examine the relationships among food label knowledge, use, and consumption patterns among obese and normal-weight elementary school children. The research was conducted from August to October 2025 in 10 elementary schools in Makassar City, South Sulawesi, Indonesia. A total of 2,761 students had their weight and height measured to calculate their Body Mass Index for age Z-score (BAZ), which was used to determine their nutritional status. Participants were selected for this screening phase using the Probability Proportional to Size (PPS) method. The PPS method was applied to ensure a more representative sample of elementary school students in Makassar City, making the study's findings more applicable to the region's school-aged children. This study received approval from the Hasanuddin University Research Ethics Committee.

### Study Population and Sample

The study population comprised elementary school children aged 8–12 years enrolled in schools in Makassar City, South Sulawesi, Indonesia. The sample comprised 402 children: 201 obese (case group) and 201 with normal nutritional status (control group). Obesity was defined as a BAZ > +2.0 SD, in accordance with the World Health Organization (WHO) Child Growth Standards 2007 [17]. The control group comprised children with a BAZ between -2.0 SD and +1.0 SD, representing the normal nutritional status category per WHO standards. Children with BAZ between +1.0 and +2.0 SD classified as overweight were explicitly excluded from both groups to maintain a clear anthropometric contrast between case and control and to avoid diluting the group comparison. The minimum sample size was calculated using the case-control study formula in OpenEpi Version 3, with reference to previous research in the Indonesian population [18]. Sample collection was carried out in 3 main stages, starting with anthropometric measurements (weight and height) of all students (4th–6th grade) in 10 selected elementary schools to determine their nutritional status. Based on the results, participants were randomly selected through age-, gender-, and school-matching.

The inclusion criteria for this study's participants included school-aged children in upper grades (4th, 5th, and 6th grade); case groups consisted of children with obese nutritional status, and control groups included children with normal nutritional status based on BAZ, children whose parents or guardians were willing to provide signed informed consent to participate in this research, and children who purchased UPF in the last

1 month. The criterion requiring UPF purchase within the preceding month was established as a methodological necessity to ensure the construct validity of the measurement of food label use, as only participants with recent, direct experience interacting with packaged UPF products could provide valid responses regarding actual label-reading behavior. This criterion was applied identically to both groups.

**Food Label Literacy**

The instruments used to measure food label literacy, including the knowledge and use of food labels, were structured questionnaires. Food label knowledge was assessed using a 15-item structured questionnaire comprising 2 main components. The first component consisted of 10 items adapted from FLLANK, also known as the "Food Label Quiz" by Yale-Griffin Health (https://yalegriffinprc.griffinhealth.org/products-resources/prc-products/food-label-literacy/), an instrument previously developed and validated for school-aged children [19] which requires students to compare Nutrition Facts panels between two food products (2 crackers, 2 cookies, 2 cereal bars, 2 cereals, and 2 breads) to identify the healthier option based on whole-grain content, dietary fiber, ingredient list length, and the absence of high-fructose corn syrup and hydrogenated oil. Although these 10 questions were previously validated for school-aged children, validation was repeated after adjustments and translation into Indonesian. To ensure content relevance for the Indonesian regulatory context, key terminology was systematically aligned with Indonesian Food and Drug Authority (FDA) standards, such as “Nutrition Facts” was rendered as “Informasi Nilai Gizi” and “% Daily Value” was replaced with “% Angka Kecukupan Gizi” in accordance with Indonesian FDA regulation, ensuring that items reflect label terminology as it appears on products available in the Indonesian market. The second component consisted of 5 items developed by the researchers to assess food label knowledge domains beyond nutrition facts panel including expiration date interpretation (1 question), allergen labelling (1 question), halal logo recognition (1 question), health and warning claims (1 question), and the general definition and purpose of food labels (1 question), ensuring domains are relevant to Indonesian children’s food purchasing context. Before the main data collection, the instrument was administered to 30 elementary school children (8–12 years old, not included in the main sample) as part of a pilot study. Item-level validity was assessed using Pearson correlation, with all 15 items meeting the validity threshold $r > 0.30$ ($r = 0.369–0.826$). Internal consistency reliability was assessed using Cronbach’s alpha ($\alpha = 0.871$). Items that required repeated clarification during pilot administration were revised for clearer language prior to finalization. The total score was calculated and categorized as “good” (>80% correct), “moderate” (60–79% correct), and “low” (<60% correct) [20].

Food label use was assessed with a structured questionnaire that used a 5-point Likert scale, previously used in nutritional research, to quantify label use behavior [21, 22]. The Likert scale was used to measure how often children read and use information on food labels when making purchasing or consumption choices. The scale included "Always", "Often", "Sometimes", "Rarely", and "Never". To minimize social desirability bias and strengthen validity, strategies were employed such as interviews were conducted one-on-one and face-to-face sessions in a calm and private setting to reduce peer influence on responses and emphasized that there were no right or wrong answers; actual food and beverage packaging of products commonly available in the children’s environment including products from school canteens and nearby food outlets were presented as concrete visual cues to anchor responses to specific and recognizable label use experiences to reduce reliance on abstract self-assessment, also to enhance reporting accuracy children were also asked to recall the last time they had interacted with the packaging before providing their responses; and lastly parents or guardians were consulted to corroborate children’s reported label use behavior providing an external verification layer that partially offsets individual self-report bias.

**Consumption Measurement**

Children's food consumption was assessed over the past month using the SQ-FFQ, which was specifically designed to evaluate what children eat, including a list of commonly consumed foods among school-aged children in Indonesia. Prior to the main data collection, a pilot study was conducted with 30 elementary school children to assess the instrument’s suitability for the study population across 4 components. First, food list adequacy was evaluated by comparing SQ-FFQ items against foods reported in 2 non-consecutive 24-hour dietary recalls administered to the same pilot participants, and frequently reported items absent from the initial list were added accordingly. Second, portion size appropriateness was assessed by comparing

children's habitually reported serving sizes from recalls against SQ-FFQ portion categories with adjustments made to reflect locally typical consumption amounts using the Indonesian Ministry of Health 2014 Food Photo Book as a standardization reference. Third, cognitive testing was conducted to evaluate children's comprehension of question wording, frequency response options, and portion-size concepts, and items were revised when repeated clarification was required. Fourth, interviewer feasibility was assessed through supervised practice interviews to standardize interviewer technique, resolve procedural inconsistencies, and establish a realistic interview duration.

To minimize the potential for recall bias, trained interviewers used visual aids, including examples of household portion sizes, actual food packaging for commonly consumed products, and the Indonesian Ministry of Health 2014 Food Photo Book. Furthermore, structured face-to-face interviews were conducted in a quiet environment, lasting about 30–35 minutes per child, to ensure thoroughness and consistent responses. Parents or guardians were also involved to confirm the types and frequency of food and beverages consumed by the child, thereby reducing sole reliance on children's retrospective self-recall.

All food and beverage items in the SQ-FFQ were independently and systematically classified into NOVA groups by two investigators, using the operational definitions established by Monteiro [5]. Each item was reviewed individually and assigned to 1 of 4 NOVA groups based on the extent and purpose of industrial processing. NOVA Group 4 (UPF products) was defined by the presence of ingredients not typically used in home cooking, including flavorings, emulsifiers, preservatives, artificial sweeteners, and other cosmetic or technological additives. SSB was identified as a sub-category of NOVA Group 4 beverages containing added free sugars. No disagreements arose between the two investigators during the classification process, reflecting the operationally unambiguous nature of NOVA Group 4 classification for the food items predominant in this population, including packaged snacks, bottled beverages, instant noodles, and fast food products. NOVA Group 4 items were subsequently used for all UPF consumption analyses.

Consumption data were converted into energy and nutrient intakes (protein, fat, carbohydrates, fiber, sugar, and sodium) using the Nutrisurvey software database for Indonesian foods. Calculations covered overall or total foods, UPF, and SSB. Adequacy was determined by comparing actual intake with the 2019 Indonesian Recommended Dietary Allowance (RDA) for each gender and age group. For sugar intake, an additional comparison was made with the WHO recommendation of <10% of total daily energy intake [23].

**Statistical Analysis**

Data analysis in this study was performed using SPSS version 26. An initial Chi-Square test was applied to analyze sample characteristics, sociodemographic data, and differences between case and control groups for categorical variables (gender, school, religion, parental income, parental occupation, and parental education). Before testing numerical variables (age, weight, height, BAZ, class, daily pocket money, and number of siblings), normality was assessed with the Kolmogorov-Smirnov test. Because most data were not normally distributed ($p < 0.050$), non-parametric tests were used. Consequently, the Mann-Whitney U test was employed to compare differences between the two groups in food label knowledge and use. Further analysis examined the relationship between food label knowledge/use and consumption (total, UPF, and SSB) using logistic regression to calculate Odds Ratios (ORs) with 95% Confidence Intervals (CIs), with reference categories chosen based on data distribution to ensure stable OR estimates. Nutrient intake (energy, protein, fat, carbohydrates, fiber, sodium, and sugar) was analyzed to determine the mean, standard deviation, and percentage adequacy relative to the 2019 Indonesian RDA and WHO guidelines, and group comparisons were performed using Chi-Square tests.

To assess the independent association of UPF and SSB consumption with obesity after controlling for total energy intake, the energy proportion approach was used. The energy proportion from UPF and SSB was calculated as:

Energy proportion = (Energy from UPF or SSB ÷ Total daily energy intake) x 100%

This approach inherently adjusts for total energy intake by using it as the denominator in the proportion calculation. Binary logistic regression was then performed with obesity status as the dependent variable and the energy proportion from UPF (or SSB) as the sole independent variable. To examine whether food label knowledge and use moderate the

relationship between UPF/SSB consumption and obesity, an interaction test was used. The interaction terms were created by multiplying each energy proportion variable for UPF and SSB with food label knowledge and food label use, and 2 binary logistic regression models were subsequently constructed.

All continuous predictors were mean-centered prior to computing interaction terms to reduce structural multicollinearity. Post-centering diagnostics confirmed negligible multicollinearity among non-interaction predictors, with variance inflation factors (VIFs) <5 (range: 1.007–1.032), whereas interaction terms showed elevated VIFs in the UPF model (VIF = 7.257 and 6.787) and the SSB model (VIF = 7.942 and 8.593). These values reflect structural multicollinearity, an algebraically inevitable consequence of including product terms derived from continuous predictors, not a symptom of problematic data redundancy. More importantly, a Condition Index below 30 (maximum observed: 9.140) provided additional confirmation that no harmful multicollinearity was present. Model fit was confirmed using the Hosmer-Lemeshow goodness-of-fit test, which yielded $p > 0.050$ (UPF model: $p = 0.921$; SSB model: $p = 0.545$), indicating robustness of the models.

## RESULTS

### Sample Characteristics and Sociodemographic

A total of 402 school-aged children consisted of 201 obese and 201 normal-weight children, with a male majority (61%) in both groups. As shown in Table **1**, anthropometric profiles, including body weight, height, and BAZ, differed significantly between groups ($p < 0.001$), confirming adequate case-control separation. Sociodemographic characteristics, including school grade, religion, number of siblings, parental income (Makassar City Minimum Wage), pocket money in Indonesian Rupiah (IDR), parental occupation, and education level, were comparable between groups ($p > 0.050$), indicating successful matching and homogeneity of background characteristics.

### Food Label Knowledge and Use with Children's Consumption

As shown in Figure **1**, food label knowledge was significantly lower in obese children ($p < 0.001$), with the majority (73%) classified in the "low" knowledge category. In comparison, most normal-weight or non-obese children fell in the "moderate" category (58%). Food label use did not differ significantly between groups ($p = 0.190$), with "sometimes" being the predominant frequency in both groups ($n > 40\%$).

Table **2** further shows that neither knowledge nor use was significantly associated with dietary consumption in most categories ($p > 0.050$). The only notable exception was among normal-weight children who "rarely" used food labels, who had 3.696 times higher odds of UPF consumption compared to those who "always" used them (OR = 3.696, 95% CI: 1.027–13.301, $p = 0.045$). However, this isolated finding should be interpreted cautiously, given the uneven distribution of the sample across exposure categories.

### Consumption of UPF and SSB

Table **3** presents nutrient intake and adequacy by children's nutritional status. Obese children consistently showed higher nutrient adequacy across all nutrients than normal-weight peers, with most exceeding the RDA, except for fiber, which remained inadequate in both groups (36.34% vs. 25.98% RDA). UPF contributed over half (51% RDA, 955 ± 949 kcal) of daily energy needs in obese children and was substantially higher than in normal-weight children (30% RDA, $p < 0.001$), along with proportionally larger contributions of protein, fat, carbohydrates, sodium, and sugar. SSB contributed a smaller but notable share, most evident for energy (13% RDA in obese children, $p = 0.007$), while other SSB-derived nutrients showed no significant between-group differences.

As shown in Table **4**, the proportion of energy from UPF was significantly associated with obesity after adjustment for total energy intake, and each 1% increase in the contribution of UPF to total daily energy intake was associated with a 1.8% increase in the odds of obesity (aOR = 1.018, 95% CI: 1.003–1.034, $p = 0.021$). In contrast, the proportion of energy from SSB showed no significant association (aOR = 1.012, 95% CI: 0.987–1.037, $p = 0.361$). The interaction tests revealed no significant moderation effects. Food label knowledge ($p = 0.263$ for UPF, $p = 0.064$ for SSB) and food label use ($p = 0.819$ for UPF, $p = 0.101$ for SSB) did not significantly modify the relationship between UPF or SSB consumption and obesity in children.

## DISCUSSION

This study demonstrates a significant and consistent association between UPF consumption and childhood obesity, corroborating global evidence on

**Table 1: Sample Characteristics**

| Characteristics | Obese (n = 201) | Normal (n = 201) | Total (n = 402) | p-value |
|---|---|---|---|---|
| | mean ± SD or n (%) | | | |
| **Anthropometric Profiles** | | | | |
| Body Weight (kg) | 52.47 ± 9.96 | 30.53 ± 5.94 | 41.50 ± 13.70 | <0.001 [a] |
| Height (cm) | 143.62 ± 7.42 | 137.79 ± 8.95 | 140.70 ± 8.71 | |
| BAZ | 2.64 ± 0.58 | -0.51 ± 0.80 | 1.06 ± 1.73 | |
| **Gender** | | | | 1.000 [b] |
| Male | 123 (61) | 123 (61) | 246 (61) | |
| Female | 78 (39) | 78 (39) | 156 (39) | |
| **Classes** | | | | 0.673 [a] |
| 4th grade | 76 (38) | 66 (33) | 142 (35) | |
| 5th grade | 54 (27) | 67 (33) | 121 (30) | |
| 6th grade | 71 (35) | 68 (34) | 139 (35) | |
| **Religion** | | | | 0.200 [b] |
| Islam | 194 (97) | 198 (99) | 392 (98) | |
| Christian | 7 (3) | 3 (3) | 10 (2) | |
| **Daily Allowance (IDR)** | 11,970 ± 10,595.24 | 10,930 ± 7,832.31 | 11,450 ± 9,319.69 | 0.340 [a] |
| **Parental Income** | | | | 0.150 [a] |
| < City Minimum Wage | 47 (23) | 58 (29) | 105 (26) | |
| ≥ City Minimum Wage | 154 (77) | 143 (71) | 297 (74) | |
| **Father's Occupation** | | | | 0.098 [b] |
| Civilian Serving | 43 (21) | 35 (17) | 78 (19) | |
| Private Employees | 47 (23) | 4 (2) | 51 (13) | |
| Self-employed | 57 (28) | 45 (22) | 102 (25) | |
| Labourer/Street Vendor | 16 (8) | 27 (13) | 43 (11) | |
| Others | 38 (19) | 90 (45) | 128 (32) | |
| **Mother's Occupation** | | | | 0.216 [b] |
| Civilian Serving | 42 (21) | 29 (14) | 71 (18) | |
| Private Employees | 16 (8) | 22 (11) | 38 (9) | |
| Self-employed | 27 (13) | 39 (19) | 66 (16) | |
| Labourer/Street Vendor | 2 (1) | 5 (2) | 7 (2) | |
| Housewives | 108 (54) | 101 (50) | 209 (52) | |
| Others | 6 (3) | 5 (2) | 11 (3) | |
| **Father's Education** | | | | 0.443 [a] |
| No/Incomplete Primary Ed. | - | 1 (0.5) | 1 (0.2) | |
| Elementary School | 7 (3.5) | 5 (2.5) | 12 (3) | |
| Junior High School | 5 (2.5) | 4 (2) | 9 (2.2) | |
| High School | 64 (31.8) | 60 (29.9) | 124 (30.8) | |
| Diploma/Bachelor/Master | 124 (61.7) | 128 (63.7) | 252 (62.7) | |
| Others | 1 (0.5) | 3 (1.5) | 4 (1) | |
| **Mother's Education** | | | | 0.435 [a] |
| No/Incomplete Primary Ed. | - | 1 (0.5) | 1 (0.2) | |
| Elementary School | 6 (3) | 4 (2) | 10 (2.5) | |
| Junior High School | 2 (1) | 10 (0.5) | 12 (3) | |
| High School | 62 (30.8) | 60 (29.9) | 122 (30.3) | |
| Diploma/Bachelor/Master | 130 (64.7) | 126 (62.7) | 256 (63.7) | |
| Others | 1 (0.5) | - | 1 (0.2) | |
| **Number of Siblings** | 2.63 ± 1.33 | 2.77 ± 1.44 | 2.70 ± 1.39 | 0.387 [a] |

[a]Mann-Whitney U, [b]Chi-square.

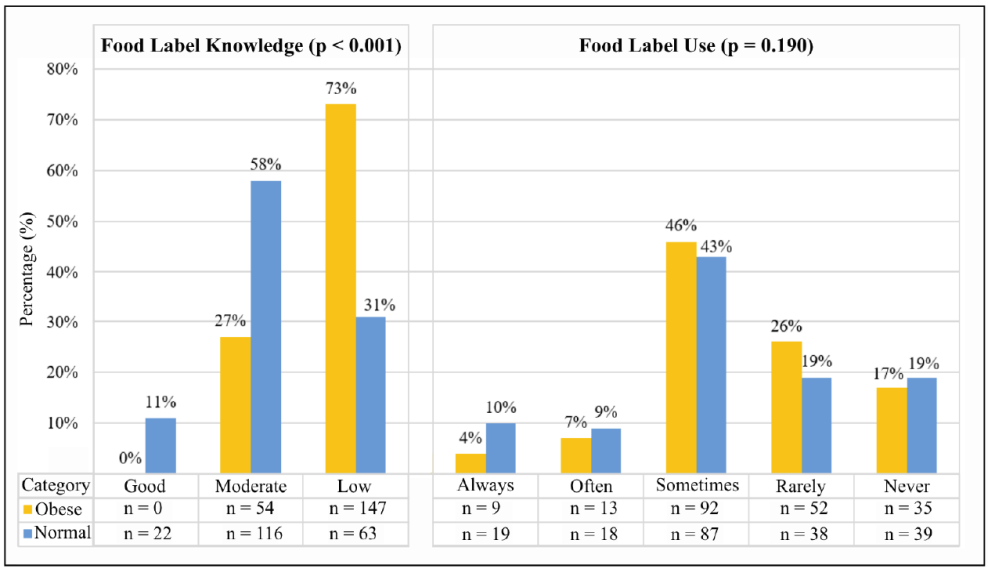


**Figure 1:** Distribution of Food Label Literacy by Children's Nutritional Status.

**Table 2: Food Label Knowledge and Use in Relation to Dietary Consumption**

| Variables | Obese (n = 201) [a] | | Normal (n = 201) [a] | |
|---|---|---|---|---|
| | p-value | OR (95% CI) | p-value | OR (95% CI) |
| **Total Consumption** | | | | |
| Food Label Knowledge | | | | |
| Good | - | - | - | Reference |
| Moderate | - | Reference | 0.936 | 0.962 (0.373–2.480) |
| Low | 0.311 | 0.699 (0.350–1.397) | 0.339 | 0.605 (0.216–1.697) |
| Food Label Use | | | | |
| Always | - | Reference | - | Reference |
| Often | 0.374 | 2.542 (0.325–19.868) | 0.962 | 1.036 (0.241–4.456) |
| Sometimes | 0.723 | 0.769 (0.180–3.284) | 0.361 | 1.684 (0.550–5.160) |
| Rarely | 0.973 | 1.027 (0.228–4.626) | 0.465 | 1.579 (0.464–5.369) |
| Never | 0.945 | 1.057 (0.221–5.049) | 0.942 | 1.047 (0.302–3.638) |
| **Consumption of UPF** | | | | |
| Food Label Knowledge | | | | |
| Good | - | - | - | Reference |
| Moderate | - | Reference | 0.836 | 1.104 (0.432–2.825) |
| Low | 0.940 | 0.975 (0.510–1.864) | 0.489 | 0.700 (0.254–1.925) |
| Food Label Use | | | | |
| Always | - | Reference | - | Reference |
| Often | 0.149 | 0.243 (0.036–1.659) | 0.148 | 2.916 (0.684–12.421) |
| Sometimes | 0.212 | 0.355 (0.070–1.803) | 0.078 | 2.916 (0.887–9.591) |
| Rarely | 0.310 | 0.422 (0.080–2.232) | 0.045 | 3.696 (1.027–13.301) |
| Never | 0.590 | 0.622 (0.111–3.498) | 0.487 | 1.587 (0.431–5.840) |
| **Consumption of SSB** | | | | |
| Food Label Knowledge | | | | |
| Good | - | - | - | Reference |
| Moderate | - | Reference | 0.113 | 2.216 (0.827–5.937) |
| Low | 0.648 | 0.858 (0.445–1.656) | 0.586 | 1.339 (0.468–3.826) |
| Food Label Use | | | | |
| Always | - | Reference | - | Reference |
| Often | 0.316 | 2.574 (0.405–16.352) | 0.280 | 2.105 (0.546–8.117) |
| Sometimes | 0.810 | 1.184 (0.298–4.708) | 0.246 | 1.885 (0.646–5.496) |
| Rarely | 0.736 | 1.279 (0.306–5.339) | 0.420 | 1.622 (0.501–5.251) |
| Never | 0.243 | 0.411 (0.093–1.826) | 0.570 | 1.404 (0.436–4.522) |

[a]Logistic regression.

**Table 3: Children's Consumption Based on Nutrient Intake and Adequacy by Nutritional Status**

| Nutrient Intake and Adequacy | Obese (n = 201) | Normal (n = 201) | p-value [a] |
|---|---|---|---|
| | Mean ± SD | | |
| **Total Consumption** | | | |
| Energy (kcal)<br>Energy RDA (%) | 2612 ± 1617<br>140 ± 85 | 1792 ± 479<br>96 ± 25 | <0.001 |
| Protein (g)<br>Protein RDA (%) | 80.32 ± 56.71<br>166.93 ± 118.40 | 58.25 ± 19.34<br>120.40 ± 40.36 | <0.001 |
| Fat (g)<br>Fat RDA (%) | 89.63 ± 62.00<br>144.33 ± 100.57 | 58.56 ± 24.32<br>93.93 ± 38.75 | <0.001 |
| Carbohydrates (g)<br>Carbohydrates RDA (%) | 306.47 ± 173.50<br>109.47 ± 61.44 | 222.85 ± 68.96<br>79.33 ± 23.12 | <0.001 |
| Fiber (g)<br>Fiber RDA (%) | 9.53 ± 6.55<br>36.34 ± 25.35 | 6.84 ± 2.87<br>25.98 ± 10.73 | <0.001 |
| Sodium (mg)<br>Sodium RDA (%) | 1,298.84 ± 1,141.36<br>105.73 ± 94.17 | 870.45 ± 429.49<br>70.91 ± 36.76 | <0.001 |
| Sugar (g)<br>Sugar Recommendation (%) | 63.40 ± 62.23<br>135.18 ± 131.56 | 43.82 ± 34.91<br>93.32 ± 71.57 | 0.002 |
| **Consumption of UPF** | | | |
| Energy (kcal)<br>Energy RDA (%) | 955 ± 949<br>51 ± 49 | 562 ± 273<br>30 ± 14 | <0.001 |
| Protein (g)<br>Protein RDA (%) | 28.87 ± 29.50<br>60.26 ± 61.25 | 18.19 ± 10.95<br>37.86 ± 23.30 | 0.002 |
| Fat (g)<br>Fat RDA (%) | 43.10 ± 40.01<br>69.46 ± 63.85 | 25.95 ± 13.34<br>41.78 ± 21.41 | <0.001 |
| Carbohydrates (g)<br>Carbohydrates RDA (%) | 87.25 ± 81.92<br>31.06 ± 28.56 | 52.93 ± 28.38<br>18.88 ± 10.04 | 0.001 |
| Fiber (g)<br>Fiber RDA (%) | 2.59 ± 2.75<br>9.80 ± 10.13 | 1.50 ± 1.01<br>5.71 ± 3.85 | <0.001 |
| Sodium (mg)<br>Sodium RDA (%) | 6.25 ± 6.27<br>7.56 ± 9.40 | 3.82 ± 2.87<br>4.57 ± 4.00 | <0.001 |
| Sugar (g)<br>Sugar Recommendation (%) | 12.52 ± 11.07<br>86.93 ± 96.62 | 7.49 ± 4.40<br>55.93 ± 55.40 | 0.002 |
| **Consumption of SSB** | | | |
| Energy (kcal)<br>Energy RDA (%) | 246 ± 337<br>13 ± 18 | 148 ± 156<br>8 ± 8 | 0.007 |
| Protein (g)<br>Protein RDA (%) | 3.98 ± 4.54<br>8.17 ± 9.50 | 3.00 ± 3.30<br>6.32 ± 7.11 | 0.135 |
| Fat (g)<br>Fat RDA (%) | 3.48 ± 6.48<br>5.56 ± 10.17 | 2.58 ± 3.73<br>4.17 ± 5.89 | 0.273 |
| Carbohydrates (g)<br>Carbohydrates RDA (%) | 34.57 ± 62.33<br>12.28 ± 21.98 | 21.64 ± 26.56<br>7.69 ± 9.09 | 0.273 |
| Fiber (g)<br>Fiber RDA (%) | 0.10 ± 0.34<br>0.39 ± 1.25 | 0.08 ± 0.26<br>0.33 ± 0.95 | 0.418 |
| Sodium (mg)<br>Sodium RDA (%) | 0.36 ± 0.67<br>0.02 ± 0.05 | 0.37 ± 0.73<br>0.02 ± 0.05 | 0.037 |
| Sugar (g)<br>Sugar Recommendation (%) | 69.38 ± 257.21<br>5.19 ± 6.72 | 28.06 ± 117.17<br>4.52 ± 7.31 | 0.135 |

[a]Chi-square.

**Table 4: The Association between UPF and SSB Energy Proportion with Childhood Obesity, and Interaction Test with Food Label Knowledge and Use**

| Variables * | p-value [a] | aOR (95% CI) [a] |
|---|---|---|
| **Consumption Effect** | | |
| UPF energy proportion (per 1%) | 0.021 | 1.018 (1.003–1.034) |
| SSB energy proportion (per 1%) | 0.361 | 1.012 (0.987–1.037) |
| **Interaction Test** | | |
| UPF with food label knowledge | 0.263 | 0.982 (0.950–1.014) |
| UPF with food label use | 0.819 | 1.002 (0.987–1.017) |
| SSB with food label knowledge | 0.064 | 0.938 (0.876–1.004) |
| SSB with food label use | 0.101 | 0.978 (0.953–1.004) |

[a]Logistic regression, * Adjusted for total energy intake using the energy proportion approach.

UPF's role in the obesity epidemic [7]. UPF contributed to over half of the daily energy intake in the obese group, far exceeding the contribution observed in the normal-weight group, which underscores UPF consumption as a dominant dietary risk factor in this urban Indonesian children's population. This high intake is concerning, given UPF's typical profile of high energy density, sugar, and saturated fat, but low fiber and micronutrients [5]. Their hyper-palatable formulation, designed to activate brain reward pathways, may encourage overconsumption and addictive-like eating behaviors in children [24].

In contrast to UPF, the proportion of energy derived from SSB was not significantly associated with obesity. This finding suggests that SSB consumption in this population may relate to obesity risk primarily through its contribution to total daily energy intake rather than through independent nutrient-specific pathways beyond energy. This is biologically plausible given that SSB is predominantly a liquid source of free sugars whose principal mechanism of weight gain is excessive caloric intake with inadequate satiety compensation [8, 9]. However, it is important to note that statistical non-significance does not preclude the existence of SSB effect through sugar-specific metabolic pathways, including fructose metabolism, insulin dysregulation, or gut microbiome alterations that are not captured by the energy proportion measure. The current analysis cannot rule out these mechanisms, and future studies employing continuous nutrient exposure variables and dietary biomarkers would provide more sensitive detection of SSB-specific effects beyond energy contribution. As this study employed a case-control design, the observed associations cannot be used to establish a causal relationship between UPF consumption and childhood obesity. Prospective or interventional studies are warranted to confirm these findings.

Consistent with the study hypothesis, obese children demonstrated significantly lower food label knowledge compared to the normal-weight group. This aligns with evidence linking poor nutritional literacy to elevated obesity risk [25] and supports the role of label comprehension in facilitating more informed food purchasing decisions [15]. The lower label knowledge in the obese group may reflect a broader nutritional literacy deficit that co-occurs with, rather than causally follows from, unhealthy dietary patterns, as both may share common determinants, including limited nutritional education, lower household nutritional awareness, and reduced exposure to health-promoting food environments. Despite this knowledge disparity, food label use did not differ significantly between groups, a pattern consistent with the well-documented knowledge-behavior gap in the health literature, in which knowledge is insufficient to drive sustained behavior change [26].

Furthermore, neither food label knowledge nor food label use revealed a significant association with dietary consumption across most categories, with one exception observed in normal-weight children. The normal-weight children who rarely used food labels had higher odds of consuming UPF than those who always used them, highlighting that using food labels is a protective habit against poor dietary choices in this group. This finding aligns with evidence that label exposure can reduce purchases of nutritionally unfavorable products [13], suggesting that food labels may serve as a protective dietary behavior in children with established healthy weight. This association was not replicated in the obese group, which may reflect the

greater entrenchment of dietary habits among children with obesity, in which cognitive nutritional information exerts less influence on habitual consumption patterns. In addition, there may be confounding factors that were not measurable in this study, such as parental feeding practices, screen time, sedentary time, physical activity levels, genetic factors, and parental BMI, which strongly influence children [27, 28].

Beyond individual cognitive factors, children's dietary behaviors are substantially shaped by their broader socioecological context, including parental dietary practices, household food availability, and the school food environment, which exert stronger influence on children's food choices than individual nutritional knowledge alone [28, 29]. In the Indonesian urban school setting, canteens have been documented to predominantly stock UPF and SSB products at accessible price points and create a structural context in which healthy choices remain constrained regardless of children's literacy or dietary intentions [10]. Behavioral factors such as physical inactivity and excessive screen time further compound obesity risk by increasing both energy imbalance and exposure to food marketing, underscoring that individual-level nutrition education is insufficient without concurrent structural and environmental interventions [27].

The interaction tests between food label variables and UPF or SSB energy proportion revealed no statistically significant moderation effects, indicating that food label literacy did not significantly modify the association between UPF or SSB energy contribution and childhood obesity in this population. These findings suggest that food label literacy, as measured in this study, did not function as a meaningful effect modifier of the dietary exposure-obesity relationship, regardless of children's level of food label knowledge or frequency of food label use. Rather than reflecting a specific epidemiological mechanism, this pattern is most parsimoniously interpreted as evidence that individual-level label literacy is insufficient to meaningfully alter the dietary behaviors that drive UPF-associated obesity risk in this population, which can be understood from several angles.

First, this knowledge-behavior gap is theoretically grounded in the Theory of Planned Behavior, which posits that intentions and actions are not solely determined by knowledge or attitudes, but are also shaped by subjective norms and perceived behavioral control [26]. In the context of children's food choices, purchasing decisions are heavily influenced by parents, taste preferences, and peer influence, which can override their own knowledge [29]. Second, it should be noted that current food labels, especially in Indonesia, may be less effective at influencing eating habits, particularly regarding UPF products. Some studies have shown that traditional nutrition facts panels are less effective at changing purchase behavior compared to interpretive front-of-package labels, such as warning labels or traffic-light systems [12, 14, 30]. Currently, in Indonesia, the FDA employs the Nutrition Facts system, which is listed on the back of the package in a numerical table format. This requires information on energy content, total fat, saturated fat, protein, total carbohydrates, sugar, and sodium [31]. While this regulation represents an important step forward, the complex back-of-package format that demands high numeracy skills makes it less accessible and less effective for children [12, 32, 33]. In contrast to the Nutri-Score system adopted by several European countries, Indonesia has not implemented front-of-package labeling on all UPF products, which would be easier to interpret and understand intuitively [34]. The Nutri-Score system's strength lies in its simplicity and visual appeal, allowing for quick processing even with minimal cognitive effort, a characteristic that is a very important feature for a population of children with limited nutrition knowledge and attention span [35].

These findings indicate that individual-level interventions must be integrated with structural changes to be effective. The WHO's recommendations for childhood obesity prevention emphasize a "whole-of-government" and "whole-of-society" approach that includes fiscal policies (taxation), regulatory policies (marketing restrictions and mandatory warning labels), and environmental modifications (school food policies) [23, 36].

These findings support policies that extend beyond voluntary consumer actions to encompass structural measures, such as implementation of interpretive front-of-package labeling systems (e.g., Nutri-Score, traffic light, or warning labels), enforcing strict marketing restrictions on UPF and SSB targeted at children, product composition regulations to reduce sugar and sodium content, imposing substantial taxes on these products, and school food environment reforms to limit UPF and SSB availability in canteens. Evidence from Chile demonstrates that such a comprehensive policy package can effectively reduce UPFs purchases [37]. Moreover, the study highlights that family-based interventions may be more effective than child-focused education alone, since targeting parental knowledge

and behaviors is key, given children's limited purchasing power and their adoption of household norms [28].

### Research Limitations

Some limitations must be acknowledged in this study. While matching has successfully balanced key baseline characteristics, residual bias from unmeasured confounders, including physical activity, screen time, sedentary behavior, sleep duration, genetic factors, parental BMI, and dietary patterns, limits this study's implications for causal inference. To address this, future studies should rigorously control for these factors at the same time. However, we attempted to increase the number of schools to include a more diverse set of participants. While the requirement for recent UPF purchase ensures the construct validity of food label literacy measurements, it limits generalizability to children with active UPF purchasing behavior. Consequently, generalizing these findings to rural settings with lower UPF accessibility requires caution or further investigation. However, given the widespread consumption of UPF among urban Indonesian school-aged children, this limitation has minimal practical impact on the study's intended scope. During NOVA classification, although no disagreements arose between the two investigators, a formal inter-rater reliability statistic was not calculated, which represents a methodological limitation. Future studies should report quantified agreement indices to further strengthen methodological rigor. This study relies on self-reported measures, leaving it susceptible to inherent limitations of retrospective dietary assessment and the absence of objective behavioral tasks, so the residual recall and reporting biases cannot be entirely excluded. Nonetheless, these risks were rigorously mitigated by employing structured, interviewer-led face-to-face sessions, using standardized visual aids to anchor responses in reality, and integrating active parental or guardian verification to cross-check self-reported results, thereby providing a more robust measurement.

## CONCLUSION

This case-control study found that UPF consumption was significantly associated with childhood obesity, while SSB showed no independent association. Food label knowledge was lower among obese children, and neither food label knowledge nor use functioned as an effect modifier in the relationship between UPF or SSB consumption and obesity among school-aged children. These findings suggest that individual-level food label literacy alone is insufficient to counteract the obesogenic food environment. Comprehensive and multi-level strategies, including front-of-pack labeling regulations, UPF and SSB marketing restrictions, school food environment reforms, and parental empowerment, are essential to effectively prevent and control childhood obesity. Future research should employ prospective designs with objective measures of label literacy and comprehensive control for environmental and behavioral confounders to establish causality and evaluate long-term intervention effectiveness.

## AUTHORS' CONTRIBUTIONS

RPI, UN, and AIAT contribute with conceptualization, methodology, data analysis, validation, interpretation, and manuscript writing. RPI collected the data. UN, NJ, BB, and AIAT contribute to the methodology, critical review, and supervision of the research.

## ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the Hasanuddin University Research Ethics Committee (Approval No.: 1496/UN4.14.1/TP.01.02/2025). Written informed consent was obtained from parents or legal guardians and children. Participants were informed of their right to withdraw at any time without repercussions. All data were anonymized, restricted to the research team, and stored securely to protect participant confidentiality.

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## CONFLICT OF INTEREST

The author states that there is no conflict in the publication of this article.

## AVAILABILITY OF DATA AND MATERIALS

Access to the dataset used in this research is available upon reasonable request to the author.

## DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work, the authors used Gemini to improve grammar, refine language, and polish. Following this tool, the authors reviewed and edited the content as necessary and take full responsibility for the publication's content. This article is entirely the result of the authors' own writing, from the initial stage through data analysis to the finalization of the manuscript.

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